

The Research on 4PL Optimal Pricing Strategy Based on the Reverse Logistics Integration

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Abstract An effective reverse logistic integration is used as an important competitive policy in the marketplace to substantially influence product sales. The purpose of this paper is to propose the use of a fourth party logistics (4PL) as a return service provider, and develops optimal decision policies for both the seller and the 4PL. A profit-maximization model is presented to jointly obtain optimal policies for the seller and the 4PL through the use of Stackelberg like game theory, where the seller acts as the leader and the 4PL acts as the follower. This paper offers a number of managerial guidelines for using marketing and operational strategy variables to influence the market reaction parameters so as to obtain the maximum benefit from the market.

Key words reverse logistic, 4PL, strategic alliances, marketing strategy

1 Introduction

In recent years, reverse logistics has become an important issue with the merchants. Allowing returns from the customer is an important marketing tool, but it gives rise to what the merchants think as the “headache” of handling the goods returned by the customer. Pogorelec maintains that the very thought of reverse logistics goes against every retailer's instincts. Reverse logistics has not enjoyed a glamorous reputation because of the misconception that it is only a cost drain and that it adds no value to the supply chain. Rogers and Tibben-Lemke found that on average, returns reduced the profitability of survey participants by 4.2 percent. The reasons include handling of returned goods, and also that the returned goods need to be serviced and sold off, destroyed or, if not defective, repackaged and sold through alternative sales channels. A generous return policy, therefore, involves both a cost outlay per item returned, and an expertise in handling the reverse flow – an expertise, the firm more often is not designed for. The problem of reverse logistics is more magnified for direct retailers doing e-business where the returns, by necessity, will need to be done through a third party logistics (3PL) provider to physically transport the returned goods.

Nevertheless, product return is a fact of life and firms have to deal with it the best way they can. Recent surveys have indicated that reverse logistics costs may exceed \$35 billion dollars per year for US companies. In addition, the continued growth of online shopping increases the need for a proven process to efficiently facilitate returns. It is estimated that 50 percent of online sales are potential returns, which makes managing reverse logistics a major priority. Many companies treat reverse logistics as a non-revenue-generating process which would often result in very few resources allocated to this part of the supply chain. This will escalate costs and jeopardize customer and brand loyalty. On the other hand, firms like Sears, Roebuck and Co. has successfully cut the return costs by implementing a product return system. Offering a generous return policy would attract more customers. This is especially true for internet purchases where almost all goods are experience goods. A generous return policy, therefore, can be an excellent marketing tool to improve the product's demand in the market. A comprehensive review of return policy literature can be found.

More and more firms now realize that the reverse logistics is a business process by itself and needs core competency to successfully manage it. As firms develop core competency in the fulfillment process, the core competency on the reverse logistics too may be difficult to attain for the same firm.

2 Model Formulation of 4PL Optimal Pricing Strategy

In the game theoretic model we develop here, the e-tailer is the firm that originally offers the product for direct sale through the internet at price p . The 4PL offers the refurbished products to the secondary market at price w . The 4PL's decision about w is clearly dependent on the original product price (w needs to be less than p). Thus, we see a natural leader-follower relationship here giving rise to a Stackelberg type game where the e-tailer is the leader and the 4PL is the follower. The importance of receiving a value w from the returned goods can be seen by the action of Estee Lauder who redistributed

150 percent more of its returns in gaining about half a million dollars which is projected to go higher. The system here consists of three parties, an e-tailer who sells a product online, a 4PL who manages the process of goods return and offers them for resale, and customers who buy the product. Even though we present our model in a scenario of an online seller who sells directly to the customer, our model would also be applicable to a traditional manufacturer of brick and mortar kind. The flow of payment is as follows. A customer buys a product from the e-tailer and pays p dollars per unit. The 4PL offers to give r dollars back to the customer as the refund amount ($0 \leq r \leq p$) in case the customer decides to return the product. A higher r is perceived by the customer as a more generous return policy. The 4PL is paid by the e-tailer s dollars ($s \geq r$) for providing the reverse logistics service. The 4PL will then refurbish the returned product (at a cost) and reoffer these returned products in the used market at w dollars per unit ($w \leq p$). We recognize the fact the refurbished item has a lower value to the customer compared to the original item. No return is allowed at this stage.

