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SIMULATION AND ANALYSIS OF DEALERS' RETURNS DISTRIBUTION STRATEGY

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ABSTRACT

Due to high demand uncertainty, excess inventory has been a key issue in inventory control. Caterpillar developed the dealers' parts inventory sharing (DPIS) and returns programs to help dealers cope with excess inventory. However, historical data show that the current returns policy has been very costly to Caterpillar due to the distribution strategy. In this project, we develop alternative returns policies and propose to use simulation to analyze the cost structure of the alternative policies, develop cost sharing schemes, and compare performance with the current policy under different scenarios. It is shown that the simulation tool we developed provides industry managers with a test ground for new returns strategies and the output analysis presents guidelines to set parameters when using the new strategies to manage returns distribution.

1 INTRODUCTION

Caterpillar (CAT) is a leading manufacturer in the heavy machine industry. The Parts and Service System (P&SS) provides service parts to thousands of the manufacturer dealers and customers all over the world. The manufacturer's responsive and comprehensive parts-delivery systems is characterized by a complex multi-echelon network which consists of several large distribution centers (DCs), a number of regional distribution centers (RDCs) and numerous independent dealerships. Dealers make inventory decisions with the tradeoffs of maintaining competitive service levels and minimizing the inventory costs. It is very important for the dealers to keep their investment on the right amount of the right types of parts in stock. Excess inventory not only incurs significant inventory costs, but also occupies warehouse space. To best serve the customers and support the dealers, the manufacturer launched the DPIS program, encouraging dealers to share their excess inventory for emergency orders from other dealers.

Besides the DPIS program, returns are another way the manufacturer helps dealers handle excess inventory. With some limitations, dealers can return most of their unsold inventory back to the manufacturer. This returns policy provides great freedom for dealers in parts ordering and stocking, but also causes great costs to the manufacturer. According to historical data, dealer returns take up 3% of the manufacturer's total inventory. They also incur significant transportation cost, multiple handling costs, and other invisible costs. Moreover, since the returned parts are invisible from the information system during the long cycle time (2~3 months on average from the time a dealer decides to return the parts until the parts are on shelf again in the manufacturer's inventory), returned parts are not fully utilized. Furthermore, historical data also show that a large portion of the returned parts are bought back by other dealers in the same region within 3 to 6 months after they are returned. This implies redundant transportation and handling cost for the manufacturer.

This problem is not unique to CAT. Most automotive companies and heavy machine manufacturers provide similar dealers' inventory sharing programs and returns policies. However, there has been no systematic research on how to jointly manage these two programs to make the system work more profitably. Different companies experiment with their own approaches to manage returns to minimize costs and at the same time maintain certain service levels. Therefore, research in this area is expected to provide industries with guidelines and methods to manage their reverse supply chain.

Research on returns is normally classified as reverse logistics. Most of the literature on product returns deals with end of life (EOL) products that are brought back to the producer or third party providers for remanufacturing, recycling, or disposal (Klausner and Hendrickson 2000, Rosenfield 1992). Some other research on returns involves reusable containers and packages (Kelle and Silver 1989). There has been very limited research addressing unsold inventory returns although they have brought increasing attention in industry. Rogers and Tibben-Lembke (1999) describe different causes of unsold inventory returns in publishing, computer/electronic, automotive, and retailing industries. They analyze the reasons for the increasing returns and illustrate industry practices on handling the returns. Dawe (1995) also provides several industrial examples of poor returns management and proposes reengineering as part of the solution. Most of the literature available on unsold inventory returns points out the existing problems, but does not provide systematic distribution planning and strategies for solving these problems.

