Analysis of Influencing Factors on the Development of CW Disposal Industry Based on DEMATEL Method

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Abstract: The Construction Waste (CW) treatment resources have increasingly aroused concern because the CW disposal industry involves many subjects, including the unstable supply of raw materials and sluggish sales of recycled products and other characteristics, and industrial development hasn't yet reached the ideal state. Based on the whole industry chain from the 4 dimensions of the government departments, construction enterprises, CW disposal enterprises, and recycled product users, the paper puts forward several factors affecting industrial development of CW disposal, and uses the quantitative application of DEMATEL method to analyze the interaction among various factors and causality. According to analysis results, resource consciousness of construction enterprise, pricing rationality of recycled products, implementation of the supporting policy, resource consciousness of CW disposal enterprises, proper project construction site, resources awareness of government and sales of recycled products sales are the key factors affecting the industrial development. Finally, the paper puts forward reasonable suggestions for the key factors in order to promote the development of building solid waste resource processing industry.

Introduction

With the continuous improvement of people's living standards, the requirements for housing standards are getting higher and higher. It is necessary to improve the city functions, and construct and reconstruct a lot of infrastructure and high standards community. In addition, the "national new urbanization plan (2014-2020)" proposed that in order to improve the urbanization rate to about 60%, it is necessary to make rural demolition and reconstruction to change the originally scattered, chaotic, and poor environment, which will inevitably produce a large number of CW. China wants to build a green, coordinated and sustainable society, so a great number of CW disposal is an urgent problem to be solved. The government has already realized the urgent problem and made great efforts to solve it. Ministry of Housing and Urban-Rural Development puts forward a program named *Green Building Materials Production and Application Action* to emphasize CW treatment and recycling. It could strengthen the production technology of recycled building materials in order to improve the amount of CW and product quality. China's CW recycling industry is still in the primary stage of development. There are two reasons for the present situation. Firstly, the State hasn't introduced the corresponding mandatory laws and operational policies for CW disposal. Secondly, government, enterprises and the public have a weak sense of resource, which results in the fact that CW disposal industry chain couldn't be recycled. Therefore, in the face of the development status of the CW disposal industry chains, this paper analyzes the relationship between the development factors of the industrial chain and makes a quantitative analysis. Finally, effective suggestions are put forward to promote the development of CW disposal industry.

Research Status of CW Disposal Industry Development

At present, many experts and scholars have already carried out CW recycling research. Based on the amount of CW, Kofoworola concludes that the amounts of CW production in the residential and non-residential construction unit area were 21.38kg/m^2 and 18.99kg/m^2 , and establishes a CW database by using long-term statistical research ^[1]. Rui Cunha uses DEA to study all the CW disposal enterprises in Portugal. He finds that many enterprises aren't efficient in management. The main reason for the poor circulation of CW disposal industry chain is lack of relevant incentive policies of the government ^[2]. Xavier Ruan sets up an economic model by collecting information on Irish CW, suggesting collecting resource taxes on CW producers and subsidizing the consumers using recycled products to promote CW recycling^[3]. Although domestic research is later than the abroad research on this issue, experts and scholars have made great progress on the actual conditions of our country. M.M. Hu takes the current situation of CW resources in Chongqing as an example. Through the field visiting and researching, four typical waste disposal methods are cost-calculated. It is found that the resource processing cost is the lowest in reality, which is expected to be the future CW disposal direction ^[4]. D.D. Qi constructs the success factor identification model of CW disposal industry, and identifies ten successful factors of CW disposal utilization. Through the questionnaire survey, the experts conclude that the key success factors are "government resource awareness", and "policy support and use of recycled products". Then they analyze these five key success factors for the decision-making departments of government to provide basis ^[5].

Currently, experts and scholars focus on the impact of several factors in the industrial development on the CW recycling industry research, but these factors are analyzed independently, so the relationship among many influencing factors are not studied. Therefore, there are fewer studies on the influence degree of other factors in industry development. Because the factors affecting the CW recycling industry are interrelated, the elements of the study can't be isolated. Based on the whole process of CW disposal and the total subjective behavior, this paper uses DEMATEL system factor analysis method to establish the model, analyzes the influence degree and the importance degree of the elements involved in the industry chain to other factors, and finds out the causal factors, results factors and key influencing factors. Finally, reasonable suggestions are put forward to promote the development of CW recycling industrial chain ^[6].

