# Cost Effectiveness and Flexibility of Reverse Logistics for Consumables and Raw Material: An Empirical Investigation

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***Abstract***
**The modern supply chain management is witnessing a radical transformation as an effect of competitive strategy. The raw material supplier as well as consumable suppliers often faces the situation of their product return. We conducted a recent survey from the raw material, consumable suppliers and the manufacturing units for examining reverse logistics performance in terms of cost effectiveness and flexibility. This study focuses on finding the relationship between the independent variables and the cost and flexibility as performance indicators of reverse logistics. The result of this study provides a template guideline for designing a cost effective and flexible reverse logistics program.**

***Keywords*** - Reverse Logistics, product design, forecasting, retrieval centres, return policies.

## 1. Introduction

The supply chains of today are experiencing a major revolution as an effect of competitive policy. Product returns back into the supply chain for many reasons. To recapture its value is the primary objective or reverse logistics function. Reverse logistics is all about handling of such a product to recapture its value. Environment issues are one among the drivers of product return [22]. The reverse logistics of raw material carries a huge cost from its return transport back to its remanufacturing [17]. Lambert et al.(2011) gives different insights to this field through their studies on this area[14]. While we scan the literature, we noticed the supply chain flexibility and cost in terms of reverse logistics have received considerably less attention.

We set our objectives with respect to these research gaps as to

1. Identify the factors influencing the cost and flexibility of reverse logistics.
2. To test the hypotheses of causal relationship between the variables
3. To offer recommendations to the enterprises to establish a cost effective and flexible reverse logistics program.

## 2. Literature Survey

Pohlen & Farris (1992) defined reverse logistics as, “The movement of goods from customer towards a producer in a channel of distribution”[21]. Many authors have defined reverse logistics in their own words however, the definitions reflect similar concept. The concept is moving of the product back into the supply chain for the purpose of capturing value or otherwise disposal. Mukhopadhyay & setuputro (2005) first proposed a planning approach of reverse logistics[18]. Reverse logistics exists within the logistics infrastructure of the company [25]. There are many broad areas of reverse logistics. While surveying the literature we noticed reverse logistics spreads over the areas like environment, customer’s satisfaction, organizational role in reverse logistics, support systems, forecasting and return policies etc. A good reverse logistics program should have flexibility and cost effectiveness. We considered these variables as the performance indicators. Blumberg (2005) gives the difference in return flow in terms of parts and sub-assemblies, consumables and material or whole unit equipment [3]. For the present study, the product returns taken into consideration are the returns in the form of raw material and consumables.

### 2.1. Theory Development

#### 2.1.1. *Development of Independent construct*

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The construct of retrieval centre refers to the collection points for return or facilities created for the customer to submit their return or to lodge their request of product return. The collection and recovery of returned items is an extremely critical issue of reverse logistics there is no comprehensive & practicable approach to resolve this issue [5]. Retrieval centre facilitate ease in submitting returns and speeds up the process of reverse logistics.

The construct of return policy refers to the established guidelines that govern the conditions on which a returned product will be accepted. Companies in highly competitive markets, have liberal return policies that reduce their customer's risks, which will in turn drive sales and customer loyalty [8]. Sales can be increased with an effective tool of return policy [16]. Reverse logistics policy restrictiveness is considered one of the program design characteristic [23].

The construct of forecasting refers to accurate forecasts of product returns. Forecasting can be an important tool for handling of return. The traditional method normally fails in forecasting the returns due to uncertainty in time & quantity of return (Mark-Gomez et al. (2002), Toktay et al.(2003) have explored many aspect of forecasting for effective management of product return [15],[27]. They exploited the fact that future returns are the function of past sales. Forecasting will aid reverse logistics as an important planning tool. Thus, forecasting remains an important construct of reverse logistics.

The construct of product design refers to conversion of ideas into reality. A good product design should aim at avoiding unwanted aspects of the product [4]. The increasing issues of environmental pollution forces a designer to give a suitable consideration for environment safety during the design process [16]. Product design facilitates reverse logistics and hence taken as an independent construct.

