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Forecast Model for Return Quality in Reverse Logistics Networks

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Abstract

Giving rise to the field of reverse logistics are legislations mandating the take-back and recovery of products, causing high costs for manufacturers but no guaranteed profitability. One way to tackle this challenge is to demystify the multi-faceted uncertainties of product returns namely timing, volume and quality, that currently inhibit optimality of reverse logistics networks (RLN).

One contributor to this risk is the uncertainty in the quality level of used electronics caused by variations in consumer usage behaviors. It would be useful if businesses could have data about the expected quality levels of future returns for efficient planning of RLN design and resource allocation. The objective of this thesis is to develop a quantitative model that can estimate the return quality of future electronics returns. The applicability of this model lies in enabling reprocessors to strategically design an RLN with the optimal number, capacity and location of the necessary facilities, with the aim of reducing the risks of costly investments, while facilitating RLNs that are both, environmentally and economically viable.

While significant literature on forecast of volume and timing of returned products exists, there is scare work on forecasting of return quality. Additionally, significant literature explores the use of IoT, RFID and prognostic health monitoring (PHM) systems, characteristic of Industry 4.0, as a method of using life cycle data to predict return quality. However, it can be argued that these costly methods can only be justified for products with long life spans. As an alternative for short-lived products, this thesis develops a forecast model for return quality based on consumer behavior trends.

The proposed forecast model incorporates three major factors that affect quality: usage, technological age, and remaining economic value of expected returns. The novelty of the model lies in deducing usage distributions through segmentation of the consumers by three socioeconomic factors: age, income, and location. These usage distributions are used to estimate remaining life of returns, the associated recovery costs and the subsequent profitability based on economic market trends.

Firstly, the methodology involves establishing a correlation between relevant socioeconomic factors and smartphone usage behaviors through statistical tests of association. To this end, empirical data from surveys has been used to derive trends between the response variables, smartphone usage and purchase behavior, and the independent variables, which are the socioeconomic factors.

Secondly, a complex system of equations is developed incorporating usage level and time-based secondary market value trends of the product. They determine the most feasible quality level of a unit based on expected profit that can be derived from it through the streams of direct reuse, refurbishing, parts harvest, or materials recycling.

For demonstration of the model, a random sample of smartphone returns based on consumers in Canada, generated using Monte Carlo Methods, is input into the forecast model to predict the output- which is the distribution of return quality from the collections in Canadian cities.

The results of this thesis can be used by original equipment manufacturers, government or third party reprocessors, to design a more efficient RLN by providing them information on what quality levels to expect from the used smartphones.

Keywords
Reverse Logistics, Return Quality, Smartphones, Socioeconomic Trends, Forecast

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Biographies

Aamirah Mohammed Ashraf is an MASc. candidate at the University of Windsor with a research interest in Intelligent Supply Chains, Reverse Logistics and Sustainable Development. Her master's thesis addresses the challenges of maximizing profitability in reprocessing of end-of-use electronics.

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