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Stochastic financial analytics for cash flow forecasting

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ABSTRACT

Accurate cash flow forecasting is essential for successful management of firms and it becomes especially critical during uncertain market and credit conditions. Without accurate cash flow forecasting, a firm may fail to meet its short-term obligations and risk bankruptcy. Accurate cash flow forecasting can be limited by a number of factors including changes in macro-economic conditions that influence liquidity in the economy, customer payment behavior that can vary from time to time as well by industry, and dynamics of the particular supply chain itself. We develop stochastic financial analytics for cash flow forecasting for firms by integrating two models: (1) Markov chain model of the aggregate payment behavior across all customers of the firm using accounts receivable aging and; (2) Bayesian model of individual customer payment behavior at the individual invoice level. As the stochastic dynamics of cash flow evolves every day, the forecast can be updated every time an invoice is paid. The proposed model is back-tested using empirical data from a small manufacturing firm and found to differ 3–6% from actual monthly cash flow, and differs approximately 2–4% compared to actual annual cash flow. The forecast accuracy of the proposed stochastic financial analytics model is found to be considerably superior to other techniques commonly used. Furthermore, in computer simulation experiments, the proposed model is found to be largely robust to supply chain dynamics, including when subjected to severe bullwhip effect. The proposed model has been implemented in Excel, which allows it to be easily integrated with the accounts receivable aging data, making it practicable for small and large firms.

1. Introduction

In order to keep businesses running with sufficient working capital and to manage cash flow efficiently, an accurate cash flow forecast is critical. Smaller firms usually incurs higher financing cost due to its credit risk and resource constraints (Baas and Schrooten, 2006). On the other hand, larger firms may find it is difficult to manage its financial assets when it moves to another stage of business life cycle (Mcmahon, 2001). Essentially, cash is the main bloodline of all firms. A firm without profit may be able to survive for a while, but without cash a firm can become insolvent, and risks bankruptcy. Cash flow forecast can serve different purposes such as treasury management, working capital financing, and business valuation.

Besides the aforementioned purposes, the cash flow forecast may be used for various strategic purposes such as controlling a group of subsidiary companies, and for general management (WWCP, 2012). For example, a firm may use variance between the actual cash flow and forecasted cash flow to diagnose underlying problems and respond in a timely manner.

Two widely used techniques for a short term cash flow forecast are the receipts and disbursements forecast technique, and a statistical technique. The former technique is to determine all expected cash inflows and cash outflows over the forecast period whereas the latter technique can be a bit more sophisticated in that it considers historical trends. Such statistical techniques include, for example, simple moving average, exponential smoothing, regression analysis, and distribution model (WWCP, 2012). Many commercial software packages for enterprise resource planning (ERP) and treasury management system (TMS) use these statistical techniques for cash flow forecast.

Several research studies have focused on developing and improving cash flow forecasting techniques. In 1950s, the idea of treating cash as products in inventory management was used to forecast and optimize the cash position (Baumol, 1952; Whitin, 1953). However, the assumption of predetermined cash flow in this body of work may not be realistic in many practical situations. Hence, another model was developed to maintain the cash position and minimize transaction fee (Miller and Orr, 1966). Several techniques have also been developed with a specific focus on construction industry (Bromilow and Henderson, 1977; Evans and

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Kaka, 1998; Hudson, 1978; Kenley and Wilson, 1986; Khosrowshahi, 1991; Miskawi, 1989; Singh and Woon, 1984; Skitmore, 1992, 1998).

Accounts receivable (AR) aging is a report classifying the length of time since invoices have been sent to various customers. This report is a part of an accounting analytics routinely used by many companies to identify irregular payments and closely monitor overdue accounts. A typical AR aging report consists of many customer accounts in the report and each different customer may have different payment behavior. AR aging and related data can be used in many ways for cash flow forecast. The pioneering efforts of Cyert et al. (1962) used Markov Chain for estimating the allowance for doubtful accounts. This was further improved by incorporating exponential smoothing to AR aging for forecasting cash flow (Corcoran, 1978; Cyert et al., 1962). Later, Kuelen et al. (1981) modified the model and improved the accuracy of the forecast by changing the total balance aging to determine probabilities of the next payments by using the accounts receivable aging (Kuelen et al., 1981). These two techniques outperform other common practices such as moving average and exponential smoothing techniques which are still widely used in practice (Beattie, 2011; WWCP, 2012). Another key development in this area is to model cash flow as a stochastic process to predict cash on-hand for short-term financial planning (Pate-Cornell, 1986; Pate-Cornell et al., 1990).