In this project, we propose to use simulation in developing alternative returns policies acceptable to both the manufacturer and the dealers to reduce the manufacturer's returns costs. We consider the two methods for dealing with dealers' excess inventory jointly — DPIS and returns. More specifically, we propose alternative returns policies in which some of the ready-to-return parts can be integrated into DPIS, which in turn encourages more sharing among dealers. A series of research questions that are of interest include:

1. What are some alternative returns policies? To what types of parts should the alternative returns policies be applied?
2. Analyze the costs of the alternative returns policies and develop cost-sharing schemes between the manufacturer and the dealers. In particular, what are the cost components in the alternative returns policies and who should pay for what costs? If the manufacturer and dealers need to share these costs, how should they be shared?
3. How can we develop a model that allows us to optimize parameters in the alternative policies?
4. How can we compare the performance of the alternative returns policies with the current returns policy?

Dealers' returns are complicated due to the following features of the problem:

1. Dealers' returns are handled through a comprehensive multi-echelon network which involves numerous independent dealerships, third-party logistics firms providing refurbishing and refurnishing services, and part of the manufacturer's parts-delivery system.
2. Dealers' returns cost functions are complex since they depend on many different costs and random demand.
3. The effectiveness of the returns distribution strategy not only influences the manufacturer's returns costs, but also has a great impact on the dealers, whose inventory decisions in turn affect the end customers.

Therefore, caution needs to be taken in implementing any change in the returns policy to assure efficiency of the whole parts-delivery network. Simulation is an ideal mechanism to analyze alternative returns policies due to its capability in modeling complex systems with voluminous input parameters and high randomness.

2 APPROACH

Figure 1 shows the framework in approaching the returns distribution problem using simulation. We start with an analysis of current returns policy to identify the different cost components and the cost sharing scheme between the manufacturer and dealers. This information is used to develop alternative policies with preliminary cost sharing schemes, which are then modeled using simulation. Simulation results are used to refine the parameters of the alternative policies. This process iteratively continues and finally performance comparison of the current and alternative policies is conducted. In this specific project, two alternative policies are developed and tested using simulation.

3 DEVELOPMENT OF ALTERNATIVE RETURNS POLICIES

Under the current returns policy, returned parts are first transported from the dealers to the contract processors (CPs) where parts are inspected, repackaged and refurbished as required. They are then transported from the CPs to the manufacturer's distribution facility where they are put back on shelf.

3.1 Alternative Returns Policy

Given the current returns policy, DPIS, and the analysis of the distribution network, the alternative policy we propose is as follows:

When a returns request is made from a dealer to the manufacturer, instead of immediately transporting the parts back to the manufacturer to put them on a shelf after a two-to-three-month invisible time in the contract processor (CP) for repackaging and refurbishing, the manufacturer buys the parts back from the dealers but still keeps the parts at either the dealer's warehouse or a 3PL (Third-party Logistics) warehouse. We call this location M_Hold. If M_Hold is chosen to be the 3PL warehouse, the manufacturer shares with the dealer the costs of using the 3PL services. In either case, these returned parts are made available on DPIS for sharing for a period of t. t is defined as the longest time the returned parts will be held in M_Hold. Any returned parts remaining after t are transported back to the manufacturer.