Establishment of Index System for Development Factors of CW Disposal Industry

Through literature reading and combing, as well as interviews with relevant experts, the paper summarizes the processing factors that affect industrial development of CW resources, establishes the index system of influence factors, and lays the foundation for the quantitative analysis of the relationship between the influencing factors. Based on the whole process of CW disposal and participation in the main behavior, the research sets up 4 dimensions: government departments, construction enterprises, CW disposal enterprises, and recycled product users, and puts up 17 factors including resource awareness of government, improvement of relevant laws and regulations, implementation of the supporting policy and so on. Finally, the index system of influencing factors of CW disposal industry was established. As shown in Table 1.

Four dimensions	Influencing factors
Government departments	Resource awareness of government F ₁
	Improvement of relevant laws and regulations F ₂
	Implementation of the supporting policy F ₃
	Perfection of the standard system of CW recycling F ₄
	Administrative supervision of government law enforcement departments F ₅
Construction enterprises	Resource consciousness of construction enterprise F ₆
	To the resource processing center distance is moderate F ₇
	The cost of resource processing is reasonable F ₈
	Getting the preferential policies F ₉
CW disposal enterprises	Resource consciousness of CW disposal enterprises F ₁₀
	Proper project construction site F ₁₁
	Stable supply of raw materials F ₁₂
	Resource processing technology maturity F ₁₃
Recycled product users	Sales of recycled products sales F ₁₄
	Recognition and acceptance of recycled products F ₁₅
	Pricing rationality of recycled products F ₁₆
	Government incentives for the use of recycled products F ₁₇

Table1 Analysis Index System of Influencing Factors for Development of CW Disposal Industry

Analysis of Influencing Factors Based on DEMATEL Model

DEMATEL is known as decision-making experiment and evaluation laboratory. It is proposed by the American Bottelle Institute. It uses the matrix tool and the graph theory to analyze the relationship of the system elements, building the direct influence matrix X , calculating the normalized matrix Y and the comprehensive influence matrix Z through Matlab software. The influencing degree of each factor on other factors and the degree of impact are calculated by the integrated impact matrix. Finally, the researchers get the central degree and the degree of each index factor, and identify the key influencing factors that affect the development of the CW disposal industry^[7].

The Analysis of the Influencing Factors Based on the DEMATEL Model is as follows:

(1) To create a direct impact matrix X . According to the above analysis, the factors affecting the development of CW disposal industry are shown with $F_1, F_2, F_3, \dots, F_{16}, F_{17}$. Assume that the n -th order matrix $X = (F)_{n \times n}$, and interview with experts in the CW disposal industry and academics. If

the factor F_i has a direct effect on F_j , the 0, 1, 2, 3, 4 scale system is used 0: there is no impact, 1:

the degree of impact is weak, 2: the degree of impact is general, 3: the impact of a higher degree, 4: a high degree of impact. Then we could invite relevant experts to rate according to the size of the

impact, that is, $F_{ij} = 0(1,2,3,4)$. Finally calculate the average of the expert scores, getting a direct

impact matrix $X = (F_{ij})_{n \times n}$, as can be seen in the Table 2

	F ₁	F ₂	F ₃	F ₄	F ₅	F ₆	F ₇	F ₈	F ₉	F ₁₀	F ₁₁	F ₁₂	F ₁₃	F ₁₄	F ₁₅	F ₁₆	F ₁₇
F ₁	0	4	4	3	4	4	2	0	4	4	2	1	0	3	2	2	4
F ₂	1	0	3	4	3	3	2	3	3	3	2	3	3	3	2	2	2
F ₃	0	1	0	2	3	3	2	2	4	3	3	3	2	3	2	3	4
F ₄	1	0	2	0	2	1	1	1	0	2	2	1	3	1	2	1	0
F ₅	1	1	1	2	0	3	1	1	0	3	2	0	2	0	2	0	1
F ₆	0	1	1	1	2	0	2	2	2	1	1	2	1	3	1	2	0
F ₇	0	1	1	0	2	3	0	4	0	0	2	3	0	0	0	3	0
F ₈	0	0	1	0	0	3	2	0	1	1	1	1	2	0	0	3	2
F ₉	1	0	0	0	0	4	0	2	0	0	0	3	0	1	2	3	1
F ₁₀	1	0	0	0	2	0	1	2	0	0	3	2	4	2	2	1	1
F ₁₁	0	0	0	1	2	3	4	3	0	4	0	3	4	2	1	3	1
F ₁₂	0	0	0	1	0	0	0	1	0	2	1	0	1	2	1	2	2
F ₁₃	0	0	1	2	0	2	0	3	1	2	0	0	0	2	2	3	2
F ₁₄	0	0	1	2	0	2	0	0	0	3	2	0	0	0	1	3	2
F ₁₅	1	0	1	2	0	2	0	1	0	2	1	0	2	4	0	3	3
F ₁₆	0	0	0	0	1	3	1	1	0	2	1	1	1	4	4	0	2
F ₁₇	1	0	0	0	0	2	1	0	0	2	0	2	0	3	4	3	0

Table 2 Direct Impact Matrix X

(2) To calculate the normalized matrix Y. $Y = X / \max_{1 \leq i \leq n} \sum_{j=1}^{j=n} x_{ij} = [y_{ij}]_{n \times n}$

(3) To calculate the comprehensive impact matrix T. It can use Matlab software to calculate the comprehensive impact matrix T, $T = Y(I - Y)^{-1}$ as can be seen in the Table 3.

