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Improving Store-level Replenishment Policies: A Study of a Medium-Size Toy Retailer

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Improving Store-level Replenishment Policies: A study of a medium-size toy retailer

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Summary:

This thesis examines the impact of adopting a more sophisticated time-series forecasting method and replenishment model on the store-level replenishment performance of a medium-size toy retailer. A comparison of the proposed replenishment policy to the toy company's current replenishment policy is made through a simulation exercise.



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KEY INSIGHTS

1. Demand forecasting is a critical component of a replenishment policy when demand is probabilistic.
2. Evaluating the performance of a replenishment policy requires understanding the performance of the policy under a range of conditions.
3. Selecting optimal replenishment parameters centrally can lead to lower total relevant costs than allowing parameters to be set at the store level.

Introduction

Replenishment policies exist to provide answers to the following questions.

1. When should the inventory level be reviewed?
2. When should additional units of a product be ordered?
3. How many units should be ordered?

High-performing replenishment policies answer these questions such that total relevant inventory cost is minimized. The total relevant inventory cost includes the cost of holding inventory in the store, the fixed cost of placing a replenishment order, and the penalty cost of losing sales due to stock outs (Silver, Pyke, & Peterson, 1998).

This thesis seeks to improve the replenishment policy of a medium-size retail toy company, herein referred to as "the Toy Company". The authors evaluate the Toy Company's current replenishment policy, identify best-practice methods for forecasting and setting replenishment parameters, propose an alternative method for forecasting and setting replenishment parameters, and compare the performance of the Toy Company's current replenishment policy to the proposed policy.

Toy Company Background

The Toy Company opened its first retail toy store in Western Europe in the early 1990's. Over the next twenty years, the Toy Company's retail footprint grew to include more than 300 stores located across South America, Central America, Asia, Europe, and

the Middle East. The Toy Company is currently considered a medium-size retailer in the global toy and game industry.

The Toy Company operates a periodic review replenishment policy with a target fill rate of 99%. Stores receive replenishment shipments with a set frequency. The store manager in each store is responsible for setting the replenishment parameters for each product. Thus, the assortment of products and the quantities of those products included in the replenishment shipment are determined by the parameters set by the store manager.

Forecasting Methods

The investigation of the Toy Company's current replenishment policy reveals that store managers' demand forecasts are inherent in the selection of the replenishment parameters for each product. To formulate their demand forecast, store managers have access to only the sales totals from the previous two weeks for each product. Additionally, there appear to be behavioral factors that contribute to each store manager's demand forecast. The result is variation in forecasting performance among the Toy Company's stores.

A study of a typical store exposes that the store managers tend to modify the replenishment parameters in reaction to changes in the average two-week sales of a product. The broader demand pattern for the product is not explicitly considered. This behavior can lead to the misinterpretation of random fluctuations in demand as changes in the demand trend. As a result, store managers set suboptimal replenishment parameters that result in stores receiving too much or too little inventory.

To identify an improved forecasting method for the Toy Company, the authors evaluate several different time-series forecasting methods described in Chopra & Meindl (2008). Each forecasting method is used to predict daily sales for a sample of products during the Spring/Summer sales season. The mean absolute deviation (MAD) of errors is used to compare the performance of the forecasting methods.

The results show that the four-week weighted moving average outperforms the other forecasting methods for the majority of products. The complete performance break-down of the various forecasting methods is shown in Figure 1.

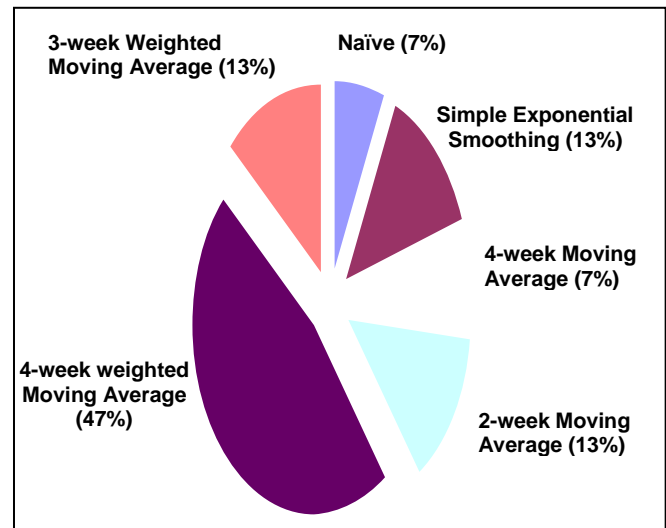


Figure 1- Summary of Forecasting Method Performance

Replenishment Models

With an improved forecasting method identified, the authors examine several replenishment models as described in Silver, Pyke, & Peterson (1998). The Toy Company has several constraints that must be considered in the choice of a replenishment model. A feasible model must support periodic inventory review, a fixed replenishment schedule, and order quantities that are multiples of the product lot size (required to maintain efficiencies in the distribution center).

