Response to Reviewer 1 Comments

First of all, we thank all the reviewers for their valuable time and constructive comments. We have thoroughly checked the English grammar and spelling in the manuscript. In the following, we would like to respond to each reviewer separately.

Reviewer #1

Point 1: In section, the Abstract should be written due to some essential points such as research purposes, research methods, research contents, and research effects, otherwise, the innovation and necessity of the manuscript will not be reflected effectively. So, authors are directed to rewrite the abstract section in the light of mentioned guidelines.

Response 1: Thank you very much for your insightful comments. We have revised the abstract section in response to your suggestions. Below, you will find the revised text, with a brief explanation of the revisions made for each section.

Research background and existing problems: To better contextualize the study, we expanded the discussion of the importance of remanufacturing and elaborated on existing issues in the field. Revised text: 'In light of resource scarcity and environmental challenges, remanufacturing bolsters resource efficiency and fosters a circular economy, with policy support being pivotal for its development. While previous studies have predominantly concentrated on the economic benefits of remanufacturing, comparatively less emphasis has been placed on its carbon emissions and the differentiated incentive-penalty policies for various recycled products.'

Research purposes: We clarified our objective in this study. Revised text: 'Our objective is to evaluate the impact of remanufacturing policies, such as carbon tax and incentive-penalty schemes, on multi-period hybrid manufacturing/remanufacturing closed-loop systems, considering different carbon emissions for new and remanufactured products.'

Research contents: We expanded our discussion on the strategies and government policies that our study explores. Revised text: 'We investigate optimal recycling and production strategies for enterprises under two distinct quality distributions (exponential and normal), and analyze the government's incentive and penalty amounts for recycled products at various quality levels.'

Research methods: We provided more details on the methods we used to ensure the robustness of our study. Revised text: 'In order to ensure the robustness of the variable quality distribution, we employ the Genetic Algorithm and the Particle Swarm Optimization Algorithm for comparative verification and problem-solving.'

Research effects: We further elaborated on our study's findings to offer more detail. Revised text: 'The study's findings reveal that: (1) irrespective of the quality distribution, enterprises consistently exhibit a preference for recycling products of the same quality level, and the range of quality for which the government offers incentives or imposes penalties remains fundamentally constant; (2) subsidies may be granted for recycled products with a quality level ranging from 0.2 to 0.4, while recycled products with a quality level exceeding 0.4 are subject to penalties.'

For the specific modifications, please refer to the abstract in the revised manuscript.

Point 2: Although authors have mentioned the research questions in a general way in the introduction section however; the research questions need to be categorically mentioned as Question 1 and Question 2 in the introduction section so that the research agenda is further clear for the reader.

Response 2: In response to your recommendation, we have highlighted the research questions—specifically, Question 1 and Question 2—in the Introduction section. Please refer to the following sentences for our specific modifications. Faced with numerous uncertainties in the remanufacturing process, manufacturers must fully understand the optimal standards for product recycling and production modes during operations. They also need to take into account the impact of remanufacturing policies to strike a balance between minimizing economic costs and carbon emissions. Simultaneously, in pursuit of a low-carbon economy, the government should identify the most beneficial remanufacturing policies for society (including carbon tax and incentive policies), effectively manage carbon emissions, and enhance product reuse rates. Therefore, this paper aims to address the following research questions: (1) How can enterprises adapt their recycling and production modes to comply with remanufacturing policies? (2) In a green and environmentally-friendly economy, how can the government implement the most effective incentive and carbon tax policies to encourage recycling and remanufacturing, while reducing pressure on both itself and enterprises?

Point 3: Authors are directed to provide a comparison table clearly stating the summary of other researches and contribution of this one.

Response 3: We appreciate your suggestion to include a comparison table that outlines the summary of other research in the field and the contribution of our study. Accordingly, we have prepared a comprehensive comparison table, as shown in Table 1, which can be found in the revised manuscript.

Table 1 Contrasting our study with referenced articles

Authors	Quality Variability	Carbon Emissions	Remanufactured Carbon Emissions	Incentive	Penalty
Salami et al. [9]	√				
Teunter and Flapper [10]	√				
Yan, Ni, and Yang [11]	√			√	
Guo and Ya [12]	√				
El and Jaber [13]	√				
Ferguson [14]	√				
Cai et al. [15]	√				
Örsdemir et al. [16]	√				
Chang et al. [17]		√	√		
Fahimnia [18]		√			
Guo et al. [19]		√			
Mohajeri and Fallah [20]		√			
Luo et al. [21]		√	√		

Yu et al. [22]		√			
Xie and Ma [23]				√	
Hong et al. [24]				√	
Wang et al. [25]				√	
Chai et al. [26]				√	
Fang and Zhao [27]				√	
Zhang et al. [28]				√	
Our proposal	√	√	√	√	√

Point 4: Research question mentioned in the introduction section, must be quoted accordingly in the result and discussion section comprehensively.

Response 4: Thank you for your insightful reminder. After refining Question 2, our research questions have gained greater clarity, enabling a more effective alignment with the discussion and conclusion sections. This paper seeks to address two key issues: one involves enterprise decision-making, and the other concerns governmental policy. In the original manuscript, we conducted separate analyses for Case a, addressing the decision-making within enterprises: firstly, in the absence of governmental policy (Table 4), and subsequently, under incentive-penalty policy (Tables 5-8). By comparing these two scenarios, we derived answers to the twin research questions of this paper: specifically, how enterprises adapt their recycling and production in response to remanufacturing policies, and how policies can be designed to incentivize enterprise recycling. Furthermore, in Case b, we undertook similar analyses in the absence of governmental policy (Tables 9 and 10), as well as under incentive-penalty policy (Tables 11-12), structuring the discussion in accordance with the two research questions. Additionally, the key conclusions presented in the Introduction are derived from the findings of the two research questions.

Eventually we also include, in Section 7, a discussion section on the two research questions as follows: Industrial sustainability necessitates continuous and consistent practices, underpinned by enduring commitment. Firms should prioritize their social responsibility by implementing strategies focused on sustainable manufacturing and remanufacturing, rather than relying exclusively on incentives and penalties. While incentives can stimulate companies to adopt sustainable actions, an indefinite dependence on them is impractical. Companies can utilize the decision-making frameworks provided in this paper to guide their recycling and remanufacturing initiatives, thereby achieving a balance between environmental and economic benefits. Furthermore, the implications of penalties need to be meticulously assessed. Penalties that are not appropriately calibrated could adversely affect the broader competitiveness of the industrial sector. Consequently, any implementation of penalty measures should be done incrementally over a reasonable transition period. Decision-makers can draw from the carbon policy and reward-and-penalty framework outlined in this study for decision-making within an acceptable range. For instance, recycled products with a quality grade between 0.2 and 0.4 could be eligible for subsidies, while those with a quality grade exceeding 0.4 should face appropriate penalties.

Point 5: A separate section should result in limitations of this study and its possible future research avenues.

Response 5: In line with your suggestion, the limitations of this study, as well as potential directions for future research, are showcased in Section 7, titled 'Summary and Conclusions'.

The specifics are as follows: This study can be expanded in several ways. First, the closed-loop hybrid manufacturing/remanufacturing system considered in this study involves numerous uncertainties, such as market demand and remanufacturing rates. Future research could therefore benefit from incorporating stochastic demand and random remanufacturing rates. Second, while our paper primarily focuses on manufacturers' recycling and production scenarios, investigating the recycling scenarios of retailers and third-party entities could be a productive direction for future research. Lastly, exploring diverse incentive measures for recyclers within the context of various recycling models is a crucial area worthy of further study.