SJSU SAN JOSÉ STATE UNIVERSITY

MTI MINETA TRANSPORTATION INSTITUTE

Information Strategies in the Electric Vehicles Battery Reverse Supply Chain with Blockchain Technology

Tianqin Shi, PhD
Yanting Huang, PhD

Project 2467
November 2025

Introduction

The rapid expansion of the electric vehicle (EV) market has led to a significant increase in the demand for the critical metals used in EV batteries. This surge in demand has created challenges in the supply chain, including potential shortages and price volatility. To address these issues and promote sustainability, efficient recycling of EV batteries is crucial. However, the EV battery recycling process faces several obstacles, such as difficulties in tracing battery origins, the complexity of coordinating the reverse supply chain (moving goods from the end customer back towards the manufacturer), and the presence of unregulated recyclers. This research explores the potential of blockchain technology to overcome these challenges and enhance the efficiency and transparency of the EV battery reverse supply chain. The primary research goal is to analyze the impact of blockchain technology on the recycling of EV batteries, with a particular focus on the role of unregulated recyclers in this process. Blockchain is a decentralized digital ledger that securely stores data across a network of computers in a way that is transparent, unchangeable, and resistant to tampering. Each "block" contains data, and blocks are linked in a chronological "chain." Blockchain tech has been used in a variety of industries to make different types of transactions more secure and efficient. By examining how blockchain might help the EV industry create a secure, traceable system for tracking batteries from end-of-life to reuse, this research supports a more resilient sustainable transportation industry.

Study Methods

This study used a mixed-methods approach, combining qualitative and quantitative research techniques. First, the research team conducted semi-structured interviews with six experts from EV and EV battery manufacturing companies in the United States and China. These interviews aimed to gather in-depth insights into the challenges faced in the current EV battery recycling processes, the impact of unregulated recyclers, and the potential benefits

and barriers to implementing blockchain technology. Second, the team developed a model based on the Stackelberg game theory that was then used to analyze the strategic interactions among different stakeholders in the EV battery supply chain. The model includes a manufacturer, a retailer, a regulated recycler, and an unregulated recycler. It compares scenarios with and without blockchain adoption to assess its impact on recycling quantities, prices, and profits. The model uses mathematical equations to represent the decision-making processes of each stakeholder and to derive equilibrium (a state where supply and demand in a market are balanced) outcomes.

Blockchain adoption can facilitate reverse supply chains if blockchain costs are sufficiently low.

Findings

The interviews revealed significant challenges in the current EV battery recycling process, including difficulties in tracing the source of waste batteries and the negative impacts of unregulated recyclers. Unregulated recyclers contribute to market disorder, engage in price competition, and often use environmentally harmful recycling methods. Blockchain technology was identified as a potential solution to enhance supply chain transparency and enable better tracking of batteries throughout their lifecycle. The game theory model provided further insights into the economic implications of blockchain adoption. The model demonstrated that blockchain adoption could increase the total recycling quantity if the blockchain implementation costs are sufficiently low. Additionally, blockchain technology can enable regulated recyclers to achieve higher buyback prices, recycling quantities, and profits compared to unregulated recyclers, but this depends on the regulated recyclers having lower per-unit operational costs. The model also showed that the regulated recycler's decision to adopt blockchain is influenced by the cost of blockchain implementation and the level of competition in the recycling market.

Policy Recommendations

The findings of this research suggest several policy and practice recommendations. Regulators should actively explore and promote the application of blockchain technology in EV battery supply chains to enhance transparency and combat unregulated recycling. Given the challenges posed by unregulated recyclers, policies should be developed to incentivize the adoption of blockchain among supply chain participants. To compete effectively with unregulated recyclers, regulated recyclers should focus on improving their recycling technologies to reduce costs. Blockchain platforms should strive to reduce implementation costs to encourage wider adoption and maximize the technology's benefits in addressing the environmental challenges associated with EV battery recycling.

About the Authors

Dr. Tianqin Shi is an Associate Professor at the Lucas College and Graduate School of Business, San José State University. Her research interests include sustainable operations management and marketing-operations interface.

Dr. Yanting Huang is an Associate Professor in the College of Management at Shenzhen University in China. Her research interests include supply chain management and operations management.

To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2467

MTI is a University Transportation Center sponsored by the U.S. Department of Transportation's Office of the Assistant Secretary for Research and Technology and by Caltrans. The Institute is located within San José State University's Lucas Graduate School of Business.