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The Study of Carbon Cost Management under the Carbon Trading Mechanism

—Based on the Value Chain Theory

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Abstract

Carbon cost management plays the key role in response to carbon market changes. According to the literature review in China and abroad, this paper breaks the limitations of existing literatures which just focus on discussing the concept of carbon cost management and accounting the carbon cost in operating activities. Combined with the management accounting role definition of full participation in business decision and based on the value chain theory, this paper introduces marketing, human resource management etc. in carbon cost management accounting scope. Also, it recognizes carbon management factors and provides accounting formulas to build a total carbon cost management system and draw its panorama. With this total carbon cost management system, companies could acquire accurate carbon cost statistics to support their business decisions in carbon market.

Keywords

Carbon Trading, Carbon Cost Management, Accounting

1. Introduction

With the establishment of the national carbon market in China in 2017, building a total carbon cost management system in line with sustainable development strategies is an important issue urgently to be solved. China has committed in *Paris Agreement* that we would reach the carbon dioxide emission peak in 2030. Besides, China would actively advocate Chinese companies to make low carbon business model and explore their emission reduction potential. These proposals commend the companies to build a strict carbon management system to control the carbon cost and keep their high performance.

Besides, the *Report of the Study of China Carbon Market in* 2017 said that

carbon price volatility was large, from 1 dollar per ton to 131 dollar per ton. Carbon price volatility brings the companies opportunities and challenges. For one thing, carbon trading drives companies to explore their emission reduction potential, control their carbon cost and make profits from carbon quota trading in market as large as possible. For another thing, optimizing the trading time to maximize the quota trading profits urges companies to execute the accurate carbon cost management system in order to evaluate the best trading time. Therefore, traditional cost management system is difficult to adapt to the companies' requirements under the carbon trading mechanism. Companies need to build a wider accounting scope model and the value-chain cost management model to adapt to the market demand.

These days, a large amount of literatures concentrate on the study of carbon financial accounting, focusing on the carbon trading right recognition, measurement and reporting. Fewer papers study the carbon cost management. Hence, according to the research statues analyses in China and abroad, this paper tries to build a total carbon cost management system to help the companies to make business decisions in carbon market.

2. Literature Review

2.1. Foreign Literature in Carbon Cost Management

Nowadays, foreign scholars regard carbon cost management as one part of carbon management accounting. Carbon Management Accounting was first proposed by the American scholars Stewart Jones *et al.* They [1] proposed that carbon management accounting was a branch of environmental management accounting, whose main research was carbon dioxide.

Carbon management accounting played a decisive role in tackling climate changes [2]. Therefore, at the prime stage of carbon management accounting development, scholars wrote a large amount of papers to discuss the content and its accounting scope. Kolk and Pinkse suggested that carbon management accounting in company included new product portfolio, product improvement, carbon quota transaction, etc. [3]. In 2008, Ratnatunga put forward a concept named Carbon Footprint, which contained business policy, human resource management, market strategy, product strategy, pricing strategy, international strategy, promotion strategy, supply chain strategy and performance evaluation [4]. Through interviewing companies participated in the Carbon Disclosure Plan, Kolk *et al.* proposed that carbon management accounting contained three layers, namely technology layer (carbon emissions), value layer (monetary measurement), and cognitive layer (low carbon consciousness) [5].

How to introduce carbon cost into the companies' product and service pricing mechanism was the difficulty in carbon accounting [6]. Next, scholars paid their attention on the accounting method of reduction cost, and carbon management system construction as well.

Ratnatunga & Balachandran raised two carbon cost management tools. One was to separate the cost related to carbon trading from materials cost, manage-

ment cost etc., and then summed them up to get the environmental cost. The other one was carbon cost accounting method based on product life cycle. Meanwhile, their paper also suggested that carbon emission cost, carbon trading cost and strategy management cost should also be considered in the carbon cost management system [7]. Based on the study of environmental management accounting made by Schaltegger & Burritt [8], Burritt *et al.* defined the content of monetary carbon accounting and physical carbon accounting under the past-oriented goal and future-oriented goal. We focused on the carbon emissions in the physical carbon accounting. While in the monetary carbon accounting, we paid more attention on the reduction investment [9]. Furthermore, Schaltegger pointed out that Burritt's paper limited its accounting scope in companies' direct emissions. Schaltegeer suggested that carbon management accounting should not only meet the social exaptation and market changes, but also contained the carbon related issues in accounting scope, such as strategy and policy formulation. Besides, Schaltegger advocated that companies could use the international three-dimension accounting method to determine the emission scope. (scope1: direct emission; scope 2: indirect emission of purchased energy; scope 3: indirect emission of purchased product and service, including transport service, outsourcing service etc.) [10].

