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A bibliometric study of China's resource recycling industry policies: 1978–2016

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ABSTRACT

Because the resource recycling industry can effectively resolve both resource and the environmental constraints, the Chinese government has integrated it into the national strategic emerging industries system and has enacted a series of policies to promote its development. To better understand these policies, we performed a bibliometric analysis to probe the evolution of China's resource recycling policies from 1978 to 2016 and the roles of core government agencies in policy-making. Co-word analyses and social network analyses were applied to map the topics of resource recycling policies and collaboration among agencies, respectively, yielding the following findings. (1) The developmental process of China's resource recycling industry policies can be divided into four stages: an exploratory stage (1978–2002), a preliminary formation stage (2003–2008), a rapid growth stage (2009–2011), and a strategic deepening stage (2012 onward). The number of policies issued at each stage has increased steadily. (2) Four topic clusters were identified from keyword networks: policy themes, waste categories, industrial chains and policy instruments. Across the four stages, policy themes evolved from macro to specific; waste categories evolved from industrial waste to production and living waste; industrial chains evolved from the recycling chain to the whole industrial chain; and policy instruments evolved from single policy instruments to mixed policy instruments. (3) Increasing numbers of government departments are becoming involved in formulating resource recycling industry policies, and cooperation among them has gradually strengthened. Our results have important policy implications for the healthy development of China's resource recycling industry.

1. Introduction

With China's rapid industrialization and urbanization, resource and environmental constraints have generated increasingly prominent contradictions. According to research by the United Nations University, from 2010 to 2015, mobile phones, computers and other electronic equipment have produced 12.3 million tons of electronic waste on the Asian continent. During this period, the amount of e-waste generated by the Chinese has more than doubled to 6.7 million tons (Goodship and Ab, 2012). As a resource consuming country, how to effectively and rationally use resources and break through the bottleneck of economic development has become an urgent problem in China. Resource recycling is not only an important means of resource conservation and a way of ensuring the supply of resources but also an effective way of curbing the deterioration of the environment and promoting the development of ecological civilization in China (Du and Zhang, 2013). Resource recycling mainly includes the comprehensive utilization of resources and the utilization of renewable resources. To standardize and promote the development of the resource recycling industry, the Chinese government has promulgated a series of policies. With the unprecedented strategy emphasis on achieving ecological civilization in China, the development of the resource recycling industry has gradually risen to the national strategic level. In 2015, the State Council clearly set out to comprehensively improve resource utilization efficiency and to promote a fundamental change in the way resources are used. The Opinions on Accelerating the Construction of Ecological Civilization in the 13th five-year plan on the development of strategic emerging industries issued by the State Council in 2016 reiterated the need for more resource recycling and for the improvement of the resource recycling system. In the past 40 years of reform and opening up, China's resource recycling industrial policy has been a continuous process of development and evolution, reflected in changes in the law and in policy concepts, priorities, objectives and instruments in different stages. Therefore, examining and analyzing the law and the direction of the evolution of China's resource recycling industrial policy has considerable theoretical and practical significance in terms of exploring the

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internal logic of policy evolution, optimizing the policy system, and promoting the steady development of China's resource recycling industry. Currently, research related to resource recycling policies has mainly focused on the following aspects: the policy status quo (Shih, 2017; Mallawarachchi and Karunasena, 2012; Wang et al., 2017a,b), policy instruments (Keiko and Kenji, 2016; Faten and Lamia, 2012), policy effect evaluation (Jaeger and Eyckmans, 2008; Shinkuma and Managi, 2010; Lu and Tam, 2013) and policy system design (Liu et al., 2014). Although papers related to many aspects of resource recycling policies have been published, none of them have been based on bibliometric analyses, meaning that such policy dynamics have not been systematically investigated. To fill this research gap, we performed a bibliometric analysis to probe the evolution of China's resource recycling policies from 1978 to 2016 and the roles of core government agencies in policy-making.

The remainder of this paper is organized as follows. Section 2 describes the research methods. Data sources and the division of research periods are presented in Section 3. Section 4 provides the results and discussion. Finally, in Section 5 we present our research conclusions and derive policy implications.

