Break the dilemma: Toward a better understanding of China's e-waste reverse logistics implementation barriers from a certified disassembler's perspective

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The consumption of electrical and electronic equipment (EEE) has become indispensable in modern society and revolutionized human beings' lives. However, when EEE goes to the end of use, e-waste is generated. E-waste is a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use (STEP, 2014). Given that e-waste contains both valuable materials and hazardous substances, managing e-waste to recreate value and reduce environmental deterioration has been a global challenge for all countries in the world (Chaudhary and Vrat, 2018; de Oliveira Neto et al., 2019; Parajuly and Wenzel, 2017; Safdar et al., 2020).

As an indispensable role of formal e-waste recycling infrastructure in China, certified disassemblers operate and contribute quality e-waste recycling under environmental scrutiny. However, The shrinking recycling rate plus a highly idle capacity forms a 'Certified Disassembler Dilemma' in China. To break the dilemma, this paper uses stakeholder analysis processes to identify the e-waste RL barriers and explores their causal relationships by using the Grey-based Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach from a certified disassembler's perspective toward a better understanding of e-waste RL implementation in China, tries to provide recommendations to decision-makers.

The study uses stakeholder analysis and identifies 6 stakeholders and respective 9 barriers (Table 1) encountered by certified disassemblers. Then the Grey-based Decision-Making Trial and Evaluation Laboratory (DEMATEL) approach is used to analyze all the barriers toward a better understanding of e-waste RL implementation barriers in China, tries to provide recommendations to decision-makers.

Table 1. A summary of stakeholder analysis-based barriers to e-waste RL implementation

Stakeholders	Barriers	Sources
Government	B1: Lack of popularisation of knowledge and government campaign for recycling e-waste	Qu et al. (2013); (Zeng et al., 2017) Li (2011) Yu (2021)
	B2: Delayed disbursements of subsidies and tighter standards for receipt of subsidies.	Chi et al. (2014) Manomaivibool and Vassanadumrongdee (2012) Xing (2019) Wang et al. (2017)

		Li et al. (2020).
	B3: Poor enforcement of regulations to control illegal disassembling workshops	Wang et al. (2012) Awasthi and Li (2017)
End-user	B4: Households have low environmental awareness	Chi et al. (2014) Liu et al. (2006) Yu et al. (2014) Abdulrahman et al. (2014) Shaharudin et al. (2015) Yuan et al. (2016)
Intermediary collector	B5: E-waste purchasing prices from intermediary collectors are high and uncontrollable	Xing (2019) Huo et al. (2018) Tong et al. (2015) Cao et al. (2016); Yu et al. (2014)
Competitor	B6: A dramatic recent increase in the number of illegal disassembling workshops	CHEARI (2021) Wang et al. (2020) Xing (2019)
	B7: The emergence of producer-run interconnected factories for disassembling e-waste under the EPR	Yu (2021)
Recycler	B8: Price fluctuation of the disassembled components and materials offered by the downstream recycler	Li et al. (2020)
Employee	B9: Employees demand hygiene and safety in the working environment elevating operating costs and the inability to create multiple revenue paths.	Yu et al. (2010) Li et al. (2020) Tong et al. (2015)

The results show that B9 (Employees demand hygiene and safety in the working environment elevating operating costs and the inability to create multiple revenue paths) is the most important fundamental cause that affects other barriers. Interestingly, the most important causal barrier is an internal barrier (i.e. a barrier deriving from the operations capability of the certified disassemblers). The other three barriers are B8 (Price fluctuation of the disassembled components and materials offered by the downstream recycler), B6 (A dramatic recent increase in the number of illegal disassembling workshops), B3 (Poor enforcement of regulations to control illegal disassembling workshops), which relate to illegal disassembling, are the significant effect barriers driven by causal barriers. Meanwhile, these three barriers B6, B8, and B3 also had the greatest prominence values, showing their influence on the other barriers. A sensitivity analysis confirmed the robustness of these results. Recommendations on improving certified disassemblers' internal operation capability are provided, including exploring the deep processing of waste materials to extract more values, extending the upstream residential collection network, and reconsidering multiple recovery options instead of keeping a single-shredding recovery strategy. Sensitivity analysis confirms the robustness of these results. Recommendations for improving certified disassemblers' internal capabilities are provided, including exploring the deep processing of the waste materials, extending the residential collection network, and reconsidering the multiple recovery options.

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