

Study on the Joint Outsourcing Mechanism of Carbon Emission Reduction in The Supply Chain Considering Risk Appetite

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Abstract: In the case of considering the risk preference, according to the problem of supply chain carbon emission reduction joint outsourcing, build the enterprise outsourcing, the supply chain, and analyze the suppliers and manufacturers of the outsourcing factors of the decision, finally summarize the research in this paper, for the risk aversion of supply chain enterprise carbon emission reduction joint outsourcing mechanism to provide certain management enlightenment, to the future research.

Keywords: Risk preference; carbon reduction in supply chain; joint outsourcing of carbon reduction.

1. Introduction

In the context of global warming, more and more enterprises begin to cooperate with third-party emission reduction agencies to outsourcing carbon emission reduction. In the process of outsourcing, due to the information asymmetry, risk preference and other factors between the principal and agent, the agent and agent. How to effectively optimize the carbon emission reduction outsourcing mechanism and improve the profitability of enterprises has become the focus that enterprises must face in the process of development.

Based on the above background, many scholars have conducted in-depth research on carbon emission reduction outsourcing in the supply chain. Zhou[1] studied the number of orders and profits of a single manufacturer, and the changes of the entire supply chain before and after the implementation of the bilateral monopoly supply chain composed of a single manufacturer and a single retailer. Liang[2] studied emission reduction cost sharing contracts through green innovation under carbon emission constraints, analyzing the optimal cost sharing ratio established by manufacturers and retail prices established by retailers. He[3] studies a service supply chain consisting of service providers responsible for carbon reduction and services and a service integrator of low-carbon advertising for three types of cost-sharing decisions, explore optimal decisions. Ghosh[4] explores supply chain coordination issues arising from the Green Supply Chain Initiative and explores the impact of cost-sharing contracts on key decisions for supply chain participants. Taleizadeh[5] Cost-sharing contracts in a closed-loop supply chain considering carbon reduction, quality improvement efforts and pricing strategies. Wen[6] explores the impact of CAT and customers' low-carbon preferences on carbon emissions reduction and promotion strategies in retailer-led supply chains. Ji[7] analyzes the green financing and emissions reduction decisions of a capital-constrained supply chain composed of a well-funded retailer. Okay[8] believes that Energy Services serves as a professional third-party provider of energy saving and emission reduction projects, and aims to design sustainable energy solutions for businesses. Yuan[9] believes that China is currently facing a severe environmental pollution problem, and contract energy management, as a new

market mechanism, can effectively reduce energy consumption.

It can be seen that in recent years, because of the low-cost, professional and efficient embedded services, low-carbon service providers have gradually been widely concerned by enterprises. How to choose to outsource carbon emission reduction in supply chain so as to improve their profitability has become the focus that enterprises must face in the process of development. On the basis of considering the risk preference, this paper analyzes the joint outsourcing of carbon emission reduction in the supply chain under the condition of risk aversion, so as to provide specific suggestions for the emission reduction outsourcing of enterprises and provide guidance and reference for the selection of carbon emission reduction outsourcing in manufacturing industry.

2. The Question Is Raised and Hypothesis

This paper considers a risk-avoiding supply chain composed of suppliers and manufacturers, and assumes that under the carbon emission reduction and carbon trading market mechanism, the government will set the corresponding carbon emission amount based on the manufacturer's historical carbon emission record. When the manufacturer has a surplus of carbon emissions, the manufacturer can sell the remaining carbon emissions in the carbon trading market; When the carbon emissions are insufficient, the manufacturer can pay a certain price to buy the required carbon emissions in the carbon emission market.

As suppliers and manufacturers are faced with the market of carbon emission quota and carbon emission right trading, and suppliers and manufacturers are limited by carbon emission technology capacity and capital, they need to outsourcing their carbon emission emission reduction services to third-party carbon emission reduction service providers. Suppliers and manufacturers have three kinds of outsourcing mode choice: the first choice is the suppliers and manufacturers respectively to meet the requirements of two different third party providers and their outsourcing mode O, the second choice is to let the suppliers do the whole supply chain, unified by suppliers to find qualified third party providers and outsourcing mode M, the third choice is to let the manufacturer do the whole supply chain, unified by the

manufacturer to find the conditions of the third party providers and outsourcing mode N. When considering the risk aversion conditions, it is assumed that the supplier and manufacturer as the employer are risk neutral, and the third party service provider as the contractor is risk aversion.