A literature review indicates that (R, s, S) replenishment model is the best performing periodic review model. In this model, additional units of a product are ordered if the inventory level falls to the reorder point s . When an order is placed, enough units are ordered to raise the inventory level to the order-up-to level S .

The (R, s, S) model, however, does not satisfy the lot size constraint faced by the Toy Company. To circumvent the lot size problem, the authors propose a modification to the (R, s, S) model. By transforming the order-up-to level to a multiple of the product lot size the constraint is satisfied. The resulting model can be described as a (R, s, nL_s) replenishment model, where L_s is the product lot size and n is an integer factor. The reorder point and order quantity in the (R, s, nL_s) model are computed based on mathematical computations for the (R, s, S) model presented in Silver, Pyke, & Peterson (1998).

Comparing Replenishment Policy Performance

The 4-week weighted moving average forecasting method and the (R, s, nL_s) replenishment model

comprise the authors' proposed replenishment policy. In order to compare the performance of the proposed replenishment policy to the Toy Company's current policy the authors devise a simulation designed to calculate and compare the average total relevant costs of both policies during the Spring/Summer selling season at a typical store. The simulation, developed in Microsoft Excel, replicates the daily inventory transactions that occur in the store and calculates the costs associated with those transactions. Four products are evaluated in the simulation. Table 1 contains the simulation results obtained for one product over 21 weeks.

(Average cost)	Current Policy	Proposed Policy
Holding Cost	€ 1,16	€ 2,55
Ordering Cost	€ 5,98	€ 1,76
Penalty Cost	€ 7,77	€ 6,48
Total Cost	€ 14,92	€ 10,78

Table 1- Simulation Results for Product 4

The simulation results show that the proposed policy results in a lower total relevant cost than the current policy for two of the four products evaluated. However, to gain additional insight regarding the performance of the two replenishment policies under varying conditions, additional scenarios are defined and simulated.

One of the primary differences between the proposed policy and the current policy is that the proposed policy incorporates information about demand distribution. Thus, the proposed policy is expected to perform well as demand variation increases. Simulation using demand patterns that contain increasing variation shows that the proposed policy consistently outperforms the current policy when the demand variation grows larger. Sensitivity analysis indicates that when the coefficient of variation of demand reaches 1.5 the proposed policy outperforms the current policy. Figure 2 contains the results of this sensitivity analysis for one product.

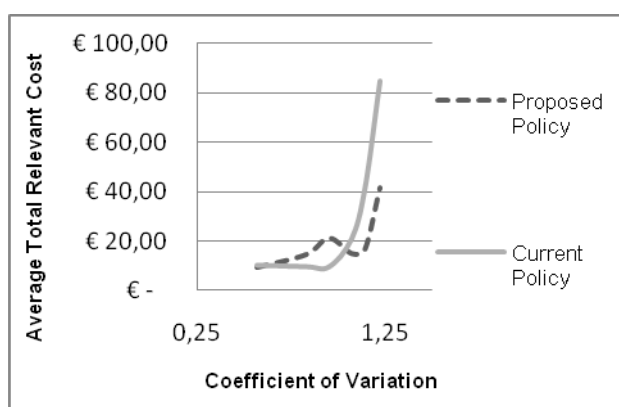


Figure 2 – Sensitivity of Product 1 Cost to Demand Variation

Since the current policy relies on store managers to set the replenishment parameters, a sensitivity analysis was performed to explore the impact on cost of the store managers selecting suboptimal parameters. The results show a significant cost increase as the parameters deviate from the optimal value, especially when demand is underestimated.

Additionally, a sensitivity analysis is conducted to determine if 99% is the appropriate fill rate all products. The results show that a 99% fill rate is not high enough to achieve the lowest cost possible from the proposed policy. The Toy Company would benefit from calculating the optimal fill rate for each product.

Conclusions

This thesis indicates four areas that the Toy Company can improve the performance store-level replenishment.

- **Forecasting** - Store-level demand forecasts can be improved by implementing the 4-week weighted moving average forecasting method.
- **Replenishment Policy** - Implementing a four-week moving average forecasting method along with the proposed (R, s, n⁺Ls) replenishment model can outperform the current policy, especially for products with large demand variation.
- **Current Policy Parameters** - Selecting the parameters that minimize total relevant cost for each product-store outperforms a system in which store managers are allowed to select suboptimal parameters.
- **Fill Rate Policy** - Using the fill rate that minimizes total relevant cost for each product-store in the proposed policy outperforms the assumption of a 99% fill rate for each product

Finally, the financial impact of implementing the four-week moving average and (R, s, nLs) replenishment model on candidate products is estimated. The Toy Company could expect a cost saving representing approximately 6.67% of the net profit.

Cited Sources

Chopra, & Meindl. (2008). *Supply Chain Management*. Prentice- Hall, Inc.

Silver, Pyke, & Peterson. (1998). *Inventory Management and Production Planning and Scheduling*. John Wiley & Sons.