



## Internal liquidity risk, financial bullwhip effects, and corporate bond yield spreads: Supply chain perspectives

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### ABSTRACT

This study explores internal liquidity risk (ILR) and financial bullwhip effects on corporate bond yield spreads along supply chain counterparties by employing American market data from year 1997 to 2008. This study finds that the ILRs of suppliers and customers positively affect a firm's bond yield spreads and the effects of customers' ILRs are greater. This research also finds a financial bullwhip effect that the ILR effect becomes greater upwardly along the supply chain counterparties. The results are robust when controlling for well-known spread determinant variables.

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### 1. Introduction

The recent global financial crisis, to a large degree, is the result of firms' liquidity crunches caused by the rampant devastating conditions of firms' financing ability and net operating cycle.<sup>1</sup> Due to the slump of equity markets and the fragility of debt markets, a firm is very hard to obtain external financing. Therefore, firms' suppliers may adopt a tighter credit policy and their customers may have problems in paying back account receivables. Under such circumstances, firms have less possibility to prolong purchase payments and hard to timely collect account receivables, which lengthens firms' net operating cycle (Tsai, 2008),<sup>2</sup> indicating a dete-

riorated internal liquidity condition.<sup>3</sup> The phenomenon of domino effect reveals that the internal liquidity risks spreading from supply chain counterparties increase a firm's uncertainties in both available liquidity and obligation payments. These uncertainties lead to an increase in a firm's flow-based corporate credit risk as described by Chen et al. (2011a,b). That is, the supply chain relationship provides a channel to transmit the cash flow variations of suppliers and customers to a firm and therefore the internal liquidity risks are rampant along supply chains. However, few existing studies consider the risk transmission effects of internal liquidity risk "spreading" through supply chains, such as incorporating suppliers'/customers' internal liquidity risk effects into corporate credit model settings or investigating their effects on bond yield spreads. To address the issue, this study employs American bond market data to examine the internal liquidity risk effects of a firm's supply chain counterparties on the firm's bond yield spreads.

Among the corporate credit risk related works, the issue of exploring the determinants of corporate bond yield spreads becomes one of the most noticeable topics. Most extant studies explore the effects of firm or bond characteristics on bond yield spreads from structural credit model perspectives, including lever-

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<sup>1</sup> Net operating cycle (also called "length of cash cycle") is equal to the sum of average inventory days and average outstanding days of account receivable days minus average days of account payables. An increase in account receivable days or a decrease in account payable days prolongs the length of net operating cycle, indicating a worse corporate liquidity condition.

<sup>2</sup> Tsai (2008) describes the relationship between supply chain cash flow risk and inventory risk by employing three time related factors that impose significant influences on the cash conversion cycle and cash flow variations, including the lead time, credit periods of account receivables and account payables, and early receipt/payment patterns.

<sup>3</sup> Corporate internal liquidity, different from trading liquidity (external liquidity), is defined as a firm's ability to fulfill its obligatory payments. Neither the Merton-type structural nor the reduced form credit models consider it into their settings.

age ratio (Collin-Dufresne et al., 2001), equity volatility (Campbell and Taksler, 2003), trading (external) liquidity risk (Warga, 1992; Longstaff et al., 2005), tax effect (Qi et al., 2010), information asymmetry and information uncertainty (Yu, 2005; Liao et al., 2009; Lu et al., 2010; Güntay and Hackbarth, 2010). Different from the above studies, Chen et al. (2011b) investigate bond yield spreads determinants from a flow-based credit model perspective and demonstrate that a firm's internal liquidity risk significantly affects its bond yield spreads when controlling for yield spread determinant variables well known in the literature.<sup>4</sup> In addition, from the 0 chain, Chen et al. (forthcoming) show that suppliers' information flow risk plays an important role in explaining a firm's bond yield spreads. Though many studies have explored the determinants of bond yield spreads, a significant unexplained portion still exists. As a result, based upon Chen et al. (forthcoming, 2011b), this study aims to fill the gap from the prospective of internal liquidity risk "spreading" along supply chain.

Regarding the discussions of the relation between a firm's credit risk and the supply chain characteristics, most studies focus on the wealth effects of financial distress between a firm and their rivals or supply chain counterparties. More specifically, they investigate the effects of bankruptcy announcements on the equity value of the bankrupt firm's competitors (Lang and Stulz, 1992), and those of both its customers and suppliers (Hertzel et al., 2008). Although Kale and Shahrur (2007) investigate the relationship between corporate capital structure and the characteristics of suppliers and customers,<sup>5</sup> they do not further explore credit risk related issues. Similar studies also include Titman and Wessels (1988) and Banerjee et al. (2008). In addition, Chen et al. (forthcoming) explore the relation between corporate bond yield spreads and supply chain characteristics from an information flow risk viewpoint. Itzkowitz (2011) investigates how the buyer–supplier relationship affects suppliers' cash holdings.<sup>6</sup> Therefore, according to the above discussions, few studies directly discuss how a firm's supply chain characteristics affect its credit risk from the perspective of internal liquidity risk.