2.1 The demand functions of e-tailer and 4PL

We have two demand functions; demand for the original items offered by the e-tailer and demand for the refurbished items offered by the 4PL. The first demand function is formulated as follows. We assume that a generous return policy offered to the customer will generate higher demand in the first market. Similarly, tightening return policy would decrease the demand. A higher price would have a negative impact on the primary demand. The two types of products, new and refurbished, offered in the market have the flavor of direct competition. A much lower price for the refurbished item, though having a lower value than the original item, may take away some of the primary demand. Primary demand, then, will be an increasing function of w . The demand for the original item D_1 , thus, is a function of p , r , and w : $D_1 = f(p, r, w)$

$$\text{Equation 1 with } \frac{\partial D_1}{\partial p} < 0, \frac{\partial D_1}{\partial r} > 0, \text{ and } \frac{\partial D_1}{\partial w} < 0$$

$$\text{Equation 2 } D_1 = \alpha_1 - \beta_1 p + \delta(p - w - v)$$

Without any loss of generality, we assume a linear demand function as used by many researchers in this area. The linear demand equation will help us get the insights from the model vis-à-vis optimal policies instead of intractable equations leading to no solutions. We will thus assume that the demand of the product will take the following form:

$$\text{Equation 3 } D_2 = f(p, w)$$

We will explain the last term after we introduce the secondary demand function. For the secondary demand, there is no return policy offered and w acts like price. Thus, the demand for the used product D_2 is:

$$\text{Equation 4 with } \frac{\partial D_2}{\partial p} > 0, \text{ and } \frac{\partial D_2}{\partial w} < 0$$

$$\text{Equation 5 } D_2 = \alpha_2 - \beta_2 w + \delta(p - w - v)$$

We will assume that the demand of the product will take the following form:

$$\text{Equation 6 } R = \phi + \psi \gamma$$

We now explain the last term in equations (3) and (6). Because the two products are in direct competition, there will be a migration of demand from one to the other. This migration will depend on the relative values of the two products. Note that $p-w$ is the price advantage of the refurbished product. However, this price advantage is moderated by a loss of value, v , for the refurbished product. The effective price advantage then is reduced to $(p-w-v)$. δ , a migration parameter, is used to get the amount of demand lost by the new product to the refurbished product. Note that the flow could be the other way round. That case will be automatically taken care of by the signs. The parameters α_i , β_i , and γ ($i=1, 2$) and all > 0 , are explained as follows. α_i represents the base demand which does not depend on the prices or the return policy. This base demand depends on factors such as product quality, brand image, and general economic factors manipulations of which are outside the scope of this paper. β_i is the sensitivity of the demand with respect to price. Specifically, as p or w increases, the demand is reduced from its base value at the rate of β_1 or β_2 , respectively. γ is the sensitivity of demand with respect to the return policy and represents the rate of demand increase from the base value as return policy become more generous (r increases).

2.2 The return quantity function

In our model, the e-tailer allows the customer to return the item via 4PL for a refund of r dollars. While this policy will motivate more primary demand (equation (3)), this will also generate more quantity returned by the customer. We model this by the following linear equation:

$$\text{Equation 7 } \pi_1 = pD_1(p, r, w) - sR(r)$$

where R is the returned quantity ($0 \leq R \leq D_1$). Parameter $\psi > 0$ is the rate of return with respect to the refund amount r motivating more people to return because returning the item becomes more and more worthwhile. $\phi > 0$ is a base return quantity which depends on factors other than the refund amount.

