

## Comparison Between the Two End Circular Economy Index Systems of Manufacturing Industrial Chain to Form into a Unified System

ZHENG Jiliang<sup>1,\*</sup>; ZHENG Chen<sup>2</sup>

<sup>1</sup>Faculty of Management & Economics, Kunming University of Science & Technology, 650093, China

Professor, mainly engaged in circular economy, sustainable development management of manufacturing industry.

<sup>2</sup>School of Banking and Finance, University of International Business and Economics, Beijing, 100029, China

\*Corresponding author.

Address: Faculty of Management & Economics, Kunming University of Science & Technology, 650093, China

Email: jlzheng704@163.com

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### Abstract

The two ends of manufacturing industrial chain refer to the resource industry and consumption product industry. Under the construction of circular economy, the focuses of the two kinds of industries are not the same, and huge difference exists. It is necessary to build up a unified circular economic index system in the situation of green supply chain management. Thus, the features, achievements and trends about circular economy development of the two ends of manufacturing industrial chain have been compared and analyzed here, and a unified circular economic system frame or model has been studied and proposed. An idea of transmitting the unified environmental management requirements along industrial chain through weight variable is proposed also.

**Key words:** Manufacturing industry; Industrial chain; Circular economic index system

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### INTRODUCTION

The two ends of manufacturing industrial chain refer to the upper and lower reaches of it. In it, the upper reach industry goes in for the mining and production of raw materials such as iron steel, nonferrous metal, building material, coal, and other raw materials, which is called as the resource industry in general. The lower reach industry provides the final products for consumer such as household appliance, motor vehicle and etc. So far, a lot of researches have been carried out on the circular economy or green product index system of the upper and lower reaches of manufacturing industrial chain. But the built index system for both ends of industrial chain is independent for each other owing to different features of industries, which are classified into the different sort of industry actually. However, we found out that many items in the circular economy index system or green product index system are similar. Therefore, it is necessary to conduct a unified and systematic research on them. In the situation and trend of green supply chain management, to transmit the unified environmental management requirements along industrial chain from an end to the other should be considered as well. Based on the above view, after analyzing and comparing the circular economy or green product index system of the upper and lower reaches of manufacturing industrial chain, a unified circular economic index system frame or model for the two ends of manufacturing industrial chain with perspective of circular economy have been built up primarily, which may reflect the transmitting of environmental management at the same time.

# 1. REFERENCE SUMMARIZATION AND REVIEW ABOUT THE CIRCULAR ECONOMY INDEX SYSTEM OR GREEN PRODUCT INDEX SYSTEM OF MANUFACTURING INDUSTRIES

## 1.1 References Summarization

There are a lot of researches on the circular economy index system of the upper reach industry. For example, Cui Shujun and et al (2008) divided the index system of iron industry into three parts: resource consumption, comprehensive utilization and waste discharge. Li Caihong (2007) divided the index system of chemical industry into such parts as reducing utilization of resources, comprehensive utilization, recycle and reuse of resource, industrial structure and development capability of circular economy. Gao hong and et al (2007) divided the index system of yellow phosphorus industry into parts as efficiency, material recycle, technological innovation & achievement transformation capability, resource exploitation & ecological restoration, regulation & policy. Jiang Tao and et al (2007) divided the index system of coal industry into several categories: management, economy, ecological protection, and circular economy. There are some researches with perspective of resource industries. For example, Sha Jinghua and et al (2008) classified the index system of mining industry as economic and social benefit, exploitation and utilization of mineral resources, comprehensive and recycle utilization, and ecologic environment protection. Shi Jijin (2008) divided the index system of mining industry into such parts as social economy, energy consumption, pollution discharge and recycle utilization. Zheng jiliang (2008) divided the index system of energy-intensive industries into three categories of economic performance, environmental performance and social performance, their particular indexes were given also.

