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YU-JING CHIU
Department of Business Administration, Chung Yuan Christian University, Taiwan

MING-HUNG YANG
Department of Business Administration, Chung Yuan Christian University, Taiwan

CHIN-YI CHEN
Department of Business Administration, Chung Yuan Christian University, Taiwan

KEY FACTORS OF REVERSE LOGISTICS MANAGEMENT IN WASTEWATER TREATMENT INDUSTRY

Abstract:

Technology products are changing with each passing day, and the process of producing these products re-quires many organic solutions that can seriously pollute water resources. Therefore, the introduction of reverse logistics management in the waste liquid recycling industry is an important issue. Domestic companies face many management problems when they enter the waste recycling industry. It is important to choose key factors for efficient management. This study first explores and establishes the management factors related to the waste solution recycling industry through literature review and expert opinions and experience, and then constructs and establishes the management factors of the waste solution recycling industry through DEMATEL-based ANP (DANP). Research results show that the criteria of "momentum in dealing liquid waste", "environmental policies and regulations ", "amount of waste", "equipment cost" and "secondary pollution " are revealed to be the signifi-cant criteria of management in the wastewater treatment industry.

Keywords:

Wastewater treatment; Key factor; DANP

1. Introduction

There has been a tremendous rise worldwide in the amount of industrial sewage generated over the last few years owing to increase in population, number and size of tech products, and use of disposable chemical sewage. As a result of recent environmental crises, industrial sewage treatment and management have become increasing important. Intensified environment regulation pressure and demand for momentum in dealing industrial sewage have led to significant change of the role played by recycling industry over the past few years.

The total value of product of Taiwan's environmental protection industry has been steadily growing; especially in 2007, the industries of environmental protection services gigantically grew to form 53.4% of the total value of product of Taiwan's environmental protection industry. Influenced by the financial crisis in 2008, Taiwan's value of product in environmental protection performed negative growth until 2009 and thence rebounded (Industrial Development Bureau, Ministry of Economic Affairs, Taiwan 2012). The total volume of the industry will not rise sharply in 2016 owing to the global economic recovery is still subject to uncertainties and the rise of China's red supply chain would prevent Taiwanese electronics companies from increasing spending and bring down the total volume of waste treatment and disposal in Taiwan.

The construction of this paper is organized as follows. Section 1 provides an introduction which includes the research motive, abstract practices in environmental protection industry market, especially in Taiwan and methodology. Section 2 reviews the academic evidence on waste management and its implications for key factors of assessment system. Section 3 describes a hybrid methodology that combines DEMATEL and ANP with empirical case studies about electronic wastewater management. Section 4 and Section 5 lead to research results, conclusion, managerial insights and the direction for future researches.

2. Waste management

Waste management is all the activities and actions required to manage waste from its inception to its final disposal (United Nations. New York: UN, 1997). This includes amongst other things, collection, transport, treatment and disposal of waste together with monitoring and regulation. It also encompasses the legal and regulatory framework that relates to waste management encompassing guidance on recycling, etc. There are common major factors in the success of the major management programs of the nation programs (Nilsson-Djerf, 1999). In order to achieve a comprehensive assessment, this study expands the scope of literatures to the waste recycling industry rather than only focusing on the researches of wastewater recycling and treatment.

Waste management strategy takes into consideration the sustainable development objectives, such as economic aspects, environmental consequences, and social issues (Roussat et al., 2009). These environmental management measures include environmental policy and planning, legal requirements, staff training and internal and external communication (ISO. 2015). As the result from survey results reflected that regulations and environmental policies for waste management are generally effective. This is in line with Karavezyris (2007) who suggested that government plays a significant role in promoting waste management practice by enforcing policies for the whole recycling industry. Research and development (R&D) can provide guidelines and technical support for waste reduction reuse, recycling and disposal, and which should focus on government policies waste management technologies.

Attitudes and behaviors are necessary to effectively improve waste management, growth and performance, as well as to reduce the environmental degradation of the recycling industry. This resonates with the research which has assented that the practitioners' awareness of resource saving and environment protection is a vital driver in order to waste minimization (Osmani et al., 2008). The important and significant factors that affect attitudes toward waste management include contractor size, source reduction, reuse and recycling measures, frequency of waste collection, staff participation in training programs and waste disposal method. We generalized related factors such as recycling-related education and skill-level of employees, contractor experience in recycling works, source-reduction measures, reuse of materials, waste disposal behaviors and attitudes toward and found significant factors affecting on waste management (Begum et al., 2009).

