A decision and operations model for reverse logistics in the computer industry

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Introduction

A number of studies have been made for reverse logistics to model recycling, repairing or repackaging operations. The decision making model proposed in this research will attempt to treat returns differently under different states of return quality. Currently, there are few critical decisions that one has to make in reverse logistics and are based on intuitive judgement than on some scientific grounds.

The model will help the decision makers to determine the type for the recovery process (reuse, repair and scrap) and the location to store these returns after the recovery process or exchanging with suppliers.

minimise the recovery costs ➔ maximise the profit for reverse logistics
Literature review

Most reverse logistics models can be found in the Operations Research literature.

• **Linear Programming** (Crainic et al, 1993; Jayaraman, 1995; Ritchie, 2000; Fleischmann et al, 2001; Chou, 2005; Schultmann, 2006; Lu et al, 2007)


• **Heuristics** (Gupta, 1993; Barros et al, 1998; Marin et al, 1998; Richter, 2000; Jayaraman et al, 2003; Mourao and Amado, 2005)

• **Fuzzy and Neuro-fuzzy methods** (Marx-Gomez et al. (2002)

• **PetriNets** are used by Moore, Gungor and Gupta (1998, 2001)

• **Non-linear Programming** (Jayaraman et al 1998; Richter, 1999; Sarkis 2001

• **Stochastic Programming** (Gupta, 2003; Listes, 2005, 2007; Biehl et al, 2007;

• **Two-stage Stochastic Programming models** (Alonso-Ayuso, 2003; Santos et al, 2005; Goh, Lim and Meng, 2007)

• **Nagurney and Toyasaki (2005)** used a network equilibrium model to establish variational inequality formulation
Decision making framework for reverse logistics
The steps for making the return decision are as follows:

1. Is this part at the End of Life-cycle (EOL)?
   -- If this part is at EOL, it is scrapped; otherwise, proceed to the next step.

2. Is it a make part or a buy part?
   -- Make part flows through step 3 while Buy part flows through steps 4 and 5.

3. What is the condition of this make part?
   -- If this part is in good condition, it is directly sent to good part inventory for storage.
   -- If this part is in poor condition, it is directly sent to scrap.
   -- If this part is serviceable, it is sent for repair or remanufacturing.

4. Is this buy part under supplier warranty?
   -- If this part is not under warranty, it is directly sent to scrap.
   -- If this part is under warranty, go to step 5.

5. Can this part be credited from supplier without returning to the supplier?
   -- If this part can be credited, it is sent to scrap. Otherwise, the part is sent to supplier for exchange and returned to good parts inventory for storage.
This decision process has two outcomes:

-- return the part for storage
-- simply scrap it.

Using the framework from the following figure, two sets of equations can be developed for the reverse logistics:

-- return for make parts: parts that are manufactured internally
-- return for buy parts: parts that are purchased from suppliers and Original Equipment Manufacturer (OEM).
Equations used for manufacturing parts:
The profitability of reverse logistics can be computed using Equation (1):

\[
\text{Max } \sum_{p=1}^{n} \text{Net\_profit} = \\
\left[ \sum_{p=1}^{n} \text{Rqty\_reuse}_{ip} \times \text{Profit\_reuse}_{jp} + \sum_{p=1}^{n} \text{Rqty\_repair}_{ip} \times \text{Profit\_repair}_{jp} \right. \\
\left. + \sum_{p=1}^{n} \text{Rqty\_scrap}_{ip} \times \text{Profit\_scrap}_{ip} - \sum_{p=1}^{n} \text{Cost\_revlog}_{ip} \right]
\]

Subject to

\[
\sum_{p=1}^{n} \text{Net\_profit} \geq 1 \quad p = 1, 2, \ldots n \text{ make parts}
\]

\(\text{Rqty\_reuse}_{ip}, \text{Rqty\_repair}_{ip}\) and \(\text{Rqty\_scrap}_{ip}\) are non-negative for all \(i\) and \(j\),

where

\(p\) refers to each part number within a set of manufacturing parts,
Rqty_reuse\_jp, Rqty\_repair\_jp and Rqty\_scarp\_jp are number of part p for reuse, repair and scrap collected at i and sent to designated facilities j for processing,

Profit\_reuse\_jp is the unit profit generated for reusing part p from repackaging facility j and can be calculated using Equation (2):

\[
\text{Profit\_reuse\_jp} = \text{Price\_reuse}_p - \text{Cost\_reuse\_jp}
\]  \hspace{1cm} (2)

**Equations used for purchasing parts:-**

\[
\text{Max} \sum_{p=1}^{n} \text{Net\_profit} = \\
\left[ \sum_{p=1}^{n} \text{Rqty\_exchange\_jp} \times \text{Profit\_exchange\_jp} \right. \\
+ \sum_{p=1}^{n} \text{Rqty\_credit\_ip} \times \text{Revenue\_credit\_ip} \\
+ \sum_{p=1}^{n} (\text{Rqty\_scrap\_ip} + \text{Rqty\_credit\_ip}) \times \text{Profit\_scrap\_ip} - \sum_{p=1}^{n} \text{Cost\_revlog\_ip} \left. \right]
\]

Subject to

\[
\sum_{p=1}^{n} \text{Net\_profit} \geq 1 \quad p = 1, 2, \ldots, n \text{buy parts}
\]

Rqty\_exchange\_ip, Rqty\_credit\_ip and Rqty\_scrap\_ip are non-negative for all i and j
Using Dell Computer to validate the model:-
For verification and validation purposes, a case study is used to test the decision making framework and LP model.

The reverse logistics network for Dell Computer consists of suppliers, manufacturing facilities and customers. Customers return their products through a logistics provider and these products are sorted depending upon their condition. Some are remanufactured or repaired, while others are sent back to the suppliers for exchange if their warranties are still valid, and the rest are scrapped.

Based on the results obtained, the following policies are recommended to maximise manufacturer’s profitability for reverse logistics.

It is recommended to centralise the reverse logistics operations for parts with high return volume and high quality. High volume will lower the freight costs due to the economies of scales and it is still cheaper to repair centrally as the cost of freight contributes to a lower percentage than their repair costs as demonstrated (in LP model).

It is better to decentralise the reverse logistics operations for parts with low quality, since most of the returns will be scrapped locally as the freight costs are higher than the scrap cost.
For parts with very low return volume, it makes more economical sense to outsource the reverse logistics operations to other service providers since the overhead costs are high to manage such low return volume.

Conclusions:

• The decision making framework has demonstrated how computer companies can evaluate their viability for international reverse logistics operations. The analysis develops insights for international issues such as custom duties and international freights and their strategic importance for reverse logistics.
• The model can be applied to other manufacturing sectors (Chemical, Consumer goods, High Tech, etc.) where the products can be refurbished or reworked.
• It can be extended to Third-Party Logistics (3PL) offering reverse logistics services.
• Managing reverse logistics in a global context involves more international issues as compared with managing reverse logistics operations within a country.