Nowadays, emission right marketization makes carbon management stay in an uncertain environment. Through qualitative research in two energy companies in Australia (energy delivery company and energy production company), Wahyuni & Ratnatunga drew the conclusion that despite the two companies belonged to the same industry, they would build different carbon strategies and carbon management models in the light of carbon disclosure extent, policies and corporate competency. Hence, carbon quota transaction should be regarded as an important factor included in carbon management accounting system [11].

2.2. Chinese Literature in Carbon Cost Management

In recent years, with the proposal of low carbon economy and the development of carbon market, Chinese scholars have begun to discuss the construction of carbon cost management system. By using foreign literatures for reference, Xu & Zheng proposed that companies needed to make total carbon cost analyses using a suitable accounting method. Secondly, in order to adapt to the Chinese carbon market, companies also needed to develop a report-making process based on the carbon emission and transaction. It could help decision-makers to evaluate various carbon reduction measures and then adjust the companies' reduction strategies and target in time [12]. Sun put forward that carbon management was a branch of management focusing on greenhouse gas emission. The target of carbon management was to found a lowest reduction expenditure and the most efficient way to reduce carbon dioxide emissions [13]. Wang proposed that we should regard carbon accounting as a generalized collective concept. From this perspective, carbon accounting contained carbon cost accounting, carbon management accounting, carbon auditing, and even the carbon strategy management

accounting as well. Moreover, Wang's paper clearly pointed out that carbon management accounting was the product which combined the carbon emission cost management in daily operation activities and the strategy management [14]. Tu reckoned that companies did need to develop a management tool and set rules and regulations to evaluate the corporate carbon emission activities. Therefore, companies could introduce carbon budget as low carbon management incentives. Also, he definitely pointed out that carbon budget accounting scope contains four budget modules. These modules were clean energy procurement, low carbon materials procurement, low carbon technology investment and energy-efficient equipment procurement as well [15]. What's more, by simulating JN thermal power plant, Tu also showed the carbon budget process and gave us the budget results and budget report to teach us how to make a carbon budget for the companies [16]. Zhang suggested that companies could learn from the theories and methods of cost effectiveness, risk prevention, budget control in environmental management and management accounting to build corporate carbon management framework. The framework mainly included carbon emission calculation, carbon transaction risk, carbon cost, carbon budget and carbon reduction performance evaluation [17].

3. Construction of Carbon Cost Management System

At the very beginning, management accounting was positioned as pure information support provider. However, with the increasingly important role of management accounting, it began to change its position to management and control functions [18] [19]. In other words, management accounting was not merely regarded as pure information support provider. It also entirely participated in corporate plan-setting, decision-making, risk control and performance evaluation and helped decision-makers to set, executed, and finally established corporate operation goals [20].

Carbon Management accounting contains three processes, which are target control, process control, and result control. Cost management is the qualitative reflect of process control. Hence, it is necessary for us to make sure the accounting scope of total carbon management cost, detail the cost management factors, ultimately in order to accurately calculate the carbon management cost and grasp the carbon transaction opportunity in time.

3.1. Analyses of the Defects of the Current Carbon Cost Management Study

Up to now, the study of carbon cost management could be roughly divided into two parts. One is focusing on the concept definition discussion, the other one is keeping an eye on cost accounting scope discussion. Both these two parts have their own limitations.

At the part of the concept definition discussion, discussions still stay at the qualitative level, and regard carbon management accounting as their research object. Some literatures pay attention on discussing and setting the precise defi-

nition of carbon management accounting [10] [12] [14]. Others make a step further, listing the detailed content and modules in carbon management accounting [3] [4] [5] [10] [17]. However, a lack of literatures specifically explain what carbon management factors should be included in different parts and how to precisely calculate the carbon management cost of different modules. All in all, scholars have not yet formed a systematic carbon cost management model.