Because the techniques and regulations of recycling are pretty complicated, the decision makers follow the order below on the management of regeneration. From the angle of economy, the momentum that the industries are running with is of the top concern, and secondly the cost of the equipment. Cost comparisons are a crucial element of any sustainability assessment (Eggimann et al., 2016). For evaluating the investment costs, land costs, such as waste treatment facilities and the transportation vehicles costs to evaluate the operational costs, maintenance costs, energy costs and other operating costs are also taken into account in waste recycling industrial (Stefanović et al., 2016).

From the angle of environment, the harmful chemical materials, acid and oily sludge could cause severer secondary pollution which caused in the process of recovery of wastewater treatment, such as air pollution and water pollution. In 2006, EPA, Taiwan issued guidelines and standards for environmental pollution control, including interim uniform effluent limits for all categories of industrial water. Now many Taiwan’s manufacturing of industry comply with the environmental policies and regulations, process releases huge amount of acid, base chemical materials, and organic liquid wastes. Simultaneously, unsuitable wastewater treatment will generate large volumes of secondary resources. The results show that recycling capacity or momentum in dealing liquid waste must increase if the rising quantity of wastewater is to be handled properly. On the other words, the public acceptance is an indicator that depends on the level of the waste treatment technology (Stefanović et al., 2016). The waste recycling industries should have the communication ability and apply the environment regulations.

Criteria	Explanations
(C1)Environment policies & regulations	To comply with environment policies or regulations and commitments of it is public.
(C2)Equipment cost	Industrials are willing to invest in using application and development of municipal waste treatment technology equipment.
(C3) Cost of manipulating	The cost of liquid waste-to-energy.
(C4) Classification and storage	Hazardous wastes are classified on the basis of their biological, chemical and physical properties and also storage basis of its materials.
(C5) Environmental awareness of employee	Industrials provide adequate education and training to all staff working with safe working procedures for standard activities and wastewater management workers should be trained in proper waste handling.
(C6) Momentum in dealing liquid waste	Wastewater treatment volume.
(C7) Communication ability	Industrials consider the social responsibility of the public and emphasize the internal and external communication.
(C8) Economical value	The economic activity that industrials creates through the recycling of waste solutions.
(C9) Secondary pollution	The pollutions caused in the process of recovery of wastewater treatment, such as air pollution and water pollution.
(C10) Amount of waste	Total amount of waste generated during the wastewater treatment and recovery process.

Table 1 Criteria of evaluating system

The literature is converged to transform into evaluation factors and definitions that works for empirical case of liquid waste recycling industries. The conducted literature review has shown that (MCDA) quite often used as a decision-making technique in the waste management. Onüt and Soner (2008) used AHP and TOPSIS for transshipment site selection in Istanbul. However, some factors are related not independent. The AHP cannot explain the entire management situation. And few researches apply hybrid method of DNAP to evaluate key factors in waste management; the motivation for this study is to conduct an application of DANP in the sector of waste management.

3. The DANP method

3.1 The DANP method

The method employed can be summarized as follows.

Step 1: Generating the direct-influence matrix.

Experts are asked to present the degree of direct influence that each criterion $_i$ exerts on other factor $_j$ as indicated by Z^{ij}, matrix Z of direct relations can be constructed.

Step 2: Normalizing the direct relation matrix

Based on the direct-influence of matrix Z, which was subsequently normalized to yield a normalized direct influence matrix D, which is acquired from Eqs. (1) and (2).

$$D = \lambda Z \quad (1)$$

$$\lambda = \min\left\{\frac{1}{\max_i \sum_{j=1}^{n} \alpha_{ij}}, \frac{1}{\max_j \sum_{i=1}^{n} \alpha_{ij}}\right\}, \in i,j = \{1,2,3,\dots,n\} \quad (2)$$

Step 3: Getting the total-influence matrix T which can be acquired using Eq. (3)

$$T = D + D^2 + \cdots D^h = D(I-D)(I-D^h) = D(I-D)^{-1} \quad (3)$$

when $h \to \infty, D^h = [0]_{nn}$' where $D = [d_{ij}]_{n\times n}$, $0 \le d_{ij} < 1, 0 < \sum_{j=1}^{n} d \le 1, 0 < \sum_{1}^{n} d_{ij} \leqq 1$

If at least one column or one row sum equals 1(but not all) in $\sum_{j=1}^{n} d_{ij}$ and $\sum_{i=1}^{n} d_{ij}$, then that $\lim_{l\to\infty} D^h = [0]_{nn}$'

Step 4: Obtaining the inner dependence matrix. The sum of the rows $\sum_{i=1}^{n} t_{ij} = t_i$ are separately denoted as vector $R = (r_1,\dots,r_i,\dots r_n)'$ And vector $D = (d_1,\dots,d_j,\dots d_n)'$ by using Eqs. (4)-(6). Let $i = j$ and $i,j = \{1,2,3,\dots,n\}$.

