Supply Chain Finance and Impacts of Consumers' Sustainability Awareness[*†]

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Abstract

Several new methods have been proposed for supply chain finance (SCF) with bank credits, but none of them mentions how to solve the borrowers' moral hazard problems in SCF. This paper examines the moral hazard problem in supply chain financing with procurement contract (or purchase order). We show that since supply chain is an up-down directed structure, when financing with the procurement contract, the supplier's effort monitoring task can be rendered to the procurement contract, which can secure the supplier's optimal effort and capital choices in production. Hence, compared to separate lending, the supplier's credit rationing problem can be mitigated, and most importantly, banks' under-estimation on the supplier's default risk and the over-estimation on the retailer's default risk will both decrease. We further show that the retailer's corporate social responsibility expenditure can increase consumers' brand recognition, thus when facing demand shocks arising from consumer's unexpected concerns, the retailer can better stabilize the firm value.

JEL classification: G21, M11, M14

Keywords: Supply Chain Finance, Bank Credit, Moral Hazard, Default Risk, Corporate Social Responsibility

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1 Introduction

Capital-constrained enterprises usually borrow loans from banks, but banks' lack of full information on the investment projects or the moral hazard problems often prompt them to cap the credit size to avoid substantial financial risks. The recent economic downturns have further decreased the granting of new loans considerably, causing a significant increase in the cost of corporate borrowing (Ivashina and Scharfstein, 2010).[1] The shortage of fund not only hinders the growth of small businesses, but also disrupts the whole supply chains. In a survey on the 2008 financial crisis, 13% of companies claimed that the deterioration of their key suppliers' financial standing had caused supply chain disruptions (Aberdeen Group, 2008).

There are therefore increasing needs for solutions and programs that can optimize the working capital. One of the most important approaches raised so far is the supply chain finance (SCF) (Polak et al., 2012). SCF aims to optimize financial flows at an inter-organizational level (Hofmann, 2005) through solutions implemented by financial institutions (Camerinelli, 2009) or technology providers (Lamoureux and Evans, 2011). In business practices, Babich (2010) reported that Ford subsidized its component supplier during the disruption in 2005. General Motors and Chrysler also struggled with their supplier problems in 2009 (see Sherefkin, 2009; Ernast & Young, 2010), as most of their suppliers faced capital shortage.

Among the various methods, *SCF with trade credit* has been proved an effective model to motivate suppliers to increase sales and profits in supply chain management (Coulibaly et al., 2013; Garcia-Appendini and Montoriol-Garriga, 2013). SCF with trade credit (or reverse factoring)[2] means that a corporation extends its credit to an upstream/downstream partner using short-term loans (i.e., accounts payable or accounts receivable) (Yan et al., 2016). Researchers have investigated the advantages of trade credit financing from various aspects, including monitoring borrowers' revenue (e.g., Jain, 2001), enforcing credit repayment (e.g., Cunat, 2007), renegotiating debt (e.g., Wilner, 2000), or salvaging repossessed inventory upon borrower's default (e.g., Maksimovic and Frank, 2005).

[1] For example, the U.S. Department of Treasury reported that the 22 largest banks have a sizeable decrease in small-business lending by $12.5 billion in 2010. As the capital market is tightened, it is reported that "access to credit" has become the second in the top 10 risks for businesses across the globe (see Ernst & Young, 2010).

[2] See Gelsomino et al. (2016) for a throughout review on supply chain finance.

However, granting trade credit could also exacerbate negative effects such as cash flow shortages and default risks, which can severely damage firms' profitability or even lead to bankruptcy. There are increasing evidences showing that nonpayments by trade debtors are the prime causes for financial distress and bankruptcy (Bradley and Rubach, 2002). For example, Jacobson and Schedvin (2015) showed that trade creditors have experienced significant trade credit losses due to trade debtor failures and that the trade credit failure propagation mechanism is driven by both credit losses and demand shrinkage.