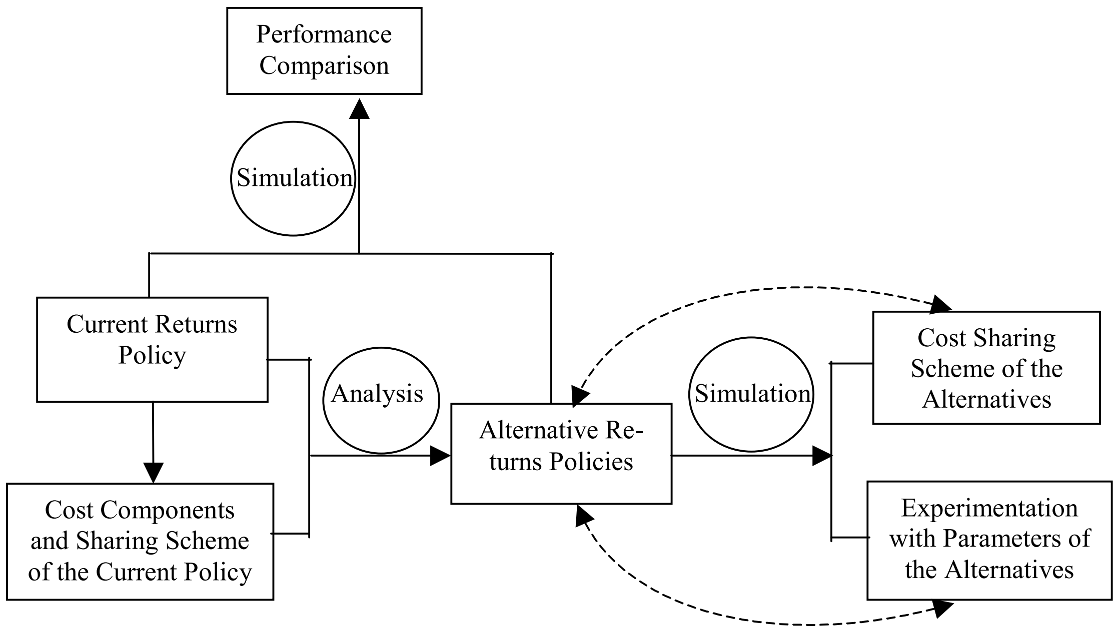

Figure 1: Framework of Returns Project

The policies we study using simulation in this project are defined as follows:

1. *Current Returns Policy*: Returned parts are transported back to the manufacturer immediately after the returns request is approved.
2. *Complete-share Alternative Policy (CSAP)*: Returned parts are kept in M_Hold for a period of t for sharing. During this period, they can be used for emergency orders from dealers all over the parts-delivery network as well as replenishment orders (called stock orders) from dealers in the same region.
3. *Limited-share Alternative Policy (LSAP)*: Returned parts are kept in M_Hold for a period of t. During this period, they are used to share with other dealers for emergency orders only.

3.2 Cost Sharing Scheme

There are many costs involved in the returns process and they will be discussed in detail in Section 4. In this section, we discuss costs that can be shared by the manufacturer and dealers and develop the cost sharing scheme.

1. *Returned parts buy-back cost and regular order penalty cost.* The manufacturer pays full credit to returned parts in good condition. However, in order to prevent the dealers from abusing the policy, the manufacturer charges a service fee (α% of the parts' values) whenever the dealers ask to use the parts for non-emergency situations (regular orders) within a certain period of time (t') after they have returned the parts.
2. *Holding costs and handling costs of returned parts*. Generally, parts holding costs include the opportunity cost of the investment on these parts (which is the greatest part of the holding cost), warehouse space cost, insurance and taxes, breakage and spoilage, obsolescence costs, etc. In the alternative policy, the manufacturer pays all the holding costs except the warehouse space cost. The dealer shares the cost by providing the warehouse space and paying the handling costs for the returned parts if M_Hold is his own warehouse. In the case where a 3PL warehouse is used, the manufacturer and the dealer share the service charge of the warehouse space and handling costs.
3. *Stock order (filled by the returned parts) transportation costs*. Regular stock order transportation cost is shared by the manufacturer and the dealer. In the case when stock orders are filled by the returned parts in M_Hold, transportation cost from M_Hold to the requesting dealer is paid by the manufacturer as an incentive for the dealers to use the returned parts for replenishment.

4 SIMULATION MODEL AND EXPERIMENTS

4.1 Simplified Model

Due to the complexity of the problems we want to address, we start the investigation of the alternative policies with a simplified model. Figure 2 shows the simplified model of the returns distribution problem under CSAP. D1 represents the dealer who returns the parts. D2 represents all dealers in the same region as D1. D3 represents all dealers outside the region of D1 and D2. Figures of similar models under the current returns policy and LSAP are omitted.

Although the simplified model is more tractable, simulation was used to investigate alternative returns policies for the following reasons.

1. At the investigation stage, simulation is more flexible than the analytical models in exploring and comparing different policies.
2. Simulation models are more scalable than the analytical models. More dealers and distribution facilities can be easily added into the simplified model for further investigation.
3. Although simplified, the model still involves many variables and costs which are hard to analytically computed due to a multiple sources of uncertainties in the system.
4. Simulation models can also be easily used to study the system behavior during the transition stage from the current policy to the alternative policies, while analytical models are more suitable for analysis of the long-term behavior of the alternative policies.

