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Modified top down approach for hierarchical forecasting in a beverage supply chain

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Abstract

In this paper, we propose a new approach for hierarchical forecasting, which represents the modification of the commonly used "top down" approach. The proposed method is based on projecting the ratio of bottom and top level series into the future, rather than using average historical proportions and proportions of the historical averages, as in standard top down approaches. Forecasted projections are then used for determining how the "base" forecasts of the top series will be distributed to the revised forecasts for every series at the bottom level of the hierarchy. Revised forecasts for all series in the hierarchy are obtained in the same manner as in standard top down methodology. In order to estimate the accuracy of the proposed model, the simulation study is performed. Results demonstrate that the "modified" top down model significantly outperforms standard top down approaches. Beside comparison with the top down approach, the model is compared with the bottom up method, and two newly proposed approaches: top down forecasted proportions and optimal combination approach. Overall, the bottom up method shows the lowest forecasting error. Results also reveal that the modified top down model demonstrates good performance, since its forecasts are close to the forecasts of the top performing model. In the end, we demonstrate our method and others in forecasting the beverage distribution network.

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Keywords: hierarchical forecasting; modified top down approach; time series; beverage supply chain.

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1. Introduction

Forecasting is a critical business process for nearly every organization and often it is the very first step organizations must undertake when determining long-term capacity needs, annual business plans, and shorter-term operations and supply chain (Bozarth & Handfield, 2008). The application of forecasting methods in a supply chain (SC) started in the 1960s and it was related to the inventory management. In that time, researchers treated the two subjects as inter-related, driven by the practical requirements of designing and implementing inventory systems (Boylan & Syntetos, 2008). Today, these areas are separated in two disciplines, and developed without significant interaction. Boylan and Syntetos (2008) argue that more effort is needed to close the gap between inventory management and demand forecasting, and they state that "the interactions between forecasting and inventory models have been rather neglected". Forecasting is also important for production planning. Production managers need future demand forecast to plan and schedule a production and determine other related activities, like requirements planning and purchasing. Fildes and Beard (1992) dealt with the application of forecasting in production and inventory, and proposed the "ideal" design of a forecasting system for production and inventory-control. Beside production and inventory management, forecasting also impacts the physical distribution. Physical distribution is one of the key business processes in SC, which provides the delivery of the finished products to the market, and consequently obtaining the surplus of the observed SC. To do so, logistics must be consistent with the products it supports as customers tend not to place any difference between a product and the distribution system that supplies it (Hesse & Rodrigue, 2004). On the other hand, physical distribution is a significant generator of logistics costs, and managers are on the constant pressure to obtain as much full truck loads as possible in transportation. In order to achieve full truck loads, they need reliable information about the size of future good flows, type of goods, delivery directions, quantities, timing of demand, and other related information which significantly influence the decisions regarding the transportation scheduling and delivery. Therefore, while dealing with the organization and synchronization of SC processes, managers have special interest in acquiring information about future demand, disaggregated according to the information they need in order to plan the business processes in SCs (different demand attributes). This is the point where hierarchical forecasting (HF) is needed. Hierarchical time series represent multiple time series that are hierarchically organized and can be aggregated at several different levels in groups based on products, geography or some other features (R. J. Hyndman, Ahmed, Athanasopoulos, & Shang, 2011).

In literature, two general approaches are suggested for developing HF. First approach is labeled as a "top down" strategy, since a single forecast model is developed to forecast an aggregate - or family total which is then distributed to the individual items in the family based upon their historical proportion of the family total. The second is named as a "bottom up" strategy, since multiple forecast models based upon the individual item series are used to develop item forecasts (Fliedner, 1999). Recently, two new approaches are proposed: top down forecasted proportions and optimal combination approach. In this paper, we propose a new approach for HF, by modifying the top down methodology. Modification consists in proposing a new way for determining how the top level forecasts will be distributed to the bottom level series. Accordingly, we are modifying the top down procedure and producing the forecasting proportion ratios, which serve as disaggregating functions, in partitioning the top level forecast. Our motivation for developing a new approach based on the top down methodology is low performance of standard top down models in recent studies. Therefore, we have tried to develop the top down model which will be more accurate and thereby more competitive with other HF approaches.

The remainder of paper is organized as follows: next section provides theoretical background of the HF methodologies. Section 3 presents the core of the paper, where the simulation study, i.e. the evaluation of different HF models, also including the newly proposed modified top down approach (MTD), is performed. In Section 4, the forecasting of beverage distribution network is demonstrated. We conclude our paper in Section 5, where discussion of results and the final remarks are provided.

2. Methodology

In literature, there are five HF methodologies that are most commonly used. HF methodology is essentially the way of how the base forecasts are combined in order to produce revised forecasts. By base forecasts, we consider independent forecasts that are generated by some of the forecasting methods (for example: exponential smoothing,