On the other hand, the existing literatures about cost accounting scope discussion are fewer than the concept definition discussion ones, and the accounting scope is relatively narrow. A lot of scholars put forward their own ideas in the content of accounting scope. At present, the papers merely focus on calculating the carbon management cost in operating activities [15] [16], ignoring carbon management cost incurred by the support activities, such as employee training and policy formulation. It leads to managers make decisions using inaccurate carbon management cost, which hardly guide them to seize the carbon transaction opportunity in time.

Now, this paper concludes the current defects of carbon management cost study in Table 1 and Table 2.

3.2. Logical Basis of Carbon Cost Management System: Value Chain Theory

Carbon cost management system needs to solve two important issues. The first one is to ensure the accounting scope of carbon management cost and the carbon management key factors in order to evaluate the carbon reduction investment per ton and provide managers information about carbon management cost control. Secondly, providing comparison base for the carbon market price, in order to guide companies to seize carbon quota transaction opportunities and

Table 1. Current defects of carbon management cost study (Concept definition discussion literatures).

Author	Representative Viewpoints	Defects
Stewart *et al.* [1] Sun [13]	1. Discuss the concept of carbon management accounting. 2. Carbon management accounting is a branch of environmental accounting. 3. The target of carbon management accounting is to manage the carbon emission.	1. Still use carbon management accounting as research objective. 2. No special literatures discuss carbon cost management. 3. Still stay at the qualitative study and simply list the content and modules of carbon management accounting, but have no idea in the carbon management factors in every module.
Kolk & Pinkse [3] Ratnatunga [4] Kolk *et al.* [5] Burritt *et al.* [8] Wahyuni *et al.* [11] Schaltegger [10] Wang [14] Zhang *et al.* [17]	1. Discuss the content of carbon management accounting. 2. Carbon management accounting not only contains carbon emission cost management in operating activities, but also includes carbon strategy cost management. 3. Strategy costs include human resource management, market management etc.	

Table 2. Current defects of carbon management cost study (Accounting scope discussion literatures).

Author	Representative Viewpoints	Defects
Ratnatunga *et al.* [7]	Put forward two accounting tools 1. Seperate carbon related cost from materials, salaries etc. and then sum them up to get the carbon cost. 2. Carbon cost based on the product life cycle.	1. Research gaps in carbon cost management and accounting methods. 2. Have not yet formed a systematic and unified accounting system. 3. Accounting scope is relatively narrow, just including carbon management cost in operating activities, ignoring cost incurred by the support activities, such as employee training and policy formulation, which leads to the cost underestimation.
Burritt *et al.* [8]	Mainly calculate the carbon emissions and carbon reduction investment	
Schaltegger [10]	Use international three-dimension accounting method to ensure the corporate carbon emissions	
Xiao & Zheng [12]	Need to design carbon report editing process to disclosure corporate carbon emissions and carbon transactions	
Tu *et al.* [15] [16]	Carbon cost contains clean energy procurement, low carbon materials procurement, low carbon technology investment and energy-efficient equipment procurement	

maximize their carbon trading profits as large as possible. Hence, companies should not only consider carbon management cost in operating activities, but also take corporate green supply chain target into account under the background of low carbon economy [21] [22]. Through analyzing carbon management factors on every link of corporate value chain, companies totally account carbon management cost and dig up their space of energy saving and carbon reduction as far as possible.

Based on the consensus that carbon management accounting should contain carbon emission cost management and the carbon strategy cost management, and combined with the command of green supply chain, this paper introduces value chain theory [23] as the theoretical basis in the construction of carbon cost management system. This system will recognize carbon management factors from primary activities and support activities, and then form accounting formulas to calculate the total carbon management cost for companies.

3.3. Cost Management System Construction: Carbon Management Factors Analyses and Cost Accounting

According to Porter's Value Chain Theory, this paper recognizes carbon management factors and form corresponding accounting formulas from primary activities and support activities.

3.3.1. Primary Activities

Primary Activities comprise inbound logistics, operations, outbound logistics,

marketing & sales, and service as well. In the inbound logistics, operations and outbound logistics activities, corporate carbon management factor is mainly to approve corporate carbon dioxide emission (ton). More specifically, based on the international three-dimension accounting method, in the inbound logistics and outbound logistics, we approve the indirect carbon emissions of purchased transportation service in green supply chain. In the operation activities, we intensively calculate the carbon emissions in scope 1 and 2, which means to ensure the direct emissions and indirect emissions of purchased energy. Compared with the above carbon emissions to the original resources, we could get the carbon reduction under the low carbon management measures.