Recently, several new methods have been proposed for another model, i.e., *SCF with bank credit*. For example, Tunca and Zhu (2018) considered "*buyer intermediated financing*", where the retailer uses its credit as collateral to help a capital-constrained supplier get financing from a bank in pre-shipment period. Yan et al., (2016) considered bank financing with a manufacturer's credit guarantee, i.e., the upstream provides critical credit guarantee to the downstream partner by offering the opportunity to rapid obtain loan from the bank. Huang, Wu, and Chiang (2018) proposed "*buyer back purchase order financing*" where a buyer (retailer) uses its purchase order and guarantee as collateral to help a capital-constrained supplier get financing from a bank in pre-shipment period. Slightly differently, Reindorp, Tanrisever, and Lange (2018) and Wu (2017) analyzed "*purchase order financing*' where the supplier uses purchase order from a retailer (buyer) as a collateral to get lending from a bank in pre-shipment period. Although these methods are shown useful to accelerate financial flows for supply chain members, the benefits for the lenders are seldom mentioned. Moreover, no research has addressed how to solve the borrowers' moral hazard problems, which are related to the borrower's repayment abilities and hence are important for banks' loan decisions.

In this paper, we attempt to propose a model of SCF with procurement contracts that can mitigate the borrower's moral hazard problem and reduce the lender's credit risks. We show that since the supply chain is an up-down directed structure between suppliers and retailers, when financing with the procurement contract, the supplier's effort monitoring task can be rendered to the procurement contract, which can secure the supplier's optimal effort and capital choices in production. Hence, compared to separate lending, the supplier's credit rationing problem can be mitigated, and most importantly, the banks' under-estimation on the suppliers' default risks and the over-estimation on the retailer's default risk will both decrease. The under-estimation on default risks arises because under separate lending, the bank ignores the value connection with downstream retailer and the

risk contagion from the retailer.[3] The over-estimation on the retailer's default risk can be mitigated because the procurement contract has secured the supplier's optimal effort and capital choices, thus reducing the production uncertainty and the retailer's default risk.

In addition, there has been growing consumer awareness of corporate social responsibility across the globe. In 2015, Cone Communications and Ebiquity jointly conducted a survey of 9,709 consumers in nine of the largest countries in the world by GDP to learn about their perceptions and behaviors related to corporate social responsibility (CSR). Many consumers have strong accountability to address social and environmental issues and are primed for participation in CSR efforts with the understanding that firms should do more than just making a profit (CONE-Communication/Ebiquity, 2015). Many firms feel that environmental and social sustainability risks are on the rise. In particular, these firms believe that these risks can affect their reputation and market demand if they are not managed properly especially when their supply chain operations are conducted in emerging markets (PwC report, 2008).

In this paper, we will show that the retailer's CSR expenditure can increase consumers' brand recognition, so when facing demand shocks arising from consumer's unexpected concerns on worker safety, child labor or counterfeits, the retailer can better stabilize firm value and hence decrease the default probability, because the negative impacts on the retailer's final demand will be counteracted by the positive effects on brand recognition.

Our model is a four-stage game with a retailer and a supplier under demand uncertainty. In the first stage, the retailer offers a procurement contract consisting of the purchase amount and a payment regulated by the individual rationality and incentive compatibility conditions. Then, in the second stage, both the supplier and the retailer seek for external funding from a third-party, i.e., the bank, to pay the expenditures needed for production (including capital and effort costs). Under demand uncertainty and not knowing the supplier and retailer's effort decisions, the bank needs to decide whether to provide the loans. If any of them cannot receive funding, the production will not proceed. In the third stage, given the purchase order, the supplier chooses the least effort and capital to achieve the purchase amount, considering the uncertainty in production. Finally, the product is shipped to the retailer, who will seek for the least effort, capital and CSR expenditure to maximize the firm value, considering the random shock in demand. If the retailer remains

[3] Jacobson and Schedvin (2015) pointed out this failure propagation mechanism with trade credits.

solvent, the payment will be paid to the supplier, and the loans and interests are paid back to the bank.

We will present two schemes: separate lending and joint lending. Under separate lending, the bank uses historical effort and capital records to evaluate the supplier and retailer's repayment abilities. A credit rationing problem happens if these historical effort and capital levels are lower than the borrowers' optimal capital and effort levels. Since the supply chain network is up-down directed, there can be both under-estimation for the supplier's default risk and over-estimation for the retailer's default risk. We will demonstrate that these problems can be mitigated under joint lending; When the procurement contract is used for bank lending, since the monitoring task on supplier's effort and capital decisions can be rendered to the retailer's procurement contract, the supplier's optimal effort and capital levels can be secured, and there will be no credit rationing problem for the supplier. The joint default probability is lower under joint lending.