In these equations, vector D and vector R denote the sum of rows and the sum of columns from the total-relation matrix. In these equations, vector D and vector R denote the sum of rows and the sum of columns from the total-relation matrix respectively as follow:

$T = [T_{ij}]_{n\times n'}$, and the use of superscript denotes transposition.

$$T = [T_{ij}]_{n\times n'} \quad i,j = 1,2,3,\dots,n \quad (4)$$

$$R = [t_j]_{1\times n} = [\textstyle\sum_{j=1}^{n} t_{ij}]_{1\times n} \quad (5)$$

$$D = [t_i]_{n\times 1} = [\textstyle\sum_{i=1}^{n} t_{ij}]_{n\times 1} \quad (6)$$

3.2 Based on the DEMATEL method to find influential weights of DANP

We suppose a system contains three criteria D_1, D_i and D_n, the total influence matrix T was used to normalize the total influence matrix to obtain the unweighted matrix for ANP, a new total-influence matrix T_c as shown in Eq. (7).

$$T_c = \begin{matrix} & \\ D_1 & \begin{matrix} c_{11} \\ c_{12} \\ \vdots \\ c_{1m_1} \end{matrix} \\ \vdots & \\ D_i & \begin{matrix} c_{i1} \\ c_{i2} \\ \vdots \\ c_{im_i} \end{matrix} \\ \vdots & \\ D_n & \begin{matrix} c_{n1} \\ c_{n2} \\ \vdots \\ c_{nm_n} \end{matrix} \end{matrix} \overset{\begin{matrix} D_1 & \cdots & D_j & \cdots & D_n \\ c_{11} \cdots c_{1m_1} & & c_{1j} \cdots c_{jm_j} & & c_{n1} \cdots c_{nm_n} \end{matrix}}{\begin{bmatrix} T_c^{11} & \cdots & T_c^{1j} & \cdots & T_c^{1n} \\ \vdots & & \vdots & & \vdots \\ T_c^{i1} & \cdots & T_c^{ij} & \cdots & T_c^{in} \\ \vdots & & \vdots & \ddots & \vdots \\ T_c^{n1} & & T_c^{nj} & & T_c^{nn} \end{bmatrix}} \quad (7)$$

Step 5: Building unweighted supermatrix by comparing the criteria, as shown in Eq. (8).

$$W = \begin{matrix} & \\ D_1 & \begin{matrix} c_{11} \\ c_{12} \\ \vdots \\ c_{1m_1} \end{matrix} \\ \vdots & \\ D_i & \begin{matrix} c_{i1} \\ c_{i2} \\ \vdots \\ c_{jm_j} \end{matrix} \\ \vdots & \\ D_n & \begin{matrix} c_{n1} \\ c_{n2} \\ \vdots \\ c_{nm_n} \end{matrix} \end{matrix} \overset{\begin{matrix} D_1 & \cdots & D_j & \cdots & D_n \\ c_{11} \cdots c_{1m_1} & & c_{1j} \cdots c_{jm_j} & & c_{n1} \cdots c_{nm_n} \end{matrix}}{\begin{bmatrix} W^{11} & \cdots & W^{1i} & \cdots & W^{1n} \\ \vdots & & \vdots & & \vdots \\ W^{j1} & \cdots & W^{ij} & \cdots & W^{jn} \\ \vdots & & \vdots & \ddots & \vdots \\ W^{n1} & & W^{in} & & W^{nn} \end{bmatrix}} \quad (8)$$

Because the influence degrees between criteria in the total-influence matrix T_c are different, which is formed by the DEMATEL, all criteria of the total-influence matrix T_c should be normalized, which is denoted by T_z. The normalized elements of the total influence T_z are $t_{ij}^{z} = t_{ij}^{c} \div \sum_{i=1}^{n} t_{ij}^{c}$, take for example as shown in Eq. (9)

$$T_z = \begin{bmatrix} t_{11}^{z} & \cdots & t_{1j}^{z} & \cdots & t_{1n}^{z} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{z} & \cdots & t_{ij}^{z} & \cdots & t_{in}^{z} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{z} & & t_{nj}^{z} & & t_{nn}^{z} \end{bmatrix} \quad (9)$$

Step 6: Form the weight supermatrix W^{α} , as shown in Eq. (10).

$$W^{\alpha} = T_z W \quad (10)$$

Step 7: Limiting the weighted supermatrix for the weights.