According to Chen et al. (2011a,b), internal liquidity risk is a type of flow-based credit risk, relating to a firm's ability to meet its payment obligations, and therefore relying upon the firm's capability in cash flow generating and external financing. This study views the internal liquidity risk "spreading" along supply chain as a type of cash flow variation risk transmitted through supply chains. Tsai (2008) provides an insightful look at supply chain cash flow risks and employs cash conversion cycle (or operating cycle) to describe the variations of product flow and cash flow. Hence, internal liquidity risks not only transmit the uncertainties of a firm's suppliers'/customers' available funding liquidity and payment obligations (Chen et al., 2011a,b) but also deliver their operating variation risks (Tsai, 2008) to the firm. Therefore, through supply chain relationship, a firm's suppliers'/customers' internal liquidity risks affect the firm's credit risk from the perspectives of both flow- and stock-based (structural) credit models.

Moreover, this study also explores the existence of "financial bullwhip effect", namely investigating whether or not the internal

liquidity risk effect becomes greater upwardly along the supply chain counterparties. The "bullwhip effect" describes the phenomenon of the increasing propagation of operational volatility from bottom to top along a supply chain that is mainly referred to inventory and order flows (Lee et al., 1997; Power, 2005). Many studies demonstrate the bullwhip effect in a supply chain from different perspectives, including information sharing (Lee et al., 2000), information distortion (Lee et al., 2004), bankruptcy events (Lee et al., 2004; Mizgier et al., 2012) and systematic risk (Osadchiy et al., 2011).<sup>7</sup> Most of them devote themselves to exploring the bullwhip effect from the perspectives of inventory flow risk and information flow risk rather than that of cash flow risk. For a firm's internal liquidity risk (Chen et al., 2011a,b), it is an appropriate proxy for a firm's financial risk. Different from the previous studies, this study firstly explores the "financial bullwhip effect" on bondholders' wealth along a supply chain by examining whether the internal liquidity risk effect on bond yield spreads becomes greater upwardly along the supply chain counterparties.

This study empirically investigates the effects of a firm's supply chain counterparties' internal liquidity risks on the firm's bond yield spreads when controlling for well-known variables affecting corporate credit risk, such as (operating) cash flow volatility, leverage, equity volatility, maturity, coupon, issuance amount, credit rating, information asymmetry, R&D intensity, and a firm's industry concentration, by employing a preliminarily screened sample of 2022 yearly bond observations with supplier identifications and 1453 yearly bond observations with customer identifications from year 1997 through 2008. Empirical results of this study show that both suppliers' and customers' internal liquidity risks play an important role in explaining a firm's bond yield spreads. When controlling for well-known variables, firm bond yield spreads increase 16.65 bps and 27.57 bps per standard deviation increase in suppliers' and customers' internal liquidity risks, respectively (the suppliers' and customers' internal liquidity risks are estimated by the standard deviations of their previous eight-quarter internal liquidity levels). The influences of a firm's suppliers' and customers' internal liquidity risks on the firm's bond yield spreads are roughly one ninth and one third of that of leverage ratio, respectively. Besides, the results reveal that the internal liquidity risk effects of customers on a firm's bond yield spreads are more significant than those of suppliers. The empirical results also show that booming macroeconomic conditions significantly alleviate internal liquidity risk effects of suppliers, whereas they insignificantly affect those of customers. Especially, similar phenomenon occurs in a firm's suppliers. A supplier's bond yield spreads increase 21.47 bps and 33.73 bps per standard deviation increase in the internal liquidity risks of the supplier's suppliers and the supplier's customers, respectively. Combining with the previous results, the internal liquidity risk effect on bond yield spreads becomes greater upwardly along the supply chain counterparties, namely the financial bullwhip effect. Furthermore, this work includes the information flow risk (Chen et al., forthcoming) in the empirical investigations and the results reveal that the information flow risk and internal liquidity risk of suppliers both significantly explain a firm's bond yield spreads. However, there exists a trade-off relationship between these two risk effects.

In addition, this study considers the business relationship among a firm's suppliers (or customers) into the research design

<sup>4</sup> These control variables include traditional accounting measures of corporate debt servicing ability, such as interest coverage ratio, debt service coverage ratio, quick ratio, and ratio of operating income to sales, and an additional structural form credit risk measure, the cash flow volatility.

<sup>5</sup> Kale and Shahrur (2007) find that a firm's leverage is positively related to the concentration levels in its supplier and customer industries. Additionally, firms that deal with R&D-intensive suppliers (customers) and firms with high intensities of strategic alliances and joint ventures with suppliers (customers) have lower credit risk.

<sup>6</sup> Itzkowitz (2011) mentions that suppliers in buyer–supplier relationships hold more cash than suppliers not in important relationships and cash holdings increase proportionately with relationship importance. The relationship importance is measured by the percent of sales and sales concentrations.

<sup>7</sup> Lee et al. (2000) quantify the bullwhip effect and show the potential of variance reduction due to information sharing. Lee et al. (2004) demonstrates that the information transferred through transaction "orders" tends to be distorted and misguides upstream supply chain members in their inventory and production decisions. Mizgier et al. (2012) introduce an agent-based model of a supply chain network in bankruptcies cases and show how the bullwhip effect may lead to bankruptcy. Osadchiy et al. (2011) document that the relation between the degree of systematic risk and bullwhip effect in supply chain.

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