Apart from external bank credits, the alternative channel of funding is trade credit financing, where one firm extends its credit to an upstream/downstream partner using short-term loans (i.e., accounts payable or accounts receivable) (Yan et al., 2016). Most of the literature addresses the cases where the supplier deliberately delays collecting the payment, so that the downstream retailer has enough capital for production. However, according to the sequence of actions in production, this payment is supposed to be paid to the supplier after the retailer's value is realized. Delaying to collect this payment for a longer period cannot help with the retailer's production decisions. Moreover, since trade credit is issued after production and shipment, offering to pay the procurement payment earlier to the supplier cannot help to monitor the supplier's current production either. Thus, trade credit cannot help to mitigate the moral hazard problem and may lead to sequential trade credit losses.

From this aspect, our paper provides a new model for bank financing, where the procurement contract is used to monitor the supplier's effort, enhance the benefits of bank financing and mitigate the moral hazard problems in the up-down directed structure with a supplier and a retailer. In addition, our paper provides the first attempt to incorporate corporate social responsibility and consumers' sustainability awareness into SCF. Our results show that the retailer's CSR expenditure can reduce the retailer's default risk and enhance the joint repayment probability.

The rest of the paper is organized as follows. Section 2 summarizes the related literature

and discusses the contribution of this paper to the existing literature. Section 3 describes a supply chain with a financially constrained supplier and retailer. By characterizing the equilibrium, we demonstrate in Section 4 that SCF with the procurement contract can help the bank monitor the supplier's effort, thus greatly reducing the bank's under-estimation and over-estimation risks as well as the credit rationing problem. We also demonstrate how the retailer's CSR expenditure can increase consumers' brand recognition, better stabilize firm value and decrease the default probability. Section 5 concludes the paper.

2 Related Literature

Our paper is related to the growing contributions that propose new methods for supply chain financing with banks. For example, Tunca and Zhu (2018) considered "*buyer intermediated financing*", where the retailer uses its credit as collateral to help a capital-constrained supplier receive financing from a bank in pre-shipment period. They showed that buyer intermediation in supplier financing can significantly improve supply chain performance because it induces lower interest rates and wholesale prices, increases order quantities and boosts supplier borrowing. Yan et al., (2016) considered bank financing with manufacturer's credit guarantee, i.e., the upstream provides critical credit guarantee to the downstream partner by offering the opportunity to rapid obtain loan from the bank. They showed that the optimal order quantity and wholesale price will be higher under the manufacturer's full credit guarantee. Huang, Wu, and Chiang (2018) proposed "*buyer back purchase order financing*" where a buyer (retailer) uses its purchase order and guarantee as collateral to help a capital-constrained supplier get financing from a bank in pre-shipment period. They found that the buyer's guarantee provision is necessary if the buyer's demand is large, the supplier's own capital is short, or the market financing interest rate is high. Slightly differently, Reindorp, Tanrisever, and Lange (2018) and Wu (2017) analyzed "*purchase order financing*' where the supplier uses purchase order from a retailer (buyer) as a collateral to get lending from a bank in pre-shipment period. They showed that the purchase order financing can constitute valuable information about the supplier's demand prospects, thereby extending her access to capital.

Our paper also suggests that a downstream retailer's procurement contract can be used as collateral to help a capital-constrained supplier receive financing from a bank in pre-shipment period. The difference is: we focus on the moral hazard problems in a

joint lending framework. We show that due to the moral hazard problems, in an up-down directed supply chain structure,[4] the bank under separate lending will bear the risks of under-estimating the supplier's default risk and over-estimating the retailer's default probability, in addition to the conventional credit rationing problems.