Although simplified, the model still captures the main points of the returns problem and therefore, the results provide good insights into the performance of the alternative policies.

In all experiments, M_Hold is assumed to be D1's warehouse, although insights obtained from the simulation results are discussed in Section 5.3 about using 3PL warehouses instead of D1's warehouse.

4.2 Performance Measures

The performance measures we select to evaluate the returns policies include the following:

1. *Manufacturer's costs and dealers' cost*
   The manufacturer's costs under different policies are the key issue in evaluating the policies. The manufacturer's cost components that may change due to adoption of different returns policies include:

   a. Holding cost for the returned parts
      This is the holding cost for all the returned parts before they are sold eventually. Therefore, if there are parts still remaining at the end of t, holding cost of carrying them until they are sold is also included. The holding cost is defined in this way so as to be able to compare with the current policy.
   b. Transportation costs for sending parts from M_Hold to fill stock orders for other dealers
   c. Stock orders handling cost
   d. Stock orders transportation cost from the manufacturer to the dealers
   e. Returned parts transportation cost
   f. Returned parts handling cost
   g. – (Penalty cost for stocking out for emergency orders)
   h. – (Regular order penalty cost).

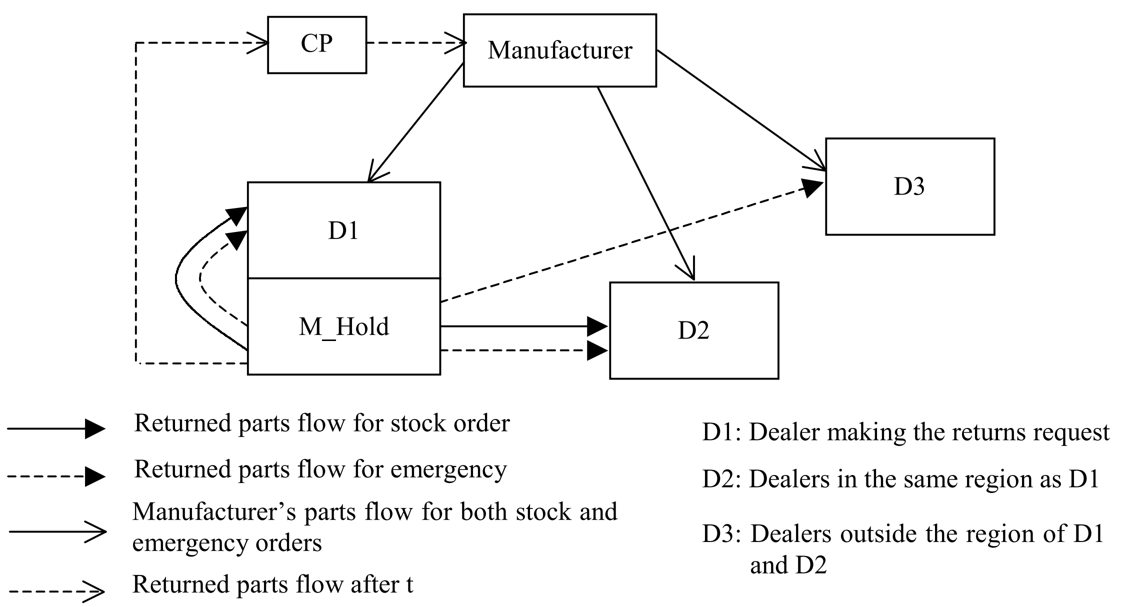

Figure 2: Simplified Model of the Returns Distribution

Items g and h are costs paid by dealers and thus are revenues to the manufacturer. Therefore, negative signs are used.