Finally, W^{α} was multiplied by itself several times until convergence to obtain the limiting supermatrix W^{*} by Eq. (11).

$$W^{*} = \lim_{r \to \infty} (W^{\alpha})^{r} \quad (11)$$

4. Empirical Example

By investigating the literature and talking with fifteen(15) experts, we got some suggestions to determine the ten (10) criteria (see note of Table 1). The fifteen (15)experts are selected based on their familiarity or experience with the destination and scales from "no influence (0)" to "very high influence (4) to distinguish the influence range between each criterion The degree of direct influence denoted by a_{ij}, that means the effect of each criterion *i* to each criterion *j*. Following the DEMATEL procedures, the average initial direct-relation matrix *Z* is a 10×10 matrix, gained by pairwise relations which are determined for modeling with respect to a mathematical relation pairwise comparisons in terms of influence and directions between criteria. As indicted by matrix *Z*, the normalized direct influence matrix was obtained using Eqs. (1) and (2). Next, the total influence matrix *T* was calculated using Eq. (3). Further, Eq.s (5) and (6) are used to search the prominence and relation of each criterion.

Next, the unweighted supermatrix form according to Step 5, the composition of a supermatrix was multiplied. Traditional ANP method seems irrational to assume equal weights, but this is not true in the real world (Guan et al., 2012), by considering the extent of the impact of various criteria, we prepare a weighted supermatrix , using Eq. (10), which is determined based on the results of DEMATEL. The limiting supermatrix generating by using Eq. (11), has an equilibrium distribution, as in the Markov chain process. Alternatives in the model can be ordered by using limiting priorities obtained from the equilibrium distribution of the supermatrix. The ANP method used to calculate global weight for understanding the maximum among the factors, is the primary factor, and all criteria are influenced by 'Momentum in dealing liquid waste (C6)'.

Table 2 Both methods criteria ranking

Criteria	weights for criteria	DANP Ranking	DEMATEL Ranking
C6 Momentum in dealing liquid waste	0.120	1	2
C1 Environment policies & regulations	0.110	2	1
C10 Amount of waste	0.105	3	3
C2 Equipment cost	0.104	4	5
C9 Secondary pollution	0.104	5	4
C8 Economical value	0.104	6	7
C3 Cost of manipulating	0.096	7	8
C4 Classification and storage	0.094	8	6
C7 Communication ability	0.082	9	10
C5 Environmental awareness of employee	0.080	10	9

Finally organizing DANP's ranking to know in average the 15 expert participants' importance to the criteria, in which 'Momentum in dealing liquid waste (C6)','Environment policies and regulations (C1)', 'Amount of waste (C10)', ' Equipment cost (C2)', 'Secondary pollution (C9)' are the key influence criteria, as shown in Table 2.

In total influence matrix to pick and simplify the total influence value of the key factors mentioned above, as seen in Fig. 1, knowing (C1), (C2), (C9) and (C10) are influenced by (C6).

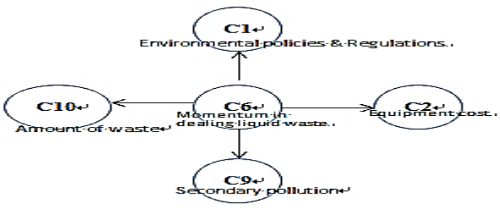

Fig. 1 Relationships of key factors

5. Conclusion and managerial insights

In the sum of above causal results, the study tried to clarify the problem of Taiwanese chemical liquid waste recycling and treatment industries and offered an explanation of sight management of waste management. The DANP method provides the ability for a decision-maker to confirm consistency and increase reliability of each waste management option's result, which analysis result is summarized below:

(1) First of all, overview the result of (C2) and (C6) are related; 'Momentum of liquid waste treating '(C6) 'influence simultaneously 'Environmental policies and regulations (C1)'.In which before the liquid waste recycling companies buying related techniques and equipment, could consider Taiwan's manufacturing procedure generated liquid types and total amount, the type of liquid waste whether being able to be recycled, and then consider liquid waste's property, to find out the most proper recycling techniques and equipment, the techniques taken should follow economical value, not only recycling quality should follow environmental regulations, and should follow, at the same time, the cost of dealing with the final wastes.

(2) Moreover, focusing on the result of (C6) influence simultaneously (C1), (C9) and (C10), the recycling and treatment industrial establish relative policies in the process of recycling or treatment not only comply with government's environmental regulations, but also consider company's policies fulfill their corporate social responsibility (CSR) or not, the companies should promise the society to fulfill environmental protection task to establish business's reputation.

There are some limitations to this paper. If we can extend more experts' opinion as reference, the study would be able to make more complete consideration, make the information of the industry richer. On the other hand, in the investigations afterwards, can compare with the waste recycle related industry abroad, in different environments, statute, and dealing ways, but still can follow this research's method to talk with experts to find out proper management key factors. The natural directions for future research, which is surveying the industrial similarities and differences MCDA methods, could be a field of theoretical study.

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