In respect of monitoring, we argue that trade credit financing (or reverse factoring (RF)) cannot help improving the retailer's moral hazard problem. Thus, our paper provides a different viewpoint from the literature comparing financing with trade credit and financing with bank credits. For example, Kouvelis and Zhao (2012) showed that when bank loans are competitive priced, supplier early payment discount scheme will induce the supplier finance the retailer at the rates less or equal to the risk-free rate. Jing et al. (2012) showed that the manufacturer should promote trade credit financing when its production cost and demand variability are relatively low or the retailer's internal capital is relatively low. Cai, Chen, and Xiao (2014) concluded that when the bank credit market is more competitive than the trade credit market, the retailer borrows bank credit prior to trade credit, but switches to exhausting the trade credit limit prior to borrowing bank credit as the internal capital declines. Chod (2016) identified that, by tying financing with physical transactions, trade credit controls the buyer's opportunistic behavior and shows that a combination of bank and supplier financing allows the retailer to get the best of both worlds. Yang and Birge (2017) theoretically and empirically showed when bank and supplier financing can be jointly used, trade credit, acting as demand risk-sharing mechanism, is preferred to bank financing. Tang et al. (2017) showed that the two finance strategies yield the same profit for the manufacturer if there is no information asymmetry, and buyer finance is better than bank finance only if the manufacturer has superior information about the supplier's effort than the bank. Deng et al. (2018) compared buyer finance with bank finance in a supply chain with one assembler and multiple heterogeneous capital-constrained component suppliers. They showed that in buyer finance the assembler should charge the suppliers the lowest possible interest rate, which may be even below its own unit capital opportunity cost, leading to interest losses in financing suppliers. However, the assembler can benefit more from enhanced inventory backup and lower component purchasing prices resulting from the low buyer-finance interest rate. These benefits of buyer finance manifest the advantage of integrating both finance and operations decisions. Fabbri and Menichinin (2016) presented

[4]Raghavan and Mishra (2011) also considered the up-down structure in supply chain. They showed that joint lending is better off for the bank and both supplier and retailer.

a new theory of trade credit in which firms can purchase inputs on credit from suppliers and the suppliers observe the input investment and guarantee purchase of quantity of inputs in the financial contracts, thus restoring the benefit of bank financing. Both Fabbri and Menichinin (2016) and our paper investigate the moral hazard problem in bank financing and show that purchase order contract can be used as collateral to mitigate this problem. However, in our paper the purchase order or procurement contract is proposed by a firm with good credit under joint lending and thus this firm does not need to purchase inputs on credit from the supplier for guarantee.

Finally, there is increasing attention on promoting participation in CSR activities in supply chains (Agrawal and Lee, 2017; Huang, Song, and Swinney, 2017; Cho et al., 2018; Plambeck and Taylor, 2016; Chen and Lee, 2016; Chen, Yao, and Zhu, 2016; Iyer and Singh, 2017; Kim, 2015; Kraft et al., 2013a, Kraft et al., 2013b). This line of literature centers on designing mechanisms or incentives to encourage supply chain members to engage in CSR activities. Recently, attention has been shifted to not only SCF but also its impacts on sustainability and CSR. Several examples have demonstrated that SCF can also be a force for social change, helping suppliers improve their environmental sustainability performance as well as enhancing their working conditions. For example, organizations such as PUMA and Levi Strauss have discovered how firms' environmental sustainability performance and their working condition could link to their finance rates. In 2016, PUMA set up a new type of SCF one where the finance rates offered to suppliers were directly linked to their sustainability and ethical practices. PUMA and Levi Strauss have a dedicated compliance team in place to visit and monitor suppliers around the world through regular audits.

Our paper contributes to the literature by incorporating CSR and consumers' sustainability awareness into consumers' brand recognition and demonstrates that a firm's CSR expenditure can increase consumers' brand recognition and counteract the negative shocks arising from consumers' sustainability awareness. Moreover, under SCF, this will further reduce the firm's default risk and enhance supply chain production.

3 The Model

We model SCF as a special form of "group lending". In traditional group lending models, the monitoring task[5] relies on social capital within a group such as personal contacts among friends or neighbors in villages (see Armend et al., 2010; Tirole, 2006). Similarly to peer monitoring in group lending, in SCF with procurement contracts, monitoring is embedded in the supplier and retailer relation, in that the procurement contract proposed by the retailer is used to monitor the supplier's effort and capital choices in production. Differently from peer monitoring in group lending, we also consider that the retailer' CSR activities can be used to stabilize the demand shocks caused by consumers' sustainability awareness.