2. *Dealers' costs*
   Dealers' costs are important in the acceptance and viability of the returns policies. Dealers' cost components that may change under different returns policies include:

   a. Regular order penalty cost
   b. Penalty cost for stocking out for emergency orders
   c. Emergency order transportation cost
   d. Lost sales penalty cost
   e. Stock order handling cost
   f. Handling cost for the returned parts in M_Hold
   g. Warehouse space cost for the returned parts in M_Hold
   h. Returned parts preparation and transportation cost
   i. – (Revenue from part sales).

4.3 Experimental Design

To investigate to what types of parts the alternative policy should be applied, we divide all the parts into three groups: fast, medium, and slow moving. For each type of parts, the demand rate, price, service level, and fixed and unit costs to handle the parts are different and are required as inputs (see simulation input data).

To determine how long the returned parts should stay in M_Hold before they are sent back to the manufacturer (*i.e.* to determine t), for each type of part, we set t at different values (t=1, 3, 5…). For each value of t, we run the simulation model for 60 months, and collect all the data at the end of simulation. Graphs are then drawn to show the relationship between the performance measures (the manufacturer's cost, D1's profit, etc.) and t. Three replications are conducted for each experiment using different random generation seeds. Experiments under the current policy, CSAP, and LSAP are conducted.

4.4 Simulation Input Data

Input data and parameters include the following:

1. Demand rates of parts for different dealers
2. Proportion of emergency orders vs. regular orders
3. Parts' costs and selling prices
4. Dealers' parts inventory control parameters (service levels, reorder points and order quantities)
5. Fixed and unit returns preparation and transportation cost for dealers
6. Fixed and unit returns transportation and handling cost for the manufacturer
7. Fixed and unit transportation cost for stock orders
8. Fixed and unit transportation cost for returned parts to fill stock order
9. The manufacturer's fixed and unit stock order handling cost
10. Parts' lost sale penalty cost
11. Unit holding cost
12. Regular order penalty cost (α% of the part's value) for using returned parts within a certain period of time (t') after the dealer returns the part
13. t'
14. Emergency order penalty cost (β% of the part's value) for dealer's stocking out for an emergency order
15. Number of parts a dealer returns (N).

5 RESULTS

In this section, simulation results are reported to show the analysis. For confidentiality requirement, input data for these results are not from the real data.

5.1 Complete-Share Alternative Policy

Figure 3a and 3b show the relationship between the manufacturer's cost under the current policy and CSAP and the time to keep the returns at D1 (t) for fast and slow moving parts, respectively. It is demonstrated in both graphs that until the returns are depleted, the longer the returns stay in M_Hold, the lower the manufacturer's cost. It is interesting to find that for slow moving parts, the manufacturer's total cost is always lower under CSAP than the current policy. This is also true for fast moving parts as long as the returns kept at D1 are not sent back to the manufacturer too soon. A closer look at the relationship between the manufacturer's holding cost and t provides better understanding.

Figures 4a and 4b show the holding cost the manufacturer pays for all the returned parts before they are sold under different policies. Contrary to our intuition, the graphs indicate that under CSAP, until the returns are depleted, the longer we choose to store the returns in M_Hold before sending them back, the lower the total holding cost for these parts is. For the fast moving parts, the holding cost starts to be higher than the current policy when t is very small. As t increases, the cost continues dropping. When t is large enough, the holding cost under CSAP may be lower the holding cost under current returns policy. For the slow moving parts, however, the holding cost is always lower under CSAP than under the current policy. The difference in the holding cost for fast and slow moving parts under CSAP results from the two elements with the opposite effects on the holding cost. One is the fact that all the returned parts sent back to the manufacturer incur on average 3 months' holding cost when they are invisible for refurbishing before they are put back on a shelf again. Since they cannot be used during this period, the holding cost is considered a "pure loss". As t increases, the number of parts to be sent back to the manufacturer decreases resulting in smaller amount of the "pure loss". However, the longer t is, the greater the opportunity loss the returned parts incur for being stored in M_Hold to fill fewer orders rather than being stored at the manufacturer's distribution center to fill orders from all over the network. Since these two effects depend mainly on the demand rate of the returned parts, the tradeoff of these two effects determines the nature of the holding cost for the returned parts.