In the lower reach industry, evaluation index system of green product, a firm's green degree or green manufacturing system rather than circular economy index system are used generally. For example, Liu Zhifeng and et al (2000) built up a green product evaluation index system, which includes product's basic, environment, resource and economy property. Zhang Yan and et al (2005) established a firm's green degree evaluation index system, which includes cleaner level of production technology, compatibility between product and environment, "three wastes" discharge and disposal level in production process, characteristics of firm's resources and energy utilization, and social influence. Cao Guozhi and et al (2006) constructed a firm's green degree evaluation index system, which includes product green level, cleaner level of production technology, and wastes discharge and disposal level. Shen Decong and et al (2006)

researched an evaluation system of green manufacturing system, which includes development degree, sustaining degree and fair degree. Zhang Qingshan and et al (2009) published a book "*Green Product Evaluation System for Manufacturing Industry*", three parts "economic attribution, technical attribution and green attribution" are included in its comprehensive evaluation index system of green product.

## 1.2 Review

Most of the upper reach industry (mineral resources exploitation and primary processing industry) is energy-intensive industry (metallurgical industry, chemical industry, building material industry and power industry), which has the feature of high energy, material consumption (including water consumption) and high discharge level. Therefore, index system designed for these industries in the circular economy, which composes of lowering energy consumption, increasing mineral resource use factor, three wastes controlling and recycling, and lowering water consumption, are usually the key components.

The lower reach industry (final consuming goods industry) has the features of long industrial chain, supply chain management, and continual growth of retrieving responsibility of the waste and old product. So, this industry pays great attention to the environmental management problems such as a product's life cycle (design, production, marketing, use and retrieving) green management, green supply management and product disassembling and recovery.

We can see that, there are some common ideas and also differences parts about green management or environmental management between the upper and lower reach industries. The common ideas are the basic patterns of saving energy, lowering consumption, reducing discharge and recycling waste with the objective to decrease the impact of production and consumption on environment. The different parts are, the degree of impact on environment and the role of basic patterns between the upper and lower reach industries. In fact, the impact of the upper reach industry on ecologic environment is much greater the lower reach industry. The role of green supply chain management in the upper reach industry is relatively small owing to the short industry chain. On the contrary, green supply chain management is attached great importance on the research of the lower reach industry owing to the long industrial chain, and the idea of a product's life cycle green management is same as green supply chain management actually.

In addition, the problem of disassembling, retrieving and recycling of waste product is being emphasized more owing to the shortening of product's life cycle, a large amount of them need to be put into production as raw materials again. This reversal direction material flow promotes the relationship between the upper and

lower reach industries. Thus, the upper and lower reach industries, as two ends of manufacturing industrial chain, are being interrelated more and more under the linking and interacting of both positive direction and reverse direction material flow. It is another point to support the idea of building up a unified circular economy index system and embody the idea of transmitting environmental management.

## **2. ANALYSIS ON THE COMPONENT PARTS OF THE CIRCULAR ECONOMY INDEX SYSTEM (CEIS) FOR EACH END OF THE MANUFACTURING INDUSTRIAL CHAIN**

### **2.1 Analysis on the Component Parts of CEIS for the Upper Reach Industry**

There are four component parts of CEIS for the upper reach industry of the manufacturing industrial chain generally. These four components and the common index in each part are summarized as below.

(1) Index of lowering energy consumption. Energy consumption includes coal and electricity consumption. Most of the energy consumption of resource industry comes from production process. The production process are divided into three parts usually, which are mining, mineral separation and smelting. So, the index of lowering energy consumption is composed of the corresponding index in the parts of mining, mineral separation and smelting.

(2) Index of improving use factor of mineral resource. They include mining availability, recovering factor of main mineral resource and accompanying mineral, average grade of utilized mineral, comprehensive use factor of mineral resource and etc.

(3) Index of three wastes controlling and recycling. ①waste water discharge under standard and reuse; ②dust discharge under standard and retrieve; sulphur dioxide under standard and retrieve; carbon monoxide under standard and retrieve; ③slag discharge under standard and reuse.

(4) Index of lowering water consumption. These include fresh water consumption amount of unit product, comprehensive water consumption and etc.

### **2.2 Analysis on the Component Parts of CEIS for the Lower Reach Industry**

There are three component parts of CEIS for the lower reach industry of the manufacturing industrial chain

generally. These three component parts and the common index in each part are summarized as below.