2. Methodology

2.1. Bibliometric analysis

Bibliometrics is a useful tool to map the literature around a research field, using quantitative and visual processes to identify patterns and dynamics in scientific publications (Pritchar, 1969). The aim of bibliometric analyses is to reveal development trends in certain areas of research (Tarkowski, 2007). The aspects of a body of literature utilized by bibliometric methods include both quantitative information (e.g., annual outputs, mainstream journals, leading countries and institutions) and qualitative data (e.g., hotspots and future research directions) (Fu et al., 2013). Early Chinese policy documents contain terms that characterize the core content of the policy (called keywords), similar to the concept of keywords in academic literature (Li et al., 2015). However, in 2012, the government began to exclude keywords from the constituent elements of policy documents. Therefore, to determine policies' keywords, we set a threshold according to the frequency of the words' appearances in the documents, and the words with high frequency were analyzed as the keywords representing the core content of the policy. In this paper, the bibliometric analysis method was used to screen for keywords with high frequency and explore potential relationships between them. We also studied the characteristics of resource recycling policies in different phases.

2.2. Co-word analysis

Co-word analysis, which is used in this paper, is a content analysis method that originated in the late 1970s. Because it is easy to perform, co-word analysies has been used to search management information systems, analyze research trends (Du et al., 2014), discover research hotspots (Du, 2015) and identify the evolution of research topics (Li et al., 2011). Similarly to co-citation and co-author analysies, co-word analysies aims to identify co-words and the co-absence of keywords (Ronda and Guerras, 2012). The co-word frequency of entries is used to measure the strength of relationships among them. Based on the co-word analysis method, there are three main steps for the extraction of core words from a policy text (Su and Xu, 2013; Luo and Zhu, 2014): (1) Extract keywords—retrieve keywords from existing policies in which keywords with high frequency are identified. In this study, we manually labeled the topics of each policy with six to ten keywords. (2) Merge adjustment—some keywords differ only very slightly from each other, which may affect the rationality of the analysis results. Therefore, these similar keywords are unified in a standard form for further study. (3) Build a co-word matrix—a co-word matrix is established by counting the frequency with which each pair of keywords occurs in the same policy text. This matrix serves as a critical input in the social network visualization software.

2.3. Social network analysis

Social network analysis (SNA) is a visual method of analyzing the connections between actors, e.g., people or groups, which can reflect the centrality of the actors and the strength of relationships among them from a statistical perspective (Newman, 2001). In a network graph, actors and relationships are represented by weighted nodes and edges, respectively (Ye et al., 2012). Due to the development of network theory and software tools, SNA has been widely utilized to investigate the evolution of research and policies. It mainly includes co-word network, cooperation networks and citation networks (Li et al., 2015). In this research, co-word networks are used to explore shifts in topics in resource recycling industry policies, while cooperation networks are used to reveal relationships among the relevant departments.

In SNA, clusters are called communities, groups or modules. In this study, clustering analysis was employed to examine the comprehensive relationship between keywords in co-word networks, indeed, clustering analysis was designed to measure the structure of networks (Wang, 2015). Cluster (or community) structure detection is crucial to revealing the underlying structure of complex networks (Jacomy et al., 2014). In general, nodes in the same cluster play similar roles in the network (Kauffman et al., 2014).

Modular functions in the Gephi software were used in this study to detect these clusters. The first important part of the Gephi software is the Layout module, in which Force Atlas2 algorithms are used to reposition the nodes in the graph. This algorithm can be used in typical networks in the Gephi environment; it spatializes a network by simulating the associated physical system. As a result, the association of a node with its 'home' cluster is identified (Kauffman et al., 2014). The second important part of the Gephi software is the Modularity module. A "Modularity Class" value is computed by means of the community detection algorithm for each node via the Louvain method. As a state-of-the-art technique, the Louvain method (LM) provides a useful tool for examining large-scale weighted networks (P. De et al., 2011). Subsequently, the partition module can be used to colorize clusters. The Gephi algorithms flow charts shown in Fig. 1.

2.4. Event sequence analysis

As policy evolution is a process-based phenomenon, analytical methods suitable for the study of social processes are required (Jiao and Frank, 2015). We adopted and followed the analytical steps of event sequence analysis (ESA) to investigate the evolution process of China's resource recycling industry policies. Event sequence analysis is a collection of methods specifically developed for longitudinal research (Spekkink, 2015). The application of ESA involves at least 4 steps: (1) defining the process, (2) collecting longitudinal data, (3) coding and grouping the data (colligation), and (4) data analysis (Spekkink, 2015). These steps, as well as their application in this research, are described in the section on the division of research periods.

3. Data sources and division of research periods

3.1. Data sources

The comprehensiveness of data collection directly affects the analytical results. Before the reform and opening up, the problem of environmental pollution in China was not serious, and there were few relevant policies. However, after the reform and opening up, the country's extensive mode of development led to increasingly serious environmental pollution and source shortages. The Chinese government began to issue relevant policies to solve this problem. This paper thus