Because different third-party service providers have different efforts for emission reduction tasks, the unit product emission reductions of suppliers or manufacturers are also different. In the case of information asymmetry, the efforts of the third-party emission reduction institutions can not be intuitively observed, so the manufacturers need to design an incentive mechanism to induce them to improve their efforts. Therefore, in view of the performance of third-party carbon emission reduction service providers, suppliers and manufacturers pay service providers by fixed payment plus performance sharing. The performance sharing is related to the incentive intensity of the emission reduction tasks outsourced by the third-party service providers.

3. Analysis of Different Outsourcing Patterns

3.1. Mode O of Outsourcing in the supply chain

When enterprises in the supply chain choose this model, suppliers and manufacturers respectively find different third-party carbon emission reduction outsourcing agencies for carbon emission reduction outsourcing. At this point, suppliers and manufacturers are responsible for their respective gains (losses) in the carbon trading market.

In this mode, the task of suppliers, manufacturers incentive intensity and the market carbon emissions trading price, the sensitivity of the demand change, the third party service service ability, the third party service carbon reduction service effort cost, risk aversion coefficient, the third party service providers to the enterprise in improving economic efficiency and service quality of risk, the basic market demand of products, and suppliers and manufacturers unit product initial carbon emissions before the carbon reduction.details are as follows:

When the fixed market demand is small, 1) The greater the trading price of carbon emission rights in the market, The less small the task incentive intensity of suppliers and manufacturers; 2) The more sensitive the price is to the change of demand demand, The less small the task incentive intensity of suppliers and manufacturers; 3) The greater the service capability of the third-party service providers, The less small the task incentive intensity of suppliers and manufacturers; 4) The greater the effort cost of the third-party service providers' carbon emission reduction service investment, The greater the task incentive intensity of suppliers and manufacturers; 5) The greater the risk avoidance factor, The greater the task incentive intensity of suppliers and manufacturers; 6) The greater the risk of the third-party service provider to the task of improving the economic benefit and service quality, The greater the task incentive intensity of the suppliers and the manufacturers.

When the market fixed demand is large, 1) The greater the trading price of carbon emission rights in the market, The greater the task incentive intensity of suppliers and manufacturers; 2) The more sensitive the price is to the change of demand demand, The greater the task incentive intensity of suppliers and manufacturers; 3) The greater the service capability of the third-party service providers, The

greater the task incentive intensity of suppliers and manufacturers; 4) The greater the effort cost of the third-party service providers' carbon emission reduction service investment, The less small the task incentive intensity of suppliers and manufacturers; 5) The greater the risk avoidance factor, The less small the task incentive intensity of suppliers and manufacturers; 6) The greater the risk of the third-party service provider to the task of improving the economic benefit and service quality, The smaller the task incentive intensity of the suppliers and manufacturers.

When the price sensitivity coefficient is small, 1) the greater the basic market demand of the product, the greater the incentive intensity of the supplier and manufacturer; 2) the greater the initial carbon emission of the unit product before carbon emission reduction, the smaller the incentive intensity of the supplier and manufacturer.

When the price sensitivity coefficient is large, 1) the greater the basic market demand of the product, the smaller the task incentive intensity of the supplier and manufacturer; 2) the greater the initial carbon emission of the unit product before carbon reduction, the greater the task incentive intensity of the supplier and manufacturer.

3.2. Mode M of carbon emission reduction outsourcing for enterprises in the supply chain

In this mode, when the supplier, as the leader of the whole supply chain, the supplier unifies a third-party service provider to outsource carbon emission reduction in the supply chain, the benefits (losses) of the whole supply chain in the carbon trading market shall be borne by the supplier.