(1) Product life cycle environmental management. This is an analyzing model of two dimensions. In it, the horizontal axis represents each phase of life cycle, which are designing, processing, packaging, marketing, using and retrieving; the vertical refers to the contents of environmental management in each phase, which are economic attribute, technical attribute, environmental attribute, resource attribute, energy attribute and social attribute.

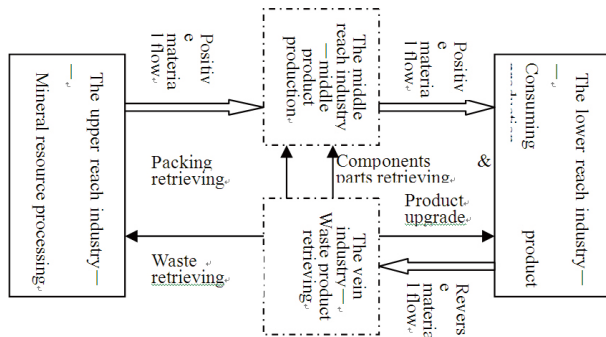
(2) Green supply chain management. In modern society, a product's life cycle has to be completed by several firms since social labor division is more professional. This is a process of supply chain management. Then, a product's life cycle environmental management is a process of green supply chain management. The environmental management in each phase of life cycle may be not successive owing to the split process among each firm's product's life cycle environmental management. Green supply chain management is to carry out the unified environmental management with perspective of supply chain, and it may solve the problems existed in process of a product's life cycle environmental management.

(3) Product disassembling and retrieving. This is one of the key points to build the circular economy index system, which will include product's disassembly, retrieval, recoverability and economy.

## **3. COMPARISON BETWEEN THE TWO END CIRCULAR INDEX SYSTEMS OF MANUFACTURING INDUSTRIAL CHAIN TO FORM INTO A UNIFIED SYSTEM**

### **3.1 The Material Flow Relationship Between the Two Ends of Manufacturing Industrial Chain**

The material flow relationship between the two ends of manufacturing industrial chain is shown in Fig.1. In figure 1, the upper reach industry and the lower reach industry are connected through the middle reach industry and the vein industry to form the positive and reverse material flow. Both of the positive and reverse material flows are the components of value chain of manufacturing industry. Based on figure 1, the key parts of circular economy in each end of manufacturing industrial chain will be compared and analyzed, and a unified CEIS is appropriate for both the two ends of manufacturing industrial chain which is tried to be built up then.



**Figure 1**  
**Material Flow Chart of Manufacturing Industrial Chain**

**3.2 Comparison on the Key Works of Circular Economy Between the Two Ends of Manufacturing Industrial Chain**

The key works of circular economy construction in the upper reach industry are listed as below. The first is saving energy. The percentage of energy consumption cost over the total product cost is great, which may reach 30%~50%. So, saving energy is not only the need to cut the cost of a product, but also the requirement of the construction of circular economy and low-carbon economy. The second is reducing discharge. That is to reduce three wastes discharge continuously, including standard compliance and recycling. The third is lowering consumption. It refers to lowering the consumption of materials, especially the consumption of ore and fresh water. The measures are, firstly, to eliminate the backward equipments, improve the second use factor of energy, and lower energy consumption of unit product; secondly, to raise the standard of three wastes reusing; thirdly, to import advanced equipment or renew old equipment.

The key works of circular economy construction in the lower reach industry is to give overall consideration on saving energy, reducing discharge, lowering consumption and product retrieving in each link of a product’s life cycle. The countermeasures are, firstly, to upgrade power

set such as electric machinery in production line, and to lower electricity consumption and power gas; secondly, the retrieving and recycling of waste oil such as the used coolant liquid or lubricating oil should be involved in the reusing of three wastes; thirdly, to carry out the obligation of product recovery, such as the works of design for disassembling, classifying and disposing of old product and retrieving of packing materials.

We can see that, the key points of circular economic work for both ends of manufacturing industrial chain are same, which are the four basic works of energy saving, discharge reducing, consumption lowering and waste reusing. However, the proportion of each work in the circular economic works as a whole is greatly different. The same key points are the basis to build up the unified frame of CEIS. The dissimilar working points may be reflected through choosing different circular economic index.

