Machine Learning-Based Demand Forecasting in Supply Chains

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ABSTRACT

Effective supply chain management is one of the key determinants of success of today’s businesses. However, communication patterns between participants that emerge in a supply chain tend to distort the original consumer’s demand and create high levels of noise. In this article, we compare the performance of new machine learning (ML)-based forecasting techniques with the more traditional methods. To this end we used the data from a chocolate manufacturer, a toner cartridge manufacturer, as well as from the Statistics Canada manufacturing survey. A representative set of traditional and ML-based forecasting techniques have been applied to the demand data and the accuracy of the methods was compared. As a group, based on ranking, the average performance of the ML techniques does not outperform the traditional approaches. However, using a support vector machine (SVM) that is trained on multiple demand series has produced the most accurate forecasts.

Keywords: new machine learning; supply chains; support vector machine (SVM)

INTRODUCTION

A major facet of businesses today is the notion of supply chain integration, whereby resources are combined to provide value to the end consumer and where all the upstream firms realize the importance of integration. Such integration often relies heavily on, or at very least includes, sharing information between various business partners (Zhao, Xie, & Wei, 2002). Although integration and sharing information can potentially reduce forecast errors, they are neither ubiquitous nor complete activities and forecast errors still abound. Collaborative forecasting and replenishment (CFAR) permits a firm and its supplier-firm to coordinate decisions...
by exchanging complex decision-support models and strategies, thus facilitating integration of forecasting and production schedules (Raghunathan, 1999). The value of information sharing across the supply chain is widely recognized as the means of combating demand signal distortion (Lee, Padmanabhan, & Whang, 1997). However, there is a gap between the ideal of integrated supply chains and the reality (Gunasekaran & Ngai, 2004). Researchers have identified several factors that could hinder such long-term stable collaborative efforts. Premkumar (2000) lists some required critical issues that permit successful supply chain collaboration, including: (i) alignment of business interests, (ii) long-term relationship management, (iii) reluctance to share information, (iv) complexity of large-scale supply chain management, (v) competence of personnel supporting supply chain management, and (vi) performance measurement and incentive systems to support supply chain management. In many supply chains there are power regimes and power sub-regimes that can prevent supply chain optimization (Cox, Sanderson, & Watson, 2001). The introduction of inaccurate information into the system could also lead to demand distortion, for example, double forecasting and ration gaming by the partners, ordering more quantities than needed despite the presence of a collaborative system and an incentive towards its usage (Heikkila, 2002).

The over-emphasis on investing in extensive relationships among the partners could lead to a “lock-in” situation, thus seriously jeopardizing the flexibility of the supply chain (Gossain, Malhotra, & El Sawy, 2005; White, Daniel, & Mohdzain, 2005). Gossain et al. (2005) have recently argued that developing robust and reconfigurable links would promote the agility of the chain in terms of offering and partnering flexibilities (Gossain et al., 2005). In their study they have found that while the quality of information sharing in a supply chain could promote the flexibility, the breadth of information shared has a detrimental effect on it. The modularity and loose couplings between the partners have been identified as positive factors in this regard. White et al. have stressed the importance of emergent technologies in promoting agility in supply chains (White et al., 2005).

In light of these considerations, the problem of forecasting distorted demand is of significant importance to businesses, especially those operating towards the upstream end of the extended supply chain. The purpose of this work is to investigate the potential value of applying advanced machine learning techniques, including artificial neural networks (ANN), recurrent neural networks (RNN), and support vector machines (SVM) to demand forecasting in supply chains. The performance of these machine-learning (ML) methods is compared against baseline traditional approaches, such as exponential smoothing, moving average, linear regression, and the Theta model. To this end we have collected the real industry data from three different sources. The first two data sets are from the enterprise systems of a chocolate manufacturer and a toner cartridge manufacturer. Both of these companies, by the nature of their position in the supply chain, are subject to considerable demand distortion. The third source of data comes from the Statistics Canada manufacturing survey. Inclusion of this survey in the study has the aim of increasing the validity and facilitating the possibility of replication of results by others.
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