3.1 The Supply Chain

We consider a supply chain comprising with a capital-constrained supplier and retailer. The retailer orders a batch of products q from the supplier, and $T(q)$ indicates the procurement contract. In what follows, we use subscripts s and r to indicate variables for the supplier and retailer, respectively.

The supplier's production technology is uncertain in the sense that q is a function of the supplier's effort $e_s \in R^+$, capital k_s, and a random term $\varepsilon \in (-\infty, \infty)$. The supplier's effort is not observable by the retailer, and the effort cost is an increasing and convex function of effort: $c(e_s)$, where $c'(\cdot) > 0$ and $c''(\cdot) > 0$. We assume that ε is distributed according to $F(.)$ and the mean is zero. To simplify, we assume that

$$q = e_s k_s + \varepsilon.$$

The supplier's output is the sum of effort-capital product and a random term. Since the supplier's effort is unobservable, the procurement contract only depends on the observable output.

The retailer's value function $V(q, e_r, k_r, O)$ is the equilibrium profit in the product market. The retailer's value is concave in output q, and increasing with the retailer's effort $e_r \in R^+$, capital k_r, and a term O which summarizes consumers' brand recognition. We

[5]Kim, Bae, and Oh (2018) examined the moderation effect of marketing activities on the bifurcated relationship between debt level and firm valuation of small and medium enterprises and Lee and Miller (2018) also examined the effect of the covenants of bank debt on the riskiness of that debt.

assume that O is influenced by the demand shock due to consumers' sustainability awareness and the retailer's expenditure on corporate sustainability activities. An example for the demand shock is the awareness for "child labor". Due to extensive media reports, firms that sell products made with child labor have encountered dramatic decline in reputation (Smith 2003). For example, in December 2009, campaigners in the UK called on two leading high street retailers (H&M and Zara) to stop selling clothes made with cotton which may have been picked by children. Anti-Slavery International and the Environmental Justice Foundation (EJF) accused H&M and Zara of using cotton suppliers in Bangladesh. It was also suspected that many of their raw materials originates from Uzbekistan, where children aged 10 are forced to work in the fields. The activists were calling to ban the use of Uzbek cotton and implement a "track and trace" systems to guarantee an ethical responsible source of the material.[6]

Hence firms have undertaken a variety of actions to improve their monitoring on suppliers practices in a more cost-effective manner (U.S. Department of Labor 2000). For example, firms collaborated through Child Labor Elimination Group in the agriculture industry of India or through the Atlanta Agreement in the global footwear industry. A data base system was set up to record information gathered from various auditing programs (e.g., the ILO's International Program on the Elimination of Child Labor). A study by Kraft et al., (2018) showed that consumers' valuations increase with a higher level of supply chain visibility. Moreover, a firm's social responsibility efforts can resonate with this firm's target consumers (with heterogeneous levels of prosociality). For example, a 2007 report claimed some GAP products had been produced by child labours. GAP acknowledged the problem and announced it is pulling the products from its shelf.[7] The New York Times reported that GAP, after the child labour report, created a $200,000 grant to improve working conditions in the supplier community.

To incorporate these evidences, we assume that

$$O(S, \mu) = S + \mu,$$

meaning that the consumers' brand recognition is comprised of a nonpositive random term $\mu \in (-\infty, 0]$ indicating the decrease in demand due to consumers' sustainability awareness,

[6] https://en.wikipedia.org/wiki/Child_labour

[7] McDougall, Dan (28 October 2007). "Child sweatshop shame threatens Gap's ethical image" The Guardian.

and the retailer's expenditure on corporate sustainability activities: $S \in [0, \infty)$. If there is no demand shock due to consumers' sustainability awareness, a higher S can increase consumers' brand recognition and increase firm value. If there is a negative demand shock, higher S can counteract the negative effect on firm value. We assume that μ is distributed according to the distribution $G(\cdot)$ and the mean is zero. Finally, the retailer's effort cost $c(e_r)$ is increasing and convex in e_r, and the expenditure on corporate sustainability activities is simply S.

