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Communication

Study on the prediction of economic efficiency for a tertiary recycling plant for waste plastics by using the environmental Kuznets' curve model

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Abstract: Plastic products are items that we use every day around us, and their replacement speed are very fast, so that to recycle waste plastic has become the focus of environmental problems. This study has proposed an optimized circular design for the recycle plant of waste plastic, therefore, and our proposed strategy is to build a new tertiary recycling plant to reduce the total generation amount of the derived solid plastic waste from ordinary and secondary recycling plants and the semi-finished products from secondary recycling plant. Results obtained from a real recycle plant has showed that to recycle the tertiary waste plastic in a tertiary recycling plant, the finished products produced from a secondary recycling plant accounts about 27% of ordinary waste plastic, and the semi-finished products that mainly is scrap hardware accounts about 1% of ordinary waste plastic. Other derived solid plastic waste accounts for 6% of ordinary plastic waste. Therefore, if the ordinary, secondary and tertiary recycle plant can be set all-in-one, it can reduce the total generation amount of derived solid plastic waste from 34% to 6%, without and with a tertiary recycling plant, respectively. It can also increase the operating income of the secondary recycle plant and the investment willingness of the new tertiary recycle plant.

Keywords: plastic wastes; circular economy; recycling plant; circular design

1. Introduction

In this paper, we have tried to develop a new decision-making strategy based on the Environmental Kuznets' Curve (EKC) model (Huang, 2020a; Huang, 2020b; Huang, 2021; Li and Huang, 2024). The waste plastics had been recycled from the material recovery station of local-government cleaning team of municipal solid wastes (MSW), it has been called as "Palmary Recycling Plant" in the world. In addition, the plant for a detailed sorting to separate the specific plastic basing on its own chemical composition out of the mixed waste plastics is called as "Secondary Recycling Plant" in the world (Kulas et al., 2023). Until now, the secondary processing wastes generated from the "Primary Recycling Plant" and "Secondary Recycling Plant" are treated by incineration in world. According to the EKC model, the middle item is the most important factor, therefore, in this study we would like to investigate the economic efficiency prediction for the first time proposed "Tertiary Recycling Plant" for a total new treatment plant for the secondary processing wastes generated from the "Palmary Recycling Plant" and "Secondary Recycling Plant".

2. Methods

EKC model is an "inverted U" curve, the optimized condition or maximum efficiency appears in the middle choice item. As decision-making is based on the logic

of the EKC model, this study called it the major concept of the "Circular Design", recently we started to develop such methods in this total new circular economy field (Huang, 2021).

This study collected and analyzed the operation parameter records of a real new built "Tertiary Recycling Plant" in Kaohsiung city, Taiwan, and the operation data was analyzed during August to October 2020. The plastic wastes used in this paper are majorly contributed from sources of household and home appliance, with a waste code number of #R-0201. From the results of physical compositions are dominated by PP, PC, PVC, ABS, PE, hard plastics, hard rubber, as shown in **Table1**.

Table 1. Physical compositions of plastic wastes from two different sources.

Waste Code#	Name	Source	Composiiton	Percentage
R-0201	Plastic wastes	House –hold waste plastic	PP	45%
			PE	4%
			PVC	3%
			PC	2%
			Ppwith talc	4.7%
			PS	15.8%
			ABS	13.7%
			Refractory ABS	4%
			Scrap metals	1%
		Home appliance waste plastic	PP	45%
			PE	4%
			PVC	3%
			PC	2%
			PP with talc	4.7%
			PS	15.8%
			ABS	13.7%
			Refractory ABS	4%
			Scrap metals	1%

3. Results and discussions

Figure 1 shows the Environmental Kuznets' Curve (EKC) Model based profit analysis of primary, secondary and tertiary recycling plants, the unit in Y-axial is the income per year (in 1000-TWD$). Results obtained from a real recycle plant has showed that to recycle the tertiary waste plastic in a tertiary recycling plant, the finished products produced from a secondary recycling plant accounts about 27% of ordinary waste plastic, and the semi-finished products that mainly is scrap hardware accounts about 1% of ordinary waste plastic. Other derived solid plastic waste accounts for 6% of ordinary plastic waste. Therefore, if the ordinary, secondary and tertiary recycle plant can be set all-in-one.

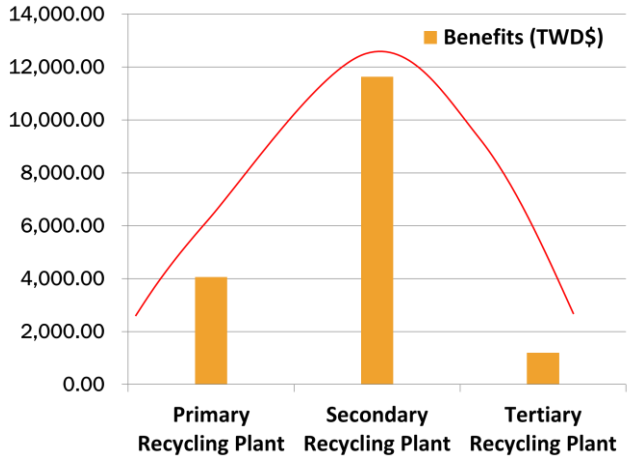

Figure 1. Environmental Kuznets' Curve (EKC) Model based profit analysis of primary, secondary and tertiary recycling plants (the unit in Y-axial is the income per year (in 1000-TWD$).

4. Conclusion remarks and policy implications

Results obtained from a real recycle plant has showed that to recycle the tertiary waste plastic in a tertiary recycling plant, the finished products produced from a secondary recycling plant accounts about 27% of ordinary waste plastic, and the semi-finished products that mainly is scrap hardware accounts about 1% of ordinary waste plastic. Other derived solid plastic waste accounts for 6% of ordinary plastic waste. Therefore, if the primary, secondary and tertiary recycle plant should be combined together to archive the maximum economic efficiency and reduce the emission of carbon dioxide in the future.

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Conflict of interest: The authors declare no conflict of interest.

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