A Bayesian Combination Forecasting Model for Retail Supply Chain Coordination

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ABSTRACT

Retailing plays an important part in modern economic development, and supply chain coordination is the research focus in retail operations management. This paper reviews the collaborative forecasting process within the framework of the collaborative planning, forecasting and replenishment of retail supply chain. A Bayesian combination forecasting model is proposed to integrate multiple forecasting resources and coordinate forecasting processes among partners in the retail supply chain. Based on simulation results for retail sales, the effectiveness of this combination forecasting model is demonstrated for coordinating the collaborative forecasting processes, resulting in an improvement of demand forecasting accuracy in the retail supply chain.

Keywords: Keywords: Bayesian Combination Forecasting Model, Retail Supply Chain Coordination, Collaborative Forecasting, Forecasting Accuracy.

1. Introduction

The supply chain coordination among partners throughout the entire supply chain has abstracted more and more attention from both the industries and the academics [1]. Various supply chain coordination solutions have been developed to streamline the supply chain management and improve the supply chain operations performance [2-4]. Collaborative planning, forecasting and replenishment (CPFR), which is an retail supply chain coordination innovation, has been adopted and implemented by many world-renowned retailers and manufacturers, such as Wal-Mart and Proctor & Gamble. CPFR concerns the collaboration where two or more parties in the supply chain jointly plan a number of promotional activities and work out synchronized forecasts, on the basis of which the production and replenishment processes are determined. The first CPFR project was piloted by Wal-Mart with its suppliers in 1995. The results of the two-year project showed that CPFR could simultaneously reduce inventory levels and increase sales for both retailers and suppliers. Since its original application was initiated, CPFR has had many successful applications in North America, Europe and China [5,6].

The collaborative forecasting plays an important part in the CPFR implementation procedure. In this paper, we will briefly review the CPFR concept and its implementation process at first. The collaborative forecasting process which is the core part of CPFR will then be mainly discussed. The collaborative forecasting process is the basics phase of the implementation of CPFR and the cornerstone to the success of CPFR projects. The collaborative forecasting process of CPFR requires a solid forecasting approach to synthesize information and knowledge from multiply parties in the supply chain. The combination forecasting method can combine forecasting models from different parties to smooth the coordination in the supply chain and reduce forecasting discrepancies. Thus, considering the multiple forms of forecasting resources in the retail supply chain, the Bayesian combination forecasting method is applied for CPFR collaborative forecasting modeling with improved forecasting accuracy and supply chain collaboration performance in this paper.

Combining forecasts is a well-established procedure for improving forecasting accuracy

which takes advantage of the availability of both multiple information and computing resources for data intensive forecasting [7]. Since Bates-Granger first proposed the combination forecasting method in 1969 [8], many kinds of combination methods have been developed [9]. Bayesian combination methods [10, 11] use the distributional properties of the individual forecasts to construct the combination. Many researches related to Bayesian combination methods have been developed in many schemes. Walz and Walz [12] compared the Bayesian methodology and multiple regression composite forecasts with macroeconomic data. And their study found that the Bayesian combination procedure produces more accurate composite forecasts than does the regression combination procedure. Hoogerheide et al [13] compared several Bayesian combination schemes in terms of forecast accuracy and economic gains. Faria and Mubwandarikwa [14] studied a nonlinear geometric combination of Bayesian forecasting models. The Bayesian combination forecasting can combine the quantitative and qualitative data and forecasting methods [15]. Demand forecasting in retail supply chain is impacted by many factors such as product promotion or social development trend. Also, subjective forecasting based on the expert experiments is often used in retail market forecasting. The Bayesian combination forecasting model is therefore considered to be a suitable collaborative forecasting approach in retail supply chain coordination.

In the first part of this paper, the CPFR retail supply chain coordination and collaborative forecasting process are discussed briefly. In the second part of the paper, a Bayesian combination forecasting method is modeled to coordinate forecasting process in retail supply chain. Finally, the simulation of this model is completed using Carrefour sales data. The simulation results showed the effectiveness of this Bayesian combination forecasting model in retail supply chain collaboration process

2. CPFR Collaboration and Forecasting

CPFR, which was proposed by VICS (Voluntary Inter-industry Commerce Standards Association) in 1995, provides retailers and suppliers with a framework for sharing key supply chain information and coordination plans. Under CPFR, supply chain partners form a consensus forecast, either by working collaboratively or by first developing their own individual forecasts, which are then used to create a consensus forecast. The key to collaboration utilizing CPFR is the jointed demand forecast between retailers and manufacturers, which is then used to synchronize replenishment and production plans throughout the entire supply chain. This coordination and information sharing allows retailers and suppliers to optimize their supply chain activities. Dirk Seifert, a professor at Harvard Business School and the University of Massachusetts, defined CPFR as "an initiative among all participants in the supply chain, intended to improve the relationships among them through jointly managed planning processes and shared information."[16].

The collaborative forecasting process, which is one of main CPFR phases that includes collaborated plan, forecasting and replenishment phases, guarantees a precise demand by implementing a jointed forecasting process inside the retail corporation and among its supply chain partners. The forecasting accuracy, an index used to evaluate the performance of CPFR collaborative forecasting process, is determined by the forecasting discrepancies between the forecasting results and actual demand values. The forecasting discrepancies may be caused by inaccuracy of the input data or differences among forecasting models used by different partners. Inaccuracy of input data may be resulted from inaccurate and un-timely sale data and the un-timely communication for changes caused by demands, such as alteration of advertisement plan or products promotion plan. A CPFR collaborative forecasting process among partners can help to improve the accuracy of data for forecasting. In this paper, we will focus on the discussion of the ways to reduce discrepancies caused by forecasting models differences. The Bayesian combination forecasting model is proposed to reduce this kind of discrepancy and improve the demand forecasting accuracy and collaboration in the CPFR implementation process.

In the CPFR collaborative forecasting process, partners in the supply chain will use different forecasting models and forecasting cycles because of their different forecasting knowledge backgrounds and resources. For example, in order