2.3 Profit functions

The profit function of the e-tailer can be written as:

$$\text{Equation 8 } \pi_1 = (\alpha_1 - \beta_1 p + \gamma r - \delta(p - w - v))p - (\phi + \psi r)s$$

Where pD_1 is the total revenue obtained by selling D_1 units at a price p per unit and sR is the total cost of the returned merchandise since s is the fee paid to the 4PL to process returned merchandise per unit.

Substituting in the expression for D_1 and R from equations (3) and (7) into equation (8), we get the expression for profit as follows:

$$\text{Equation 9 } \pi_2 = wD_2(p, w) - rR(r) + sR(r) + e(R - D_2) - cR(r)$$

For the 4PL, note that we should have $D_2 \leq R$. Also, $R - D_2$ is the quantity left with the 4PL after the secondary demand is met. Assume that $e \geq 0$ to be the salvage value per unit of these items. The profit function for the 4PL can then be expressed as:

$$\text{Equation 10 } \pi_2 = (w - e)(\alpha_2 - \beta_3 w + \delta(p - w - v)) + (s + e - r - c)(\phi + \psi r)$$

Where wD_2 is the total revenue obtained by selling D_2 refurbished units at a price w per unit, rR is the total amount refunded to customers, sR is the total amount received from the e-tailer for providing the return processing service, $e(R - D_2)$ is the total amount obtained from salvaging the unsold returned units, and cR is the total cost for the 4PL to process and refurbish the return merchandise.

Substituting the expressions for D_2 and R from equations (6) and (7) into equation (10), we have:

$$\text{Equation 11 } p^* = \frac{(\beta_2 + \delta)[2\delta\psi(e - A) - \gamma(3\phi - \psi(e - c)) + 4\psi(\alpha_1 + \alpha_2 - A\beta_2)]}{8\beta_1\psi(\beta_2 + \delta) - \delta(\gamma^2 - 4\delta\psi) - \beta_2(\gamma^2 - 8\delta\psi)}$$

As can be seen from equations (8) and (11), the effect of any change in the decision variables p , s , w , or r is not obvious because it increases one term in the profit function but reduces the other. Optimal decisions for the e-tailer is to find p^* and s^* and for the 4PL is to find w^* and r^* .

3 Results

We will now derive closed form solutions of the four decision variables. For reasons explained earlier, we assume that the e-tailer acts as the leader and the 4PL acts as the follower in a Stackelberg like game. First the best response functions for the 4PL are derived. The e-tailer, then, uses these response functions to find optimum p and s . After the e-tailer announces optimum p^* and s^* the 4PL responds by using these values of p and s to obtain the optimum w and r . The next proposition shows these results. All proofs are shown in the Appendix. We first find the best response function for the 4PL.

The results are given in the next proposition.

Proposition 1

The 4PL's response functions in terms of the seller's decision variables are given by:

$$(1) w = (\alpha_2 + \delta(p - v) + e(\beta_2 + \delta)) / (2(\beta_2 + \delta))$$

$$(2) r = (\psi(e + s - c) - \phi) / (2\psi)$$

It is interesting to note that the 4PL's pricing decision is based only on the new product price, while the return policy decision is dependent only on the service charge it is promised by the seller. The seller uses these response functions and substitutes these into his profit function given in equation (9) which now becomes a function of only his own decision variables namely p and s . In the next proposition we obtain the optimum policies for p and s in terms of only the market parameters. To keep the expressions simple, we use notation A , B , C , D , E , and F as defined in the Appendix.

Proposition 2

The optimal policies for the seller are given below in terms of only the market parameters.

(1) The optimal price of the new product is given by the equation:

$$\text{Equation 12 } s^* = \frac{\delta B + 2\delta\psi C + \beta_2 D - 2A\beta_2^2\gamma\psi}{\psi[8\beta_1\psi(\beta_2 + \delta) - \delta(\gamma^2 - 4\delta\psi) - \beta_2(\gamma^2 - 8\delta\psi)]}$$

(2) The optimal service fee is given by the equation:

$$\text{Equation 13 } w^* = \frac{\delta[4\psi(\alpha_1 + \alpha_2 + 2\beta_1(e + A)) - \gamma^2(e + A) - 3\phi\gamma - \psi(c\gamma - 2A\delta - e(\gamma + 1))]}{2[8\beta_1\psi(\beta_2 + \delta) - \delta(\gamma^2 - 4\delta\psi) - \beta_2(\gamma^2 - 8\delta\psi)]}$$

Proposition 2 gives the 4PL, who is the follower in this game, the exact values of the seller's decision namely p^* and s^* . Given the seller's lead, the 4PL now uses these values in the expression given in Proposition 1 and obtains its decisions in terms of the market parameters. These are given in the next proposition.