The construct of use of information technology refers to the use the modern IT tools as enablers. (Govindan et al.(2012) in their study of 3 PRLP proposed seven main attributes to reverse logistics. One among these attributes is the use of IT. Outbound as well as reverse flow both must accommodate transportation, warehousing as well as inventory control, the support of information technology facilitates these activities [23].

### *2.1.2. Development of Dependent Construct*

Major contributors of cost in manufacturing are production cost, productivity, capacity utilization and inventory reduction. Dowlatsahi, (2005) considered cost of reverse logistics as a strategic factor and the cost associated with it is strategic cost [6]. In the study carried by Bahjat et al. (2012) on manufacturing flexibility the cost elements of operational performance was observed to be highly influential for reverse logistics [2]. Present study considers cost as the subjective assessment of the cost benefits as an outcome of firms remanufacturing, recycling or any of the cost associated with bringing the product in a usable form.

The term flexibility refers to the ability to respond or confirm to new situations. Flexibility is normally process, or product or infrastructure related [20]. Swamidass ( 2000) defined flexibility as, "The capacity of manufacturing system to adapt successfully to changing environmental condition as well as changing product and process requirement." Since, returns may vary in their type; it is the flexibility than can take care of the variation in the type of return and hence is an important performance indicator

### *2.1.3. Conceptual Framework*

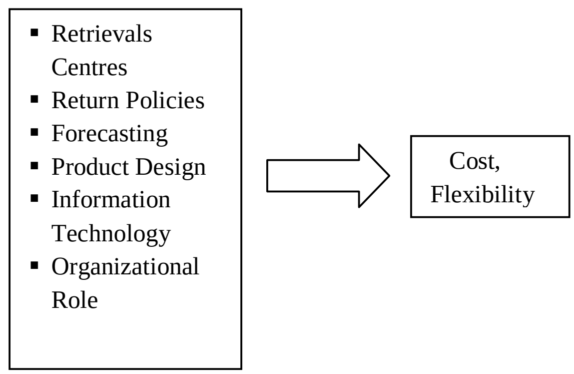


**Figure 1:** Conceptual Framework

The scope of this research is within the conceptual framework presented in the figure 1.

## 3. Research Methodology

### *3.1. Defining the Hypotheses*

H1 The ease of locating retrieval centers in the supply chain network will have significant effect on cost of the reverse logistics.

H2 Liberal return policies will have a significant effect on the cost of reverse logistics.

H3 Forecasting the expected returns will have significant effect on the cost of reverse logistics

H4 Product design strategies for environment will make a significant effect on flexibility of reverse logistics system

H5 Use of information technology as an enabler for return processing will makes a significant effect on the flexibility reverse logistics.

H6 Organizational role in decision making on the returns will make a significant effect of flexibility of reverse logistics.

### 3.2. Data Collection

We used Convenience sampling (non-probability sampling) for data collection for this study. The survey instrument was sent via surface mail, email and personal visit. We received 295 valid responses. We recorded an adequate sample size to do the factor analysis. As a general rule researcher must obtain observations five times greater than the number of variables to be analyzed [10]. This study contains 06 in dependent and 02 dependent variable, thus the sample sizes of 295 is acceptable for the further analysis.

### 3.3. Measures

Existing scales used in various research studies were used in this study. Respondents were asked to rate the prevalence factor on a 0- 5 Point scale [0= not at all, 1 = to very little extent, 2 = to some extent, 3 = to reasonable extent, 4 = to reasonably high extent, 5 = to very high extent]. The construct and scales used for this study are almost from the previous literature.

### 3.4. Construct Validity and Reliability test

We carried the exploratory factor analysis to check the factor score and loading values. The cross-loaded factors were removed from the analysis. The factors loading values are reasonably high on their respective factors i.e. always greater than 0.40, which indicates desirable convergent validity in the measures [19]. Factor loadings in matrix are with no cross loadings indicating good amount of discriminant validity.

The KMO values resulted higher than 0.5 indicating the sampling adequacy [12]. MSA (Measurement for sampling adequacy) for each variable was also checked which resulted higher than 0.5. Bartlett's test of sphericity was favorable indicating the existence correlation among the variables.