3.2 External Funding and Sequence of Actions

We assume that the capital-constrained supplier and retailer need external funding L_s and L_r, respectively, to pay the capital needed for the production (i.e., k_s and k_r) as well as the effort costs. To simplify, we assume that a commercial bank provides the only source for external funding. The commercial bank charges the competitive interest rates r_s and r_r for the supplier and retailer, respectively. To describe that the retailer has cheaper access to loans, we assume $r_s > r_r$.

Next, we assume the following sequence of actions.

(1) Under demand uncertainty, the retailer chooses the purchase amount q^* to maximize its expected value with the procurement contract $T(q)$, subject to the supplier's individual rationality constraints (IR), and incentive compatibility constraints (IC), given the supplier's optimal choices on e_s and k_s.

(2) The supplier and the retailer seek for external funding L_s and L_r, respectively, from the commercial bank. With demand uncertainty and not knowing the supplier and retailer's effort decisions, the bank needs to decide whether to provide these loans to them. If any of them cannot receive funding, the production will not proceed. We will consider two schemes: separate lending and joint lending. For joint lending, the procurement contract is used to represent the supplier's revenue for the bank loan L_s.

(3) If the loan L_s and L_r are provided by the commercial bank, the supplier, given the order q^*, now chooses the least effort and capital to achieve this amount, considering that the production is affected by the random term ε. After the supplier's effort and capital decisions, ε is realized and the actual production is denoted by $\widehat{q}$, which can be greater or smaller than q^*.

(4) The amount $min\{\widehat{q}, q^*\}$ is shipped to the retailer, who will seek for the least effort,

capital and CSR expenditure to maximize the firm value V, considering that the consumers' brand recognition $O(S, \mu)$. After the retailer's effort, capital decisions and CSR expenditure decisions, μ is realized and the firm value V is realized. If the retailer remains solvent, $T(min\{\widehat{q}, q^*\})$ is paid to the supplier, and $(1 + r_s)L_s$ and $(1 + r_r)L_r$ are paid back to the bank.

4 Characterization of Equilibrium

We will solve the game by backward induction.

4.1 Stage Four

In the final stage, the amount $min\{\widehat{q}, q^*\}$ is shipped to the retailer. The retailer chooses e_r, k_r and S to maximize the net expected firm value. That is,

$$\max_{e_r, k_r, S} E(V(min\{\widehat{q}, q^*\}, e_r, k_r, O(S, \mu)) - (T(min\{\widehat{q}, q^*\}) + c(e_r) + S) + (L_r - k_r).$$

First, the first order condition (FOC) of maximization for e_r is

$$E(V_{e_r}(\cdot)) = c'(e_r),$$

and we denote the optimal effort level by e_r^*. It is interesting to see that the retailer's effort will increase with the amount of products shipped to the retailer; that is, by the implicit function theorem we have

$$\frac{de_r^*}{dq^*} = \frac{E(V_{e_r min\{\widehat{q}, q^*\}}(\cdot))}{c''(e_r)} > 0.$$

Second, the FOC of maximization for k_r is

$$E(V_{k_r}(\cdot)) = 1,$$

and we denote the optimal capital level by k_r^*. Third, the FOC of maximization for S is

$$E(V_O(\cdot))(O_S) = 1,$$

and we denote the optimal expenditure on corporate sustainability activities by S^*.

Given the optimal choices of e_r^*, k_r^*, and S^*, and for any realized value of μ, the retailer's realized net value is

$$V(min\{\widehat{q}, q^*\}, e_r^*, k_r^*, O(S^*, \mu)) - (T(min\{\widehat{q}, q^*\}) + c(e_r^*) + S^*) + (L_r - k_r^*),$$

where $T(min\{\widehat{q}, q^*\})$ represents the payment for the shipped products if the retailer remains solvent. A high level of μ indicates more decrease in demand due to consumers' sustainability awareness, and this will decrease the retailer's realized payoff $V(\cdot)$ and increase the possibility of insolvency. Contrarily, a higher level of S^* can counteract this negative effect on the retailer's firm value and enhance the retailer's solvency.

