

Supply Chain Demand Forecasting based on Unobserved Components models

In most industries Supply Chain Management depends importantly on demand planning and forecasting. These predictions of future demand are provided by the Forecasting Support System (FSS) in order to help make resource allocation decisions regarding departments like Marketing, Finance, Inventory, Distribution, Logistic, Human Resources and Purchasing. In fact, these predictions are usually based on a mixture of statistical forecasting techniques, experience of the managers and the way that the FSS (including the people involved) combine these concepts together. Nonetheless, there is current evidence that suggest a inefficient use of this available information and so, high costs are associated with these unnecessary prediction errors. The essential problem arises because humans, including experts, are inefficient when interpreting information for a wide range of psychological and organizational reasons.

The present project has accomplished a thoroughly investigation as to the possible sources of this inefficient use of the FSS by means of a collaboration with Lancaster University Management School (LUMS) and Lancaster Centre for Forecasting (LCF).

In summary, the project outputs can be separated in two parts. Firstly, we analyze the forecasting process of a single company as an independent system. Secondly, we envisage the forecasting process within the supply chain. In this particular case, the system analysed is not a single company but the entire supply chain.

According to the first part of the project, we use State Space models to improve the forecasting process of a company.

The proposed model of the actual observations of product demand is:

$$Demand_t = a_t SystemFor_t + b_t Adjust_t$$

That is to say, the observed demand is a weighted sum of the statistical forecast and the managerial (expert) adjustment. Here we take $a_t=1$ and model the weight that should be given to the expert adjustment using a new methodology based on state-dependent parameter (SDP) estimation techniques to identify the nonlinear behaviour of managerial adjustments. The SDP technique uses a State Space framework with recursive methods like fixed interval smoothing (FIS) combined with special data

reordering and 'backfitting' procedures which show in a non-parametric way, the state dependency between the parameter under study and an associated state variable.

This non-parametric SDP estimate is used as a guideline to propose a nonlinear model that corrects the bias introduced by the managerial adjustments. One step-ahead forecasts of stock-keeping unit sales sampled monthly from a manufacturing company are utilized to test the proposed methodology. As far as the authors are concerned, this is the first time that empirical evidence has been found showing that adjustments follows a nonlinear pattern. Therefore, nonlinear models are proposed to model such managerial adjustments efficiently, leading to an optimal non-linear model that can be used to improve the company forecasting accuracy. A paper has been published in the [*Journal of Forecasting*](#), describing these results.

As we mentioned previously, this project has also explored another important key issue within supply chain demand forecasting and it is the impact of information sharing on the supplier forecasting accuracy. Essentially, the traditional Supply Chain relies on a decentralized system where each member feeds its own Forecasting Support System (FSS) with incoming orders from direct customers. Nevertheless, other collaboration schemes are also possible, for instance, the Information Exchange framework allows demand information to be shared between the supplier and the retailer.

Current theoretical models have shown the limited circumstances where retailer information is valuable to the supplier. However, there has been very little empirical work carried out. This project assesses the role of sharing market sales information obtained by the retailer on the supplier forecasting accuracy. Data have been collected from a manufacturer of domestic cleaning products and a major UK grocery retailer to show the circumstances where information sharing leads to improved accuracy. We use automatic system identification procedures to select the adequate structure for the supplier sales using the retailer sales information. The results show that the supplier can improve the forecast performance by using the market sales shared by the retailer. A [Lancaster University working paper](#) has been produced describing the analysis and models and submitted for publication.

Following on from the work that has been carried out and the promising results shown in this project, the researchers are convinced this research area of supply chain forecasting provides significant opportunities to further reduce costs for many companies and, consequently, contribute to make our society more productive and competitive.