All the constructs had Nomological validity, as the scales used for the study were existing scales with sufficient literature support [10].

Reliability was assessed using reliability coefficient Cronbach alpha. Cronbach alpha assesses the consistency of the entire scale. In exploratory studies, the suggested Cronbach alpha is a minimum of 0.60 [11], [10]. The data analysis for reliability test resulted in Cronbach alpha above 0.60 indicating significant reliability of measures.

Table 1 shows correlation matrix among the variables and indicates existence of a pattern of positive correlations in the matrix. Table 2 gives complete statistics of constructs.

**Table 1:** Correlation Matrix

| | CO | FX | PD | RC | IT | RP | OR | F |
|---|---|---|---|---|---|---|---|---|
| CO | 1 | | | | | | | |
| FX | .449** | 1 | | | | | | |
| PD | .043 | .233** | 1 | | | | | |
| RC | .293** | .221** | -.099 | 1 | | | | |
| IT | .443** | .489** | .013 | .206** | 1 | | | |
| RC | .451** | .471** | -.015 | .215** | .611** | 1 | | |
| OR | .340** | .412** | -.165** | .136* | .359** | .469** | 1 | |
| F | .440** | .457** | -.008 | .165** | .508** | .516** | .422** | 1 |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

**Table 2:** Statistics of construct

| | KMO For the Sample | Cronbach Alpha | Eigen Values | % Variance | factors indicated |
|---|---|---|---|---|---|
| PD | 0.812 | 0.930 | 6.294 | 15.461 | 04 |
| RC | | 0.786 | 1.189 | 63.149 | 03 |
| IT | | 0.826 | 3.522 | 29.091 | 05 |
| RP | | 0.819 | 2.044 | 42.378 | 04 |
| OR | | 0.827 | 1.643 | 52.987 | 03 |
| F | | 0.729 | 1.119 | 71.867 | 03 |
| CO | 0.699 | 0.677 | 1.678 | 52.104 | 03 |
| FX | | 0.819 | 3.858 | 19.922 | 04 |

## 4. Result and Analysis

We used multiple regression analysis to find the correlations between the variables. Multiple Regression is a statistical technique that can be used to analyze the relationship between a single dependent variable and several independent variable.

We used the following regression equations to the hypotheses.

$$Cost = \alpha + \beta 1 * RC + \beta 2 * RP + \beta 3 * OR + \beta 4 * F$$

***Flexibility= α + β1* PD + β2*IT + β3*OR***

Regression analysis was carried using SPSS 17. For further carrying the regression analysis we carried all those test for fundamental assumption required for multiple regression analysis.

Linearity was checked through the partial regression plot of residuals versus variables. The pattern for the plots were observed random almost similar to null plot ensuring the linearity of the phenomenon.

Normality of the error terms were tested by examining Histogram and Normal Probability plot. Histogram being the simplest diagnostic tool for normality checks [10]. The visual check of histogram indicates an approximately normal distribution. If the distribution is normal, the residual line closely follows the diagonal [10].

The examination of normal probability plot indicated the normal distribution.

Multicollinearity test was carried to examine the existence of any Multicollinearity affecting the analysis. The tolerance values and Variance inflation factors were checked and the no issue of multicollinearity was observed. Accepted level of tolerance is upto 0.10 corresponding to VIF of 10 [10].

**Table 3:** Hypothesis test results

| | Hypothesis | $R^2$, β<br>P<br>Relationship |
|---|---|---|
| **H1** | The ease of locating retrieval centres in the supply chain network will have significant effect on cost of the reverse logistics | 0.304,0.188<br>0.000,<br>**Supported** |
| **H2** | Liberal returns policies will have a significant effect on the cost of reverse logistics. | 0.304, 0.238<br>0.00<br>**Supported** |
| **H3** | Forecasting the expected returns will have significant effect on the cost of reverse logistics | 0.304, 0.244<br>0.000<br>**Supported** |
| **H4** | Product design strategies for environment will make a significant effect on flexibility of reverse logistics system | 0.381, 0.282<br>0.000<br>**Supported** |
| **H5** | Use of information technology as an enabler for return processing will makes a significant effect on the flexibility reverse logistics | 0.381, 0.369<br>0.000<br>**Supported** |
| **H6** | Organizational role in decision making on the returns will make a significant effect of flexibility of reverse logistics | 0.381, 0.326<br>0.000<br>**Supported** |