With the development and booming of green supply chain, low carbon product certification is gradually used as an important marketing tool to improve the product competitiveness. Hence, in the marketing & sales activities, the main carbon management factor is low carbon product certification acquisition and to aromatize the certification cost in the effective years to calculate the cost. In the service activities, the carbon management factor is low carbon product margin extraction.

This paper concludes the carbon management factors and accounting formulas in primary activities as shown in Table 3.

Whereby,

$$E_{\text{carbon reduction}} = E_{\text{reduction1}} + E_{\text{reduction2}} \tag{1}$$

$$C_{\text{primary activities}} = C_{\text{certification}} + C_{\text{service}} \tag{2}$$

3.3.2. Support Activities

Support activities include firm infrastructure, human resource management, technology and procurement. Specifically, the key factors in firm infrastructure are low carbon management policies and regulations formulation and the carbon accounting system construction. Companies can refer to the market price of related consulting projects, and then debit to the general and administrative fees. The key factors in human resource management activities are carbon related training and carbon related full-time staff salary. Technology activities contain the low carbon technologies research and development. The expensed R & D

Table 3. Carbon management factors and accounting formula in primary activities.

Items	Factors	Accounting Formula
Operation Activities	Carbon Emissions in Scope 1 & 2 (ton)	$E_{\text{reduction1}} = E_{\text{origional management measures}} - E_{\text{low carbon measures(clean energy etc.)}}$
Inbound Logistics Outbound Logistics	Carbon Emissions in Scope 3 (ton)	$E_{\text{reduction2}} = E_{\text{origional transportation service}} - E_{\text{green supply chain transportation service}}$
Marketing & Sales	Low Carbon Product Certification	$C_{\text{certification}} = \frac{C_{\text{certification cost}}}{\text{effective years}}$
Service	Low Carbon Product Margin	$C_{\text{service}} = C_{\text{present low carbon product margin extraction}}$

cost are debited into fees, the capitalization ones are included into the carbon management cost through amortization.

The carbon management factors of procurement comprise six parts. There are clean energy procurement, low carbon material procurement, energy-efficient equipment procurement, low carbon technology procurement, green supply chain transportation service procurement, and carbon assurance service procurement as well. The first five items are calculated based on the incremental ideas. However, the carbon assurance service fee is directly debited into present general and administrative fees.

This paper concludes the carbon management factors and accounting formula in support activities as shown in Table 4.

Whereby,

$$C_{\text{human resource management}} = C_{\text{training}} + C_{\text{salary}} \tag{3}$$

$$C_{\text{technology}} = C_{\text{expensed cost}} + C_{\text{capotalization cost}} \tag{4}$$

$$C_{\text{procurement}} = C_{\text{energy}} + C_{\text{material}} + C_{\text{equipment}} + C_{\text{new technology}} + C_{\text{transportation}} + C_{\text{assurance}} \tag{5}$$

$$C_{\text{support activites}} = C_{\text{firm infrastructure}} + C_{\text{human resource management}} + C_{\text{technology}} + C_{\text{procurement}} \tag{6}$$

Table 4. Carbon management factors and accounting formula in support activities.

Items	Factors	Accounting Formula
Firm Infrastructure	Low Carbon Management Policies and Regulations Formulation Carbon Accounting System Construction	$C_{\text{firm infrastructure}} = C_{\text{market price of related consulting projects}}$
Human Resource Management	Employee Training	$C_{\text{training}} = C_{\text{carbon related training fee}}$
	Carbon Related Full-Time Staff Salary	$C_{\text{salary}} = C_{\text{carbon related full-time staff salary}}$
Technology	Research & Development of Low Carbon Technology	Expensed Cost: $C_{\text{expensed cost}} = C_{\text{R\&D fees debit in the expense}}$ Capitalization Cost: $C_{\text{Capitalization cost}} = \frac{C_{\text{R\&D of low carbon technology}}}{\text{reduction-benifit period}}$
Procurement	Clean Energy	$C_{\text{energy}} = C_{\text{clean energy}} - C_{\text{original energy}}$
	Low Carbon Material	$C_{\text{material}} = C_{\text{low-carbon material}} - C_{\text{original material}}$
	Energy-Efficient Equipment	$C_{\text{equipment}} = \frac{C_{\text{energy-efficient equipment}} - C_{\text{original equipment}}}{\text{reduction-benifit period}}$
	Low Carbon Technology	$C_{\text{new technology}} = \frac{C_{\text{introduced low-carbon technology}} - C_{\text{original technology}}}{\text{reduction-benifit period}}$
	Green Supply Chain Transportation Service	$C_{\text{transportation}} = C_{\text{green supply chain transportation service}} - C_{\text{original transportation service}}$
	Carbon Assurance Service	$C_{\text{assurance}} = C_{\text{present carbon assurance service fee}}$