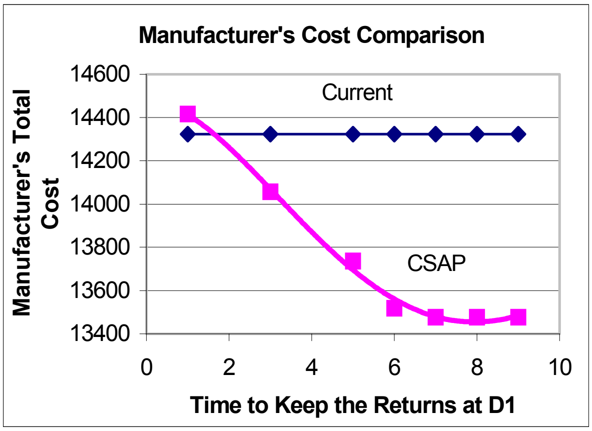

Figure 3a: Manufacturer's Cost Comparison for Fast moving Parts under Current Policy and CSAP

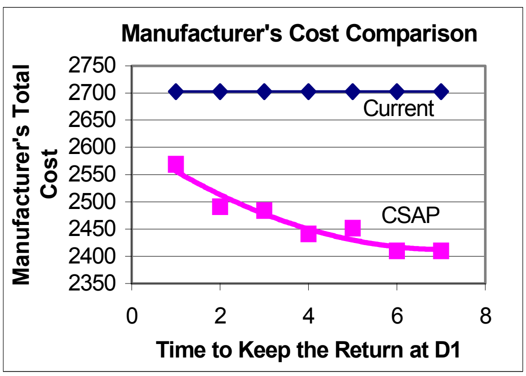

Figure 3b: Manufacturer's Cost Comparison for Slow Moving Parts under Current Policy and CSAP

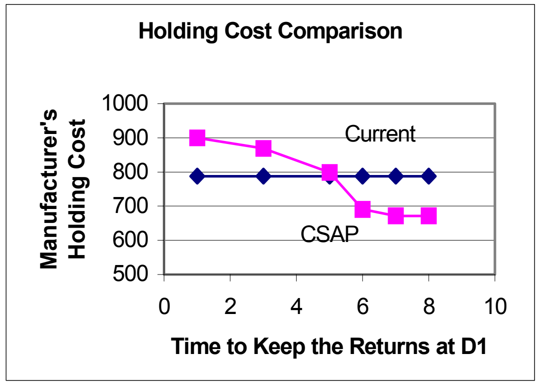

Figure 4a: Manufacturer's Holding Cost Comparison for Fast Moving Parts under Current Policy and CSAP

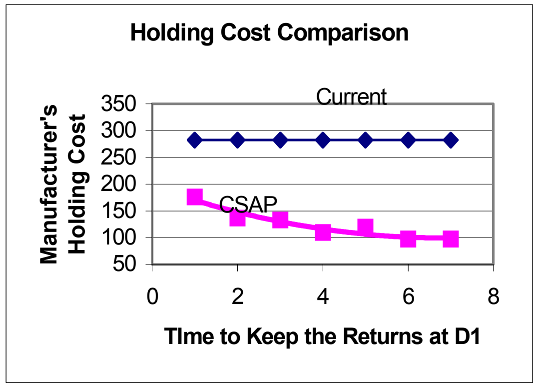

Figure 4b: Manufacturer's Holding Cost Comparison for Slow Moving Parts under Current Policy and CSAP

Figures 5a and 5b show the relationship between D1's profit and the time to keep the returns in M_Hold (t) under the current and CSAP for fast and slow moving parts, respectively. Figure 5a demonstrates that, D1's profit under CSAP is always less than with current policy, no matter how long the returned parts are kept at D1. Analysis of the cost components indicates that this is because the decrease in the preparation and transportation cost for the remaining parts sent back to the manufacturer at the end of t can not compensate for the quickly increasing handling cost and penalty cost (for using parts in M_Hold within t' after they return the parts) due to the relatively high demand rate for fast moving parts. For the slow moving parts, however, since the demand rate is much lower, the decrease in the preparation and transportation cost can always balance the handling cost and penalty cost. Therefore, D1's profit under CSAP is never below the profit under current policy and is gradually increasing as t increases until the returned parts are depleted.