	F ₁	F ₂	F ₃	F ₄	F ₅	F ₆	F ₇	F ₈	F ₉	F ₁₀	F ₁₁	F ₁₂	F ₁₃	F ₁₄	F ₁₅	F ₁₆	F ₁₇
F ₁	0.023	0.108	0.129	0.122	0.149	0.193	0.100	0.078	0.127	0.186	0.115	0.098	0.077	0.167	0.133	0.150	0.162
F ₂	0.040	0.015	0.102	0.136	0.116	0.161	0.094	0.138	0.098	0.155	0.107	0.130	0.137	0.155	0.121	0.145	0.114
F ₃	0.017	0.033	0.028	0.085	0.108	0.156	0.091	0.132	0.112	0.147	0.121	0.127	0.109	0.151	0.119	0.162	0.150
F ₄	0.031	0.009	0.063	0.026	0.071	0.070	0.048	0.061	0.016	0.093	0.078	0.052	0.106	0.069	0.083	0.073	0.038
F ₅	0.032	0.031	0.042	0.071	0.029	0.113	0.051	0.062	0.018	0.113	0.078	0.034	0.087	0.048	0.083	0.051	0.056
F ₆	0.008	0.029	0.039	0.046	0.068	0.050	0.069	0.082	0.059	0.067	0.054	0.077	0.056	0.110	0.060	0.100	0.036
F ₇	0.005	0.029	0.036	0.019	0.067	0.111	0.027	0.123	0.015	0.040	0.072	0.097	0.033	0.041	0.032	0.112	0.031
F ₈	0.005	0.006	0.033	0.015	0.019	0.105	0.066	0.031	0.034	0.054	0.044	0.050	0.069	0.040	0.033	0.109	0.071
F ₉	0.028	0.007	0.013	0.017	0.016	0.125	0.018	0.068	0.012	0.033	0.021	0.090	0.022	0.064	0.076	0.107	0.051
F ₁₀	0.030	0.007	0.017	0.025	0.066	0.048	0.047	0.081	0.012	0.048	0.095	0.072	0.125	0.090	0.082	0.075	0.059
F ₁₁	0.010	0.009	0.021	0.050	0.076	0.128	0.121	0.120	0.015	0.145	0.042	0.108	0.137	0.105	0.072	0.135	0.066
F ₁₂	0.006	0.002	0.008	0.034	0.012	0.026	0.014	0.040	0.005	0.073	0.040	0.016	0.044	0.075	0.048	0.076	0.067
F ₁₃	0.008	0.005	0.037	0.064	0.020	0.088	0.022	0.100	0.035	0.084	0.028	0.027	0.032	0.091	0.084	0.115	0.078
F ₁₄	0.008	0.004	0.033	0.061	0.022	0.079	0.022	0.027	0.009	0.103	0.071	0.026	0.032	0.041	0.057	0.105	0.071
F ₁₅	0.031	0.007	0.040	0.070	0.025	0.093	0.025	0.054	0.015	0.094	0.054	0.030	0.080	0.142	0.045	0.121	0.105
F ₁₆	0.009	0.006	0.015	0.023	0.041	0.109	0.043	0.052	0.010	0.088	0.052	0.048	0.054	0.136	0.124	0.050	0.079
F ₁₇	0.030	0.006	0.014	0.021	0.019	0.082	0.039	0.025	0.010	0.083	0.027	0.067	0.027	0.113	0.123	0.110	0.032

Table 3 Comprehensive Impact Matrix T

(4) According to the element t_{ij} in the comprehensive impact matrix T. It can calculate the

influence degree f_i of each index factor, the affected degree e_i , the center degree m_i and the cause degree of r_i , as can be seen in the Table 4. The formula for calculating the four indexes is as follows:

$$\begin{cases} f_i = \sum_{j=1}^n t_{ij} (j = 1, 2, \dots, n) \\ e_i = \sum_{j=1}^n t_{ji} (i = 1, 2, \dots, n) \\ m_i = a_i + b_i (i = 1, 2, \dots, n) \\ r_i = a_i - b_i (i = 1, 2, \dots, n) \end{cases}$$