Hence, according to formula 1 to formula 6, we could clearly calculate the total carbon management cost and the carbon reduction cost per ton. The formulas are shown as follows:

$$C_{\text{total carbon management costs}} = C_{\text{primary activities}} + C_{\text{support activities}} \tag{7}$$

$$C_{\text{carbon reduction cost}} = \frac{C_{\text{total carbon management costs}}}{E_{\text{carbon reduction}}} \tag{8}$$

In the carbon market, through comparing their own carbon reduction cost with the carbon price, companies could, on the one hand, guide themselves to seize the carbon quota transaction opportunities to maximize their profits. Furthermore, they could use these profits to reinvest the low carbon technologies, equipment etc. to lower their carbon emissions. On the other hand, by analyzing cost of every section in the carbon cost management system, companies could find their own space of reduction to help them to complete the low carbon operation transformation. Finally, compared with the carbon budget, managers urge themselves to find out the reasons of the differences, in order to force companies to further optimizing their carbon cost management system.

4. Panorama of Carbon Cost Management System

Through the above analyses, this paper construct a carbon cost management system embedded to the carbon trading mechanism. Nowadays, China is at the primary stage of carbon market. Companies have had abundant free carbon quota, accounting for at least 95% of carbon dioxide emissions. It leads to an inactive carbon market and the carbon price does be really low. Nevertheless, with the development of the Chinese carbon market, the generally reduced free carbon quota push the carbon price up. At that time, companies finish the reduction task through quota transaction much more costly. Therefore, the traditional operation-oriented cost management system (as shown in **Figure 1**) is unsuitable for companies participated in carbon market. Companies should construct a total carbon cost management system, forcing themselves to change from extensive carbon management to delicacy low carbon management. Based on the value chain theory, we detail the costs in primary activities and support activities to control the carbon cost as far as possible. Through these delicacy cost control

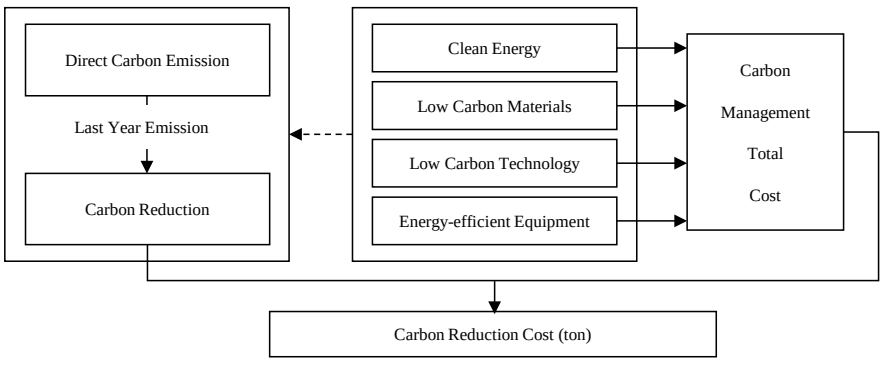

Figure 1. Traditional operation-oriented carbon cost management system.

measures, companies, for one thing, save the quota as much as possible to create profits through carbon transactions. For another thing, companies use the carbon transaction profits as subsidies in low carbon reinvestment, and finally complete the low carbon transformation and upgrade.

Based on the aforesaid ideas, this paper draws the panorama of value-chain carbon cost management system as shown in Figure 2.