At this point, the suppliers, manufacturers of incentive strength also by the market carbon emissions trading price, the sensitivity of the price of demand change, the service ability of the third party service providers, the third party service carbon reduction service effort cost, risk aversion coefficient, the third party service providers on the enterprise in improving the economic efficiency and service quality of risk, the basic market demand, and suppliers and manufacturers of unit products in the initial carbon emissions before the carbon emissions.details are as follows:

When the fixed market demand is small, 1) The greater the trading price of carbon emission rights in the market, The less small the task incentive intensity of suppliers and manufacturers; 2) The more sensitive the price is to the change of demand demand, The less small the task incentive intensity of suppliers and manufacturers; 3) The greater the service capability coefficient of the third-party service providers, The less small the task incentive intensity of suppliers and manufacturers; 4) The greater the effort cost coefficient of the carbon emission reduction service input of the third-party service provider, The greater the task incentive intensity of suppliers and manufacturers; 5) The greater the risk avoidance factor, The greater the task incentive intensity of suppliers and manufacturers; 6) The greater the risk of the third-party service provider to the task of improving the economic benefit and service quality, The greater the task incentive intensity of the suppliers and the manufacturers.

When the market fixed demand is large, 1) The greater the trading price of carbon emission rights in the market, The greater the task incentive intensity of suppliers and manufacturers; 2) The more sensitive the price is to the change of demand demand, The greater the task incentive intensity of suppliers and manufacturers; 3) The greater the

service capability coefficient of the third-party service providers, The greater the task incentive intensity of suppliers and manufacturers; 4) The greater the effort cost coefficient of the carbon emission reduction service input of the third-party service provider, The less small the task incentive intensity of suppliers and manufacturers; 5) The greater the risk avoidance factor, The less small the task incentive intensity of suppliers and manufacturers; 6) The greater the risk of the third-party service provider to the task of improving the economic benefit and service quality, The smaller the task incentive intensity of the suppliers and manufacturers.

In addition, 1) the greater the basic market demand of the product, the less the task incentive intensity of suppliers and manufacturers; 2) the greater the initial carbon emissions of the unit product before carbon emission reduction, the greater the task incentive intensity of suppliers and manufacturers.

3.3. Model N of carbon emission reduction outsourcing led by manufacturers in the supply chain of enterprises

In this mode, when the manufacturer is the leader in the whole supply chain, and the manufacturer unifies a third-party service provider to outsource carbon emission reduction in the supply chain, the benefits (losses) of the whole supply chain in the carbon trading market are borne by the manufacturer.

At this point, the task incentive intensity of suppliers and manufacturers is also affected by the above factors.details are as follows:

When the fixed market demand is small, 1) The greater the trading price of carbon emission rights in the market, The less small the task incentive intensity of suppliers and manufacturers; 2) The more sensitive the price is to the change of demand demand, The less small the task incentive intensity of suppliers and manufacturers; 3) The greater the service capability coefficient of the third-party service providers, The less small the task incentive intensity of suppliers and manufacturers; 4) The greater the effort cost coefficient of the carbon emission reduction service input of the third-party service provider, The greater the task incentive intensity of suppliers and manufacturers; 5) The greater the risk avoidance factor, The greater the task incentive intensity of suppliers and manufacturers; 6) The greater the risk of the third-party service provider to the task of improving the economic benefit and service quality, The greater the task incentive intensity of the suppliers and the manufacturers.

When the market fixed demand is large, 1) The greater the trading price of carbon emission rights in the market, The greater the task incentive intensity of suppliers and manufacturers; 2) The more sensitive the price is to the change of demand demand, The greater the task incentive intensity of suppliers and manufacturers; 3) The greater the service capability coefficient of the third-party service providers, The greater the task incentive intensity of suppliers and manufacturers; 4) The greater the effort cost coefficient of the carbon emission reduction service input of the third-party service provider, The less small the task incentive intensity of suppliers and manufacturers; 5) The greater the risk avoidance factor, The less small the task incentive intensity of suppliers and manufacturers; 6) The greater the risk of the third-party service provider to the task of improving the economic benefit and service quality, The smaller the task incentive intensity of the suppliers and

manufacturers.

In addition, 1) When the price sensitivity coefficient is small, the greater the basic market demand of the product, the greater the task incentive intensity of the supplier and the manufacturer; when the price sensitivity coefficient is large, the greater the basic market demand of the product, the smaller the task incentive intensity of the supplier and the manufacturer.2) The larger the initial carbon emission of unit product of supplier and manufacturer before carbon emission reduction, the greater the task incentive intensity coefficient of supplier and manufacturer.