**3.3 A Unified CEIS for Both Ends of Manufacturing Industrial Chain and the Component Index Selection**

A unified circular economic index system for the upper and lower reach industries of manufacturing industrial chain is built up on the basis of the industrial features and achievements made. The system is composed of energy consumption, material consumption, waste disposal and retrieving in production, recovery of product and packing material, green design, and raw material production. The key indexes of circular economy for the upper and lower reach industries have been selected primarily as shown in the table 1. In the table 1, part A and B are the basic parameters to be lowered for circular economy progress of manufacturing industrial chain; part C, D, E and F represent the controlling parameters in a product’s life cycle. These parameters may be selected respectively for the upper and lower reach industries. With the same method, the circular economic index system for the middle reach industry and the vein industry may be built up as well.

**Table 1**  
**A Unified CEIS for Manufacturing Industrial Chain and the Index Selection**

Index system composition	weight variable	Index system for upper reach industry	Index system for lower reach industry	Index system for middle reach industry (to be extended)	Index system for vein industry (to be extended)
Energy consumption (A)	Electricity consumption	X1	√	√	
	Coal consumption	X2	√		
	Gas consumption	X3		√	TA
Material consumption (B)	Raw material consumption	X4	√	√	
	Water consumption	X5	√		
Waste disposal and recycle (C)	Waste water	X6	√		
	Waste gas	X7	√		
	Solid waste	X8	√	√	
	Waste oil Waste liquid	X9		√	

To be continued

Continued

Index system composition		weight variable	Index system for upper reach industry	Index system for lower reach industry	Index system for middle reach industry (to be extended)	Index system for vein industry (to be extended)
Product and packing material discovery(D)	Old product upgrade	X10		√		
	Component part reuse	X11		√		
	Waste material reuse	X12	√	√		
	Packing material retrieving	X13		√		
Green design (E)	Design for disassemble	X14		√		
	Design for recovery	X15		√		
Raw material production (F)	Mineral mining	X16	√			
	Raw material smelting	X17	√			
	Raw material purchase	X18		√		

### 3.4 The Problem of Environmental Management Transmitting Considered in the Unified System

This problem plans to be solved through setting up the weight variable shown in the table 1. For example, in the upper reach industry, the indexes of energy and material consumption, waste disposal and retrieving have great influence, their value of weight variable will be big then; in the lower reach industry, the indexes of product and packing material recovery, and product green design have great impact, so their value of weight variable will be great. On the contrary, the value of other indexes will be smaller then. Suppose weight variable is  $X = \{X_1, X_2, \dots, X_n\}$ ,  $n$  is the number of index. In a industrial index system,  $X_i \neq 0$ , if  $X_i$  is the component part of the index system;  $X_i = 0$ , if  $X_i$  is not the component part of the index system.  $X_i$  will be bigger, if the contribution or influence of  $X_i$  is greater;  $X_i$  will be smaller, if the contribution or influence of  $X_i$  is less. It means that the weight value of  $X_i$  will be varied in different index system, and the weight value of  $X_i$  may reflect its environmental management and transmitting status along the manufacturing industrial chain (upper reach, middle reach, lower reach and vein industry). For example, the energy indexes  $X_1$  and  $X_2$  have great influence in the upper reach industry, but its influence reduce gradually along the middle reach industry and lower reach industry. Green design is considered only in the lower reach industry now, but it will be attached more importance gradually in the middle reach industry and upper reach industry.

### CONCLUSION

A unified circular economy index system (CEIS) model for both ends of manufacturing industrial chain has been established primarily. The difference between each CEIS for both ends is reflected through the index selection. The transmitting management of green supply chain is expressed primarily through setting up an index's weight variable. In this model, a CEIS of the middle reach industry or vein industry may be built up simultaneously

based on the industrial features. In this way, a unified CEIS including four kinds of industries of manufacturing industrial chain may be established. Next work is to select typical industry for case study, and to test the model's rationality and operationality. This unified CEIS will be improved and deepened in more detail.

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