5. Conclusions

With the establishment of national carbon market, it's necessary for companies to construct a delicacy total carbon cost management system. On the one hand, the carbon cost management system promotes companies to dig out their carbon reduction potentials as large as possible. Hence, companies could form a virtuous cycle from carbon reduction to low carbon reinvestment. Ultimately, this virtuous cycle pushes the development of low-carbon sustainability and helps companies to complete their low-carbon operation transformation. On the other hand, the total carbon cost management system could stimulate companies' initiatives to manage their carbon assets, in order to adapt themselves to the Chinese green finance system and prepare carbon management information in advance for decision makers to use carbon-asset pledge or invest in carbon finance products.

Nowadays, carbon cost management system construction still stays at the early stage. The existing literatures limit themselves in concept discussion and carbon cost accounting merely in operating activities. Combined with the role definition of full participation in business decision of management accounting and based

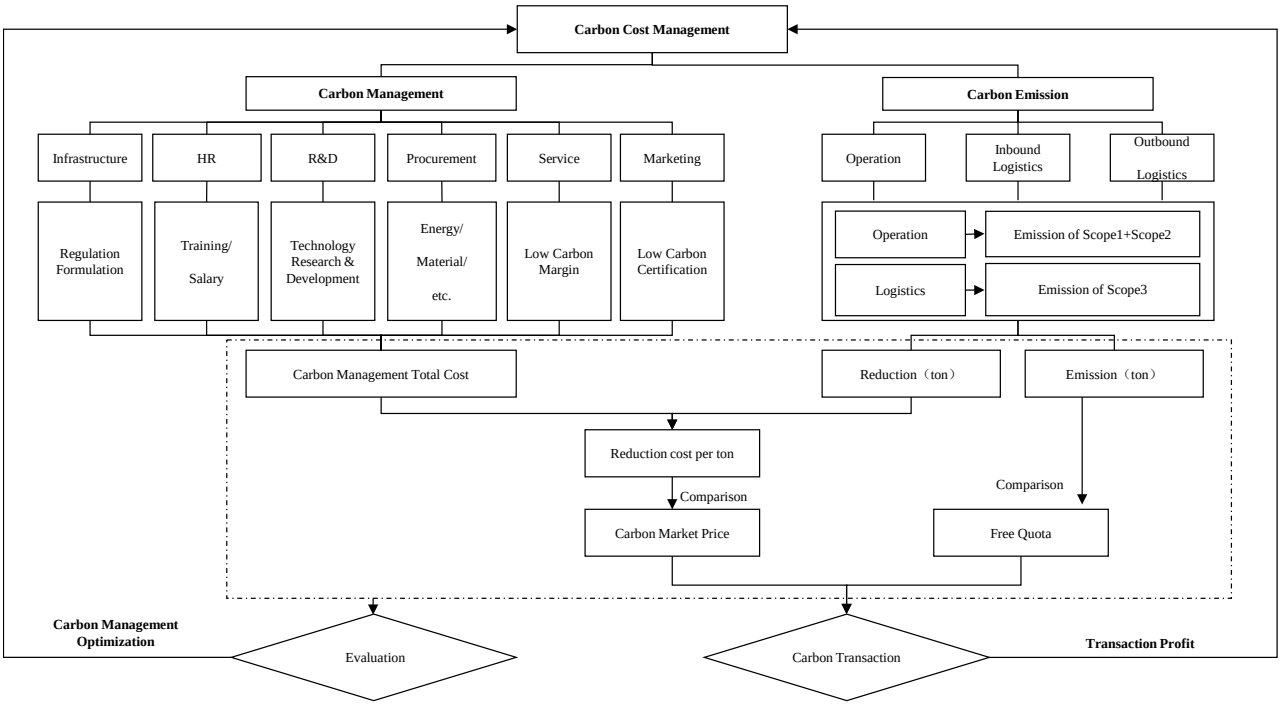

Figure 2. Value-chain carbon cost management system.

on the value chain theory, this paper introduces marketing, human resource management etc. in carbon cost management accounting scope to build a total carbon cost management system. This system provides more precise carbon management cost information for the companies.

However, this paper also has its own limitations. In the future, we could break the limitations to build a more perfect carbon cost management system through more field research and questionnaire survey.

1. Omitting some carbon management factors. This paper may omit some carbon management factors that lead to the cost underestimation. In the future, the carbon cost management system will be continuously improved to recognize carbon management factors comprehensively by field research and questionnaire survey.

2. Accounting methods needed to be improved. There is still a huge space to improve the accounting methods and formulas. Through interviewing employees and managers in the company, we could further make clear the corporate process and design more suitable accounting models.

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