Influencing factors F_i	the influence degree f_i	the affected degree e_i	the center degree m_i	the cause degree r_i
F_1	2.117	0.313	2.430	1.804
F_2	1.964	0.313	2.277	1.651
F_3	1.848	0.670	2.518	1.178
F_4	0.987	0.885	1.872	0.102
F_5	0.999	0.924	1.923	0.075
F_6	1.010	1.737	2.747	-0.727
F_7	0.890	0.897	1.787	-0.007
F_8	0.784	1.274	2.058	-0.490
F_9	0.768	0.602	1.370	0.166
F_{10}	0.979	1.606	2.585	-0.627
F_{11}	1.360	1.099	2.459	0.261
F_{12}	0.586	1.149	1.735	-0.563
F_{13}	0.918	1.227	2.145	-0.309
F_{14}	0.771	1.638	2.409	-0.867
F_{15}	1.031	1.375	2.406	-0.344
F_{16}	0.939	1.796	2.735	-0.857
F_{17}	0.828	1.266	2.094	-0.438

Table 4 Comprehensive Influence of the Factors Affecting the Development of CW Disposal Industry

(5) To draw the causal factor result analysis chart. It can use Matlab software to draw a cause-effect analysis diagram, as shown in Fig. 1.

Fig. 1 Analysis on the Factors Affecting the Development of CW Disposal Industry - Analysis of Results

Analysis of Influencing Factors

(1) To calculate the value based on the cause r_i . If $r_i > 0$, it is a causal factor, it indicates that this index has a large impact on other indicators, so it is stable and less susceptible to changes in other indicators. The causal factor is the analysis of the impact of CW disposal industry development factors that become the primary factors^[8]. From Table 4, the relatively strong causal factors can be found: resource awareness of government F_1 , improvement of relevant laws and regulations F_2 , and implementation of the supporting policy F_3 , etc. These factors are mainly based on the main behavior of the government, and it has a direct impact on the development of the CW disposal industry and other indicators. As it has public welfare and external economic characteristics, therefore, the government's laws, regulations and policies are needed to guide the development of the industry.

(2) If $r_i < 0$, it is a result factor, which indicates the index by the impact of other indicators, so these indicators have low stability, and are easily affected by other indicators. From Table 4 the relatively strong result factors can be found: sales of recycled products sales F_{14} , pricing rationality of recycled products F_{16} , resource consciousness of construction enterprise F_6 , etc. These factors are based on the main business behaviors. They are the main force to promote the development of CW disposal industry. The sale of recycled production is the main result factor, and it is also easily affected by other factors, but it is also important for entire industry chain to develop.

(3) From the center degree r_i , it can be seen that the key factors influencing the development of the CW disposal industry are: resource consciousness of construction enterprise F_6 , pricing rationality of recycled products F_{16} , implementation of the supporting policy F_3 , resource consciousness of CW disposal enterprises F_{10} , etc. It shows that these indicators are in an important position in the entire industry developing evaluation index system, and have a very strong driving role for other indicators, so they are important factors that affect the development of CW disposal industry.

Measures to Promote the Development of CW Disposal Industry

(1) Resource awareness of government plays a central role in promoting industrial development and can guide the government's behavior and formulate measures to deal with the problem. Government should recognize the urgency of CW recycling and strengthen the CW of the propaganda efforts to improve the awareness of construction enterprises.

(2) From the generation to recycled products throughout the life cycle, CW can't be separated from the supervision and management of government departments. Government should strengthen the regulation of the generation, transportation and handling of CW, and ensure that all the raw materials could be used for CW disposal industry^[9].

(3) When carrying out the project construction site, the resource processing enterprise should do sufficient market research and consider the minimum construction cost and operating cost principle.

(4) Resource processing enterprises should strengthen the market research of recycled products to forecast market demand and analyze product prices. It is also important to improve the price advantage of recycled products to attract more enterprises to use renewable products. Resource processing enterprises also needs to carry on the quality authentication to the recycled product, and eliminate user concerns.

Conclusion

This paper analyzes the factors that influence the development of CW disposal industry from four main behaviors of government departments, construction enterprises, CW disposal enterprises and recycled product users. Through the establishment of DEMATEL model, the researchers can conclude the following factors: resource consciousness of construction enterprise F_6 , pricing rationality of recycled products F_{16} , implementation of the supporting policy F_3 , resource consciousness of CW disposal enterprises F_{10} , proper project construction site F_{11} , resource awareness of government F_1 , etc. These factors are the key factors which affect the development of the CW disposal industry. Therefore, reasonable suggestions are put forward for the main influencing factors, with a view to promoting the development of the CW disposal industry.

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