Proposition 3

The optimal policies for the 4PL are given below in terms of only the market parameters.

(1) The optimal price of the refurbished product is given by the equation:

$$\text{Equation 14 } r^* = \frac{2\delta(C + 4\beta_1\phi) + \delta^2 E + \beta_2 E + \beta_2 F - 2A\beta_2^2\gamma}{2[8\beta_1\psi(\beta_2 + \delta) - \delta(\gamma^2 - 4\delta\psi) - \beta_2(\gamma^2 - 8\delta\psi)]}$$

(2) The optimal return policy is given by the equation:

$$\text{Equation 15 } \frac{\partial \pi_2}{\partial w} = \alpha_2 - 2w(\beta_2 + \delta) + \delta(p - v) + e(\beta_2 + \delta) = 0$$

We now have closed form solutions to the optimum values of all four decision variables. Having knowledge of the market parameter values, the exact optimum policies can be obtained by evaluating these expressions. We recognize that the form of the optimal policies will be dictated by the values of the market parameters. The changes in the optimal policy when these market parameters change are studied numerically in Section 4.

For demonstration purposes, we present here two graphs to show the shape of the profit functions. The profit functions shown in equations (9) and (11) can now be expressed only in terms of the market parameters by using Propositions 2 and 3. These market parameters are assumed to be known and are outside the set of our decision variables. These are, therefore, called exogenous variables. The graphs are drawn using the following values of the exogenous parameters as shown.

The exogenous parameters in our model influence the quantum of the optimal policies. It will be of interest, then, to see how the optimal policies change with any change in these parameters. In the next section, we will present the result of sensitivity analyses, where we will obtain managerial insights into these changes.

4 Conclusion

The use of 4PL as an integrating agent over the traditional 3PL services is growing recently. In this respect, the problem faced by organizations is mainly due to the fact that most of the time a 3PL that has a core competency of pertaining the outsourced function efficiently is trying to expand to 4PL functions. This can be only effective if they are equipped with models and concepts for effective decision-making as a 4PL. We proposed a model for the 4PL as an integrator of one aspect of the supply chain, namely reverse logistics. We model the problem as a game and develop closed form solutions for the optimum strategies both for the seller and outsourcing the reserve logistics and for the 4PL.

The optimum results obtained from our model are stated in terms of the market parameters. We also derived a number of insights into how a manager can influence these parameters using marketing and operational strategy variables to obtain the desired optimum values for the decision variables and get the benefit of a ripple effect to increase their profits. We showed cases where profits for the seller and 4PL both increase when the two parties cooperate, in the true sense of a strategic partner. For example, by advertising the return policy more or by redesigning their web site so that the return policy icon can easily be found, not only the e-tailer can increase its profit but also that of the 4PL's. The managerial implications described above and also in detail in Section 4 give very distinct guidelines for managers both the e-tailer and the 4PL to make optimal decisions to improve the performances of their respective firms.

A number of future research areas can be identified from the basic model we presented here. First, uncertainty can be incorporated in both the demand functions and the return function. In the case of return function, one can use probabilistic return function as customers may decide not to return an item even if they could. Second, we can use a dynamic model where the demand for a product changes over time (following the product life cycle, for example) and we will then need to determine the values of the decision variables to determine the values of the decision variables not just as a static value as in this paper, but as a time trajectory. Finally, we can investigate the role of product modularity in reverse logistics particularly for companies that operate in built to order environment.

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