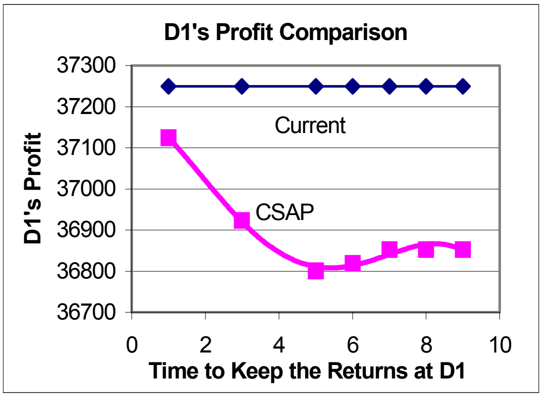

Figure 5a: D1's Profit Comparison for Fast Moving Parts under Current Policy and CSAP

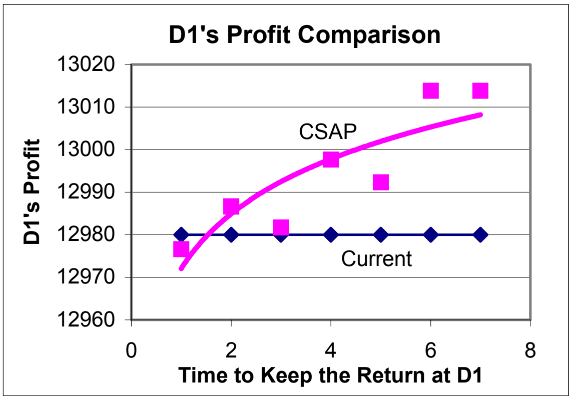

Figure 5b: D1's Profit Comparison for Slow Moving Parts under Current Policy and CSAP

5.2 Limited-Share Alternative Policy

With CSAP, we consider using the returned parts in M_Hold to fill emergency orders as well as the stock orders from the dealers in the same region (D2). With LSAP we investigate the case where the returned parts in M_Hold are used as a sharing resource to other dealers only for emergency orders. Obviously, M_Hold can still be used to fill emergency, regular, and stock orders if needed by D1.

Figures 6a and 6b compare the manufacturer's cost and D1's profit respectively under the three different returns policies (current, CSAP, and LSAP). As expected, it takes much longer to deplete the returned parts in M_Hold. Except for the case when t is very small, CSAP always outdoes LSAP in terms of the manufacturer's cost and D1's profit. This is simply due to much more holding cost incurred and the lower demand under LSAP. When t is very small, however, stock orders dominate the total request for parts in M_Hold. Accordingly, the manufacturer pays significant transportation costs to fill other dealers' stock orders and D1 pays significant handling cost for these stock orders. This leads to the manufacturer's higher cost and D1's lower profit under CSAP compared with current policy and LSAP. It is noticed that although LSAP does not perform as well as LSAP, it still is better than the current policy as long as the returns stay at D1 long enough.

Similar arguments can be made for slow and medium moving parts (graphs omitted). CSAP almost always outperforms LSAP from both the manufacturer's and D1's perspectives, but LSAP may outperform the current policy if returned parts stay at D1 long enough. For slow moving parts, the current policy provides higher profit for D1 than LSAP in all situations, but LSAP leads to lower cost for the manufacturer.

