Technological Forecasting & Social Change xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

A multiple objective stochastic programming model for working capital management

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ARTICLE INFO

Keywords:
Working capital
Stochastic goal programming
Multiple objective stochastic programming
Regression
Retailing industry

ABSTRACT

The level of working capital is one of the main financial decisions affecting a firm's value, shareholder wealth, competitiveness, liquidity, and profitability. An aggressive (conservative) working capital policy has a positive (negative) impact on profitability but a negative (positive) impact on liquidity. In this paper, we propose a multiple objective stochastic programming model to select an efficient working capital strategy that takes into consideration not only the conflicting impact of working capital policy on the two firm objectives of liquidity and profitability but also the interrelationships and stochastic aspects of the components of working capital. The proposed model was used to help a start-up retailer to determine its optimal working capital.

1. Introduction

Working capital concerns managing the day-to-day short-term operations of a firm. The three main components of working capital are accounts payable, accounts receivable and inventory. The importance of working capital is reflected by the heavy reliance of worldwide firms on it. For instance, Summers and Wilson (2000) show that 80% of daily trade transactions in the UK are on credit terms. Deloof (2003) finds that in Belgium, accounts receivable, inventory, and accounts payable represent 17%, 10%, and 13%, respectively, of total assets of Belgian firms. Furthermore, efficient working capital management protects firms from potential financial problems. During the recent financial crisis of 2007–2008, the liquidity shortage highlighted the significance of short-term financial policies such as working capital management. In a related vein, Braun and Larrain (2005) and Abuzayed (2012) argue that more attention be devoted to the level of working capital during recession and crises periods. Kaddumi and Ramadan (2012) note that U.S. finance executives became more cautious in managing firms' working capital in the aftermath of the 2008 global recession.

Working capital affects shareholder's wealth, firm value, competitiveness, liquidity, and profitability (Smith, 1980; Shin and Soenen, 1998; Lazaridis and Tryfonidis, 2006; Baños-Caballero et al., 2014; Aktas et al., 2015); therefore, firms usually aim to have a well-managed working capital, as any change in the level of the working capital can be critical. Padachi (2006) argues that managers face a trade-off between liquidity and profitability as they seek to maximize the firm's value. The level of working capital is directly linked to this trade-off as an aggressive (conservative) working capital policy has a positive (negative) impact on profitability but a negative (positive) impact on liquidity and risk. If a firm overlooks its profitability, it cannot survive in the long term, but on the other hand, if it overlooks liquidity, it may face the problem of insolvency (Vahid et al., 2012). Almazari (2013) notes that Saudi cement firms face a trade-off problem between liquidity and profitability and recommends that a more efficient working capital structure be developed. Hence, a firm needs to operate with an optimal level of working capital that maximizes the two objectives of liquidity and profitability.

The goal of this paper is to develop a model to determine the optimal working capital structure for a start-up retailer aiming to enter the Kingdom Bahrain market. The importance of working capital management increases for firms in emerging markets due to their limited external sources of finance and their heavy reliance on trade credit. Inefficient working capital is a cause of failure in small firms and start-ups (Lazaridis and Tryfonidis, 2006). The economic outlook suggests that the retail industry is one of Bahrain's most promising industries. For instance, according to the Bahrain 2014 Commercial Market Outlook (Cluttons, 2014), Bahrain's retail sector remains one of its best performing sectors due to strong demand. Furthermore, the BMI Bahrain Retail 2016 report (BMI Research, 2016) forecasts that household spending in Bahrain will increase by approximately 7% over the next five years, driven by rising incomes, tourists and positive demographic trends.

The start-up retailer seeks an efficient working capital strategy that will have a positive impact on its profitability and liquidity, given some specific constraints on its working capital components. The start-up

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http://dx.doi.org/10.1016/j.techfore.2017.05.006
Received 30 January 2017; Received in revised form 6 April 2017; Accepted 3 May 2017

retailer's total assets are constrained at BD 30 million and its debt level at BD 7.5 million. These constraints reflect that the start-up retailer is financially constrained and faces a high chance of failure. The start-up retailer also specifies that its net trade cycle is 100 days, because a longer net trade cycle might lead to liquidity problems. The main concern of the start-up retailer is the conflicting impact of working capital policy on profitability and liquidity.

To select an efficient working capital structure, we propose a multiple objective stochastic programming model that determines an optimal level of accounts receivable, accounts payable and inventory that maximizes a firm's profitability and liquidity, taking into account the stochastic nature of sales.

Our empirical study results show that the higher the accounts payable and inventory levels, the higher the firm's liquidity level, while the higher the accounts receivable level, the lower the firm's liquidity level. With respect to profitability, the accounts payable and receivable have a positive impact on the firm's profitability, whereas inventory has a negative impact on the firm's profitability.

The proposed solution strategy for the start-up retailer provides a link between two bodies of literature, working capital and operations research, by utilizing the tools of the latter to solve a prominent problem in the former. Prior working capital literature has highlighted the existence of the problem of determining the optimal level of working capital, but, as far as we are aware, we are among the first to propose a comprehensive solution approach to this problem.