4. Model Analysis and Conclusion

By calculating the expected return difference of the above three modes: outsourcing (mode O), outsourcing of suppliers dominate the supply chain (mode M) and manufacturer-led outsourcing outsourcing (mode N), and analyzing and summarizing them, the following conclusions can be drawn:

Conclusion 1: in the case of considering the risk appetite, supply chain upstream and downstream enterprises can achieve unified outsourcing, depends on the third party outsourcing service providers to retain earnings, fixed market demand, price sensitive coefficient, supply chain enterprise unit products before the initial carbon emissions and the government of the enterprise on the supply chain. When the government's carbon quotas for companies in the supply chain are too large, suppliers and manufacturers often fail to cooperate. Only when the third party outsourcing emissions service providers retain revenue, fixed market demand, price sensitive coefficient, the supply chain enterprise unit products before the difference of the initial carbon emissions and the government on the supply chain of carbon emission reduction quotas in a particular range, suppliers and manufacturers to achieve outsourcing cooperation.

Conclusion 2: When the government's carbon reduction quota between suppliers and manufacturers is too large, suppliers and manufacturers often do not choose the joint carbon reduction outsourcing strategy, so they cannot reach cooperation. Combined with the actual, when the government to suppliers and manufacturers of carbon emission quota difference is too large, get carbon quota more willing to choose outsourcing, and the rest of the carbon quota to carbon trading market for earnings, and get less carbon quota is more hope to their own carbon emissions outsourcing to other companies in the supply chain to dominate, so as to reduce the cost of the enterprise. Therefore, when the government focuses on the carbon quota gap of enterprises in the supply chain is too large, it is difficult for enterprises to reach an agreed joint outsourcing strategy of carbon emission reduction.

5. Conclusion and Outlook

This paper studies the carbon emission reduction outsourcing of supply chain when considering risk aversion, and analyzes the carbon emission reduction outsourcing strategy: whether the outsourcing of supply chain depends on the retention income of the third party outsourcing emission reduction service provider, the fixed market demand, the price sensitivity coefficient, the initial carbon emissions of unit products produced by suppliers and manufacturers before the carbon emission reduction, and the difference between the government's carbon emission reduction quota for suppliers and manufacturers. Suppliers and manufacturers can

cooperate only when the difference between the retention benefits of third-party outsourcing emission reduction service providers, fixed market demand, price sensitivity coefficient and the government's carbon emission reduction quota for supplier manufacturers is in a specific range. When the government's carbon reduction quotas for suppliers and manufacturers are too large, suppliers and manufacturers often fail to cooperate.

Through the above conclusion analysis, the following suggestions can be put forward for the supply chain enterprises: When enterprises in the supply chain consider whether to carry out supply chain joint carbon emission reduction outsourcing, they need to consider the retention income of the third-party outsourcing emission reduction service providers, the fixed market demand, the price sensitivity coefficient and the difference between the government's carbon emission reduction quota for suppliers and manufacturers. When these several influencing factors meet a specific range, the enterprise can choose the corresponding joint outsourcing strategy.

Although this paper has achieved some research results, there are still the following shortcomings: 1) This paper only studies the impact of risk aversion on carbon reduction outsourcing in supply chain, but in reality, supply chain members may have other preferences, such as fair preference, sympathy preference, etc. The combination of multiple social preferences will enable members of the supply chain to have more complex behavioral motivation in making decisions. After considering multiple social preferences, the decision of outsourcing of carbon reduction of supply chain members may draw different conclusions. 2) This paper only analyzes the three situations of suppliers and manufacturers in the supply chain, unified outsourcing and unified outsourcing. However, in reality, there are not only these three modes of outsourcing, but also the supply chain in the form of technology spillover. Therefore, more forms of supply chain carbon emission reduction outsourcing should also be considered, so as to enrich the research field of supply chain carbon emission reduction outsourcing. Therefore, in future

studies, optimizing the correlation model can be considered to enrich the related studies.

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