In general, cash flow can be viewed as a stochastic process which is sequence of random variables that depend upon a number of factors including macro-economic conditions that influence liquidity in the economy, customer payment behavior that can vary from time to time as well by the industry, and dynamics of the particular supply chain itself. For example, one of the prominent and widely studied dynamics of supply chain is the bullwhip effect in inventory. Bullwhip effect in inventory is an undesirable phenomenon in forecast-driven distribution channels where the variance of orders from downstream supply chain gets amplified as it propagates upstream as shown in Fig. 1 (Baganha and Cohen 1998; Kahn, 1987; Lee et al., 1997b, 2004; Metters, 1997). Adverse impacts of the bullwhip effect can result in excessive inventory, stock-outs, back-orders, production swing, and low utilization of distribution channels. The majority of past research of the bullwhip effect concentrated on key factors which cause such phenomenon and explanation of its existence (Burbidge, 1971; Lee et al., 1997a; Mason-Jones and Towill, 2000; Sterman, 1989). Such key factors are disorganization, lack of communication, order batching, and price variations. Interest in this area was shifted to its impacts and techniques to reduce it (Chen et al., 1998; Lee et al., 1997a). Several approaches were developed to mathematically quantify the bullwhip effect (Chen et al., 2000; Fiorolli and Fogliatto, 2008; Kim et al., 2006). Tangsucheeva and Prabhu (2013) studied the impact of the inventory bullwhip effect on the corresponding cash flow bullwhip (CFB) in a supply chain as shown in the lower graph of Fig. 1 (Tangsucheeva and Prabhu, 2013). It needs to be emphasized that the cash flow of a firm not only depends on its immediate customers but potentially also on the system dynamics of its supply chain.

There is a need for cash flow models and analytics that more fully utilize the available financial data to improve the accuracy of cash flow forecasts. In this paper, we focus on improving the accuracy of cash flow forecasting technique by modeling individual customer payment behavior for determining payment probability of individual invoices by using historic AR aging data. This individual customer level stochastic model is implemented in Excel, which is the tool used by about 70% of companies for accounting and cash flow forecasts (Fuchs, 2011). This development potentially provides users a practical and convenient forecasting tool without having to dwell on the intricacies cash flow forecasting techniques.

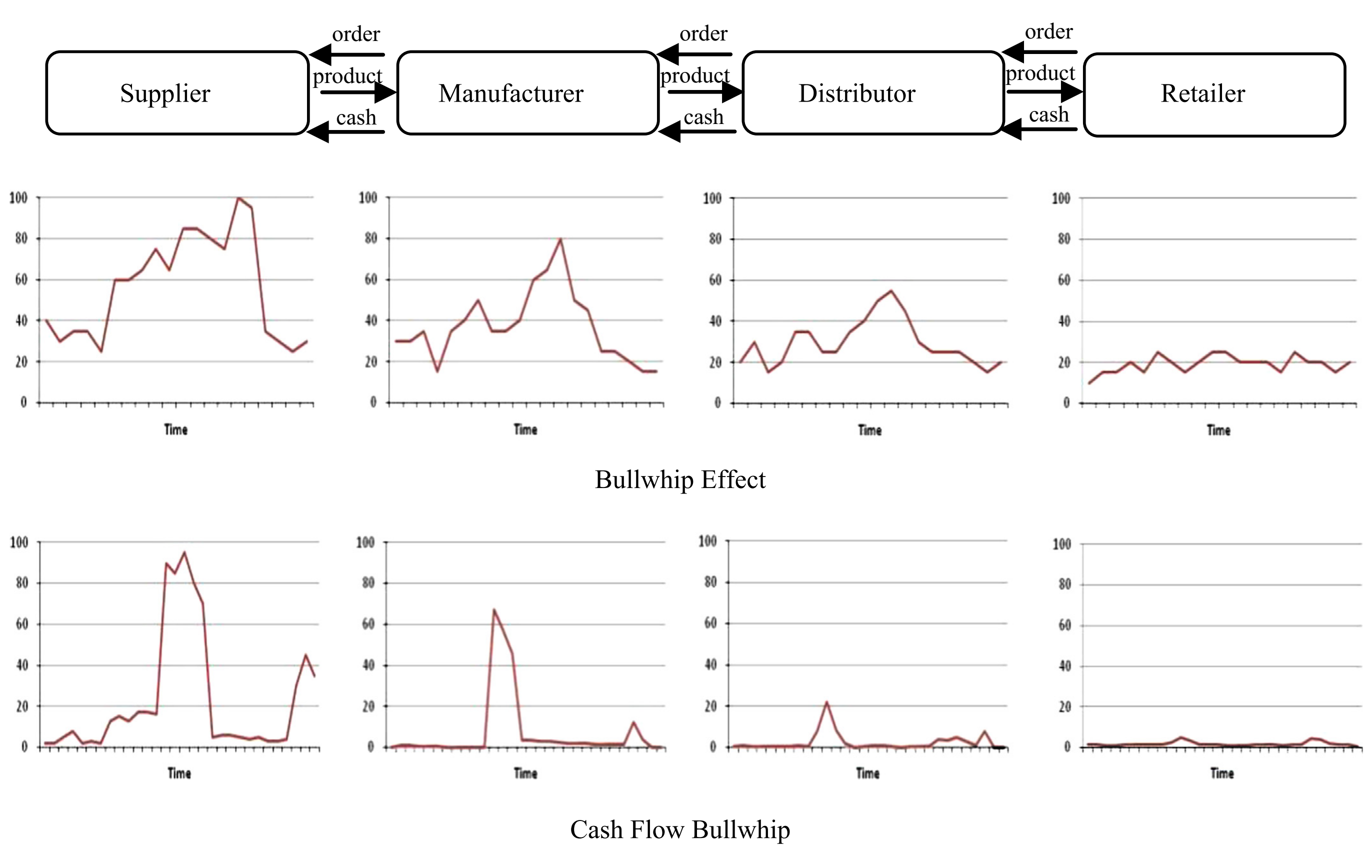

Fig. 1. Bullwhip effect and cash flow bullwhip in the supply chain.