Our model differs from other models presented in the literature (Keown and Martin, 1977; De et al., 1982; Zhang et al., 2015), as we focus on the structure of the working capital rather than the return and risk from such an investment. The findings of our paper also contribute to the strand of literature on the effect of working capital on profitability (e.g., Deloof, 2003; García-Teruel and Martinez-Solano, 2007) as well as to the works on working capital and liquidity (e.g., Kim et al., 1998). Our paper is also related to the works on the importance of working capital management in start-ups, such as Huyghebaert and Van de Gucht (2007). The empirical results highlight the determinants of profitability and liquidity of retailers in Bahrain.

The remainder of the paper is organized as follows. In Section 2, we provide a theoretical background on working capital. In Section 3, we discuss the multiple objective stochastic programming. In Section 4, we propose the certainty equivalent. In Section 5, we present the empirical study, and finally we conclude the paper in Section 6.

2. Working capital management

Working capital management is important to firms of all sizes because it grants firms financial flexibility and reduces their dependence on external sources of finance (Autukaite and Molay, 2011). This importance increases for start-ups and small firms because most of their assets are current and they are highly reliant on current liabilities (Petersen and Rajan, 1997; Afrifa and Padachi, 2016). The level of aggressiveness or conservatism of working capital policies varies across industries (Weinraub and Visscher, 1998). Retailers rely heavily on purchasing on credit because of the nature of their goods and their frequent interaction with suppliers (Giannetti et al., 2011). The number of days of inventory is shorter than average in the retail industry due to the speedy selling of goods (Koumanakos, 2008). Therefore, determining the optimal level of working capital is of great importance to start-up retailers.

There are several reasons firms use the three working capital components accounts receivable, accounts payable and inventory. Firms grant accounts receivable because it smoothes the demand for their products: firms may defer the collection of payment or extend trade receivables during periods of low demand. Fabbri and Klapper (2016) argue that accounts receivable is a less aggressive and more flexible marketing instrument than price reduction, which can cause price wars and reactions from competitors. Furthermore, firms provide accounts receivable because they have a lending advantage over banks in extending credit, mainly due to their frequent interactions with customers (Petersen and Rajan, 1997).

Firms also use accounts payable for several reasons. Accounts payable is a source of finance for firms during liquidity shocks or crisis periods because, in the case of default, suppliers are willing to grant firms renegotiation concessions (Wilner, 2000). Accounts payable also reduces transaction costs by separating payment from delivery, hence eliminating the need to hold inventories of both money and goods (Ferris, 1981).

Similarly, inventory management is another important aspect of working capital that helps firms avoid holding too much or too little inventory. Holding inventory helps to increase sales as it provides flexibility, enhances the ability to address demand swings and mitigates manufacturing disruptions. At the same time, a high level of inventory increases warehousing and storage costs, could cause spoilage and damage, and could be a shield for inefficient management and poor forecasting (Koumanakos, 2008). Several inventory management techniques to aid firms in inventory decisions have been developed, such as Material Requirements Planning (MRP) systems and Just-In-Time (JIT).

Overall, firms need to determine an optimal level of working capital that maximizes their value. For instance, having a high level of inventory and accounts receivable may lead to higher sales and profits. However, locking up funds in inventory and accounts receivable may affect a firm's liquidity and its ability to meet its day-to-day operational needs and obligations (Eljelly, 2004).

Several studies have recognized that the level of working capital affects both the profitability and liquidity of a firm; however, little attention has been devoted to the idea that working capital could affect both profitability and liquidity at the same time and that its effect could be positive on one objective and negative on the other. Therefore, our paper aims to fill this gap by determining the optimal level of working capital of a start-up retailer that maximizes both liquidity and profitability.

Our model also takes into account the constraints faced by the start-up retailer. These constraints result from the fact that the start-up retailer has no relationship history with suppliers and faces difficulties in accessing external sources of finance. As a result, the constraints concern the total assets, the working capital structure and the debt level.

3. A multiple objective stochastic programming for working capital

The main objective of the start-up retailer is to maximize its profitability and liquidity. Eljelly (2004) and Rehman et al. (2015) document the opposing relationship between profitability and liquidity in Saudi listed firms. These two objectives are of great importance to the start-up retailer because it faces limited external sources of finance and a high possibility of failure. Therefore, it would like to pay extra attention to the management of its internal sources of finance, such as accounts payable, as well as maximize its benefits from accounts receivable and inventory.

To determine the optimal level of working capital, we consider the following three decision variables related to the components of working capital: accounts payable (x_1) is money owed by a firm to its suppliers, accounts receivable (x_2) is money owed by customers, and inventory (x_3) is goods and materials used for resale.

In addition, we consider the cash and cash equivalents (x_4) along with the fixed assets (x_5) for two reasons. First, these two variables are considered to be substitute working capital, so a low level of working capital frees up funds to be invested in fixed assets or to be freely held as cash (Fazzari and Petersen, 1993; Giannetti et al., 2011). Second, both asset types are significant components of total assets, whose value is limited for the start-up retailer. In short, the optimal level of working capital cannot be determined without also determining these two