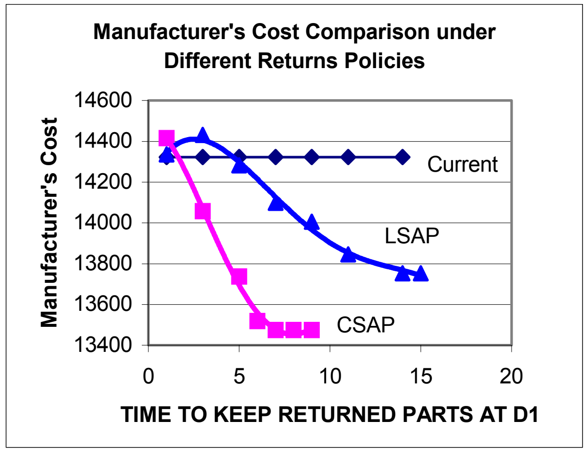

Figure 6a: Comparison of Manufacturer's Cost for Fast Moving Parts Under Current Policy, CSAP, and LSAP

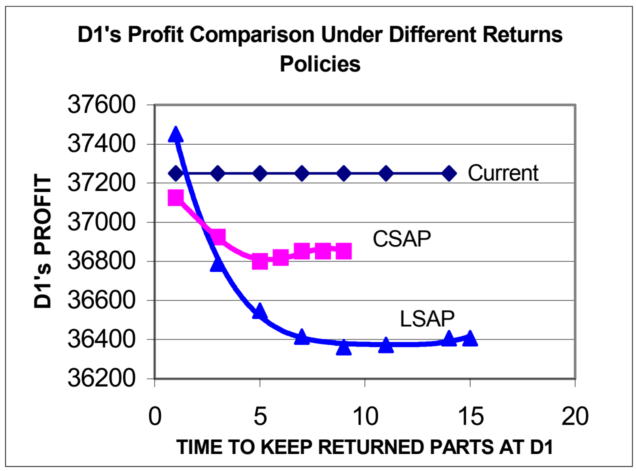

Figure 6b: Comparison of D1's Profit for Fast Moving Parts Under Current Policy, CSAP, and LSAP

5.3 3PL Warehouse Scenario

In all of the above discussions, returned parts from D1 are kept at D1's warehouse. This occupies D1's space and requires D1 to handle these parts. However, as the number of different parts put in M_Hold increases, the space required for M_Hold rapidly increases and D1's space limit might become a problem. An easy alternative is to use third-party warehouse close to D1 to store returned parts in M_Hold and let the manufacturer and D1 share the cost the service charge from the 3PL warehouse. This not only solves the space problem, but also frees D1 from handling the returned parts. A potential drawback is the double handling when transporting the parts from D1 to the 3PL warehouse. Further analysis is needed to investigate this.

Suppose the 3PL warehouse is close enough to D1 so that we can ignore the transportation cost, it is not difficult to find that this scenario is almost the same as the Base Scenario if we view D1's handling and warehouse cost for the returned parts in M_Hold as a service charge from 3PL and shift the cost from D1 to being shared by the manufacturer and D1. Similar simulation experiments can be conducted for detailed results. There are two insights, however, that can be immediately obtained from the results discussed in previous section.

1. In most cases under CSAP, the manufacturer's total cost decreases in using the alternative policy whereas D1's profit shrinks because the costs of handling and providing space to the returned parts cannot be offset by the gaining benefits of the returned parts. However, if the manufacturer shares some of the handling and warehouse costs (since the manufacturer already gains from CSAP), there may be one point at which both the manufacturer and D1 can be better off than the current policy. This is exactly what it means to use 3PL warehouse and share the service charge between the manufacturer and D1.
2. As shown in the results in previous section, parts must stay in M_Hold long enough for the benefits to outweigh the cost. To achieve this for returned parts with high uncertainty, 3PL warehouse is more flexible than building or buying warehouses.

6 CONCLUSION

In this project, we develop simulation tools to investigate Caterpillar's current returns policy and propose alternative policies to handle returns in the distribution network. Alternative policies are evaluated and compared using simulation model. It is shown that simulation provides an efficient way to deal with the complicated problems encountered in analyzing different returns policies. Simulation experiments and results provide good insights for developing alternative returns distribution strategies. Guidelines for managers to use alternative policies in real practice are also obtained.

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