H1, H2, H3 and H4 were tested through first model $R^2$ resulted in 0.304 and H5 and H6 were tested through another model, which resulted in a $R^2$ value of 0.369. Both the models had significant explanatory power to accept the resultant support to hypothesis. A minimum of 0.08 is acceptable $R^2$ value to consider the explanatory power of model [10]. The β coefficient and the P values are supporting the all the hypotheses for their positive relationship with their treatment variables.

## 5. Discussions

Hypothesis result H1 indicates that a good reverse logistics program for the enterprises should look at this facility creation for the customers. The ease of locating a retrieval centre to a customer is supported significantly to cost of reverse logistics. The ease in locating a retrieval centers would cut down on the expenses on transportation of the returns. These findings on retrieval centre are largely supporting the hierarchical structure for collection centre according to socio economic characteristics of the residential area given by [24].

The Hypothesis H2 results indicate that, the liberal policies on product return will turn out to a increase in customer satisfaction and will gain a cost advantage over remanufacturing. Automobile industry is seen much in buy back offers with liberal return policies.

Hypothesis test results H3 indicates that, forecasting the expected returns stands out to be the variable that positively and significantly affects the cost of reverse logistics.

Hypothesis test results H4, indicates that product design offers such flexibility through the aspects of disassembly, opportunities for recycling, ease in remanufacturing in a reverse logistics program.

Hypothesis test results H5 indicates that the use of information technology as an enabler supports reverse logistics program to be flexible. The capabilities of IT can be utilized for product coding and can be traced to manage its reverse logistics. This supports the idea of Richey et al. (2005), Gunasekaran, and Nagai (2004) that there is a direct effect of use of IT as an enabler for reverse logistics to make it flexible[23],[9].

Organization role in decision making on the reverse logistics is having significant effect on the flexibility of reverse logistics. This is also suggestive of alternate possibilities of action on returns in the form of hierarchy. This is in lines with the investigations of Antonio (2012) and Koste & Malhotra (1999) on flexibility of reverse logistics [1], [13].

## 6. Implications

To establish a reverse logistics as an extended responsibility of the producer has always been the challenge to the firm to maintain their competitiveness and customers satisfaction. To do so, it is necessary for them to first identify the factors influencing returns handling as independent variables. In addition, the independent variables, the factors that stand as the measures of performance of reverse logistics are also needed to be investigated. Besides knowing these two factors, it is equally important to know their relationships. With a complete knowledge base of these facts, the supply chain mangers could design an effective reverse logistics program.

The factors are to be strategic, tactical and operational in nature. They influence short term, medium term and long term planning of reverse logistics. The results discussed in earlier section provide the guidelines for the enterprises to develop an effective and efficient reverse logistics program.

## 7. Conclusions

This study has the limitation of product return in the form of raw material and consumables and the only performance measure considered for the study are cost or reverse logistics and flexibility of reverse logistics.

In this study, we have empirically studied the role of product design, retrieval centre, use of information technology, return policies, importance of organizational decision making and forecasting. The analysis of data was from small to large-scale industries. We have recognized and presented the importance of ease of locating retrieval centre for a customer to get the benefits of customer satisfaction. Further, we justified positive impact of role of retrieval centre on the cost and service of reverse logistics. We also have given a deeper insight of using information technology to improve flexibility and effectiveness of reverse logistics.

Our study has also provided a accountability on the part of organization in design making so that reverse logistics of an enterprise remains flexible and offers improved services. An interesting fact on the trend of return policies was discovered during this research. Last but not the least we discovered forecasting as a tool to improve the cost effectiveness of reverse logistics.

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