Let μ^* be the critical value for

$$V(min\{\widehat{q}, q^*\}, e_r^*, k_r^*, O(S^*, \mu^*))\text{-}(T(min\{\widehat{q}, q^*\})+c(e_r^*)+S^*)+(L_r\text{-}k_r^*)\text{-}(1+r_r)L_r=0. \quad (1)$$

The retailer remains solvent if $\mu \geq \mu^*$. Given the distribution of μ, the probability that the retailer defaults will be $Prob.(\mu < \mu^*) = G(\mu^*)$.

The probability of default will decrease with the retailer's CSR expenditure, as by applying the implicit function theorem on equation (1), we have:

$$\frac{\partial \mu^*}{\partial S^*} = -\frac{(V_O O_{S^*} - 1)}{V_O O_{\mu^*}} < 0.$$

Hence, $\frac{\partial G(\mu^*)}{\partial S^*} < 0$. That is, higher CSR expenditure will decrease the critical demand shock μ^*, and reduces the retailer's default probability.

Lemma 1 *A higher CSR expenditure can reduce the retailer's default probability.*

This lemma is consistent with recent trend in global supply chains of goods and services. While global supply chains now extend into developing countries due to outsourcing, the working conditions in supplier factories have often been found below working standards, which are routinely referred to as "sweatshops". Recent examples include the widely publicized building collapse due to poor maintenance in a garment factory in Bangladesh (Greenhouse 2013), overworked employees in Chinese electronic manufacturing units (Svensson 2012), and inadequate worker safety procedures in Samsung's manufacturing unit in Brazil (Pearson 2013).

Motivated by the challenge of ensuring safe factory working conditions in globally distributed supply chains, scholars have started to explore the roles of CSR activities in business transactions transcending firm and country boundaries (e.g., Distelhorst et al., 2016; Carroll et al., 2012). It is believed that firms are responsible for managing both economic and noneconomic practices, and for creating shareholder values by meeting the needs of nonshareholding stakeholders (Pigors and Rockenbach 2016, Guo et al., 2015).

Firms not only need to manage their own businesses but also take the responsibilities for their suppliers' factories (Short et al., 2015). This focus has significant implications for ensuring consumer confidence in firms' products, and accordingly, their profitability.

4.2 Stage Three

In the third stage, given the ordered amount q^*, the supplier minimizes its effort and capital costs

$$\min_{\{e_s,k_s\}} c(e_s) + k_s,$$
$$s.t.\ E(e_s k_s + \varepsilon) = q^*.$$

We can rewrite this minimization problem as a maximization problem, where the Lagrangian is

$$\mathcal{L} = c(e_s) - k_s + \lambda[E(e_s k_s + \varepsilon) - q^*],$$

where λ denotes the Lagrange multiplier on the production constraint.

The FOC for e_s and k_s are $\frac{\partial \mathcal{L}}{\partial e_s} = 0$ and $\frac{\partial \mathcal{L}}{\partial k_s} = 0$, respectively, and hence the optimal effort and capital levels are

$$k_s^* = \frac{c'(e_s)}{\lambda} \quad \text{and} \quad e_s^* = \frac{1}{\lambda}.$$

Replace $\frac{1}{\lambda}$ by e_s^*, so the optimal capital can be rewritten as $k_s^* = c'(e_s^*)e_s^*$. By the production constraint $E(e_s^* k_s^* + \varepsilon) = q^*$, we can conclude that the optimal effort choice e_s^* needs to satisfy

$$c'(e_s^*)(e_s^*)^2 = q^*.$$

That is, as the order increases, the supplier's effort will increase.

Given the optimal choices of e_s^* and k_s^*, for any realized value of random shock, $\widehat{\varepsilon}$, the realized production is $\widehat{q} = e_s^* k_s^* + \widehat{\varepsilon}$. Then, the amount $min\{\widehat{q}, q^*\}$ will be shipped to the retailer according to the procurement contract. If $\widehat{q} > q^*$**,** then we assume an exogenously given competitive price p^I for the inventory. The supplier's realized payoff is therefore

$$T(min\{\widehat{q}, q^*\}) + p^I \max\{0, \widehat{q} - q^*\} - c(e_s^*) + (L_s - k_s^*).$$

After substituting the values of $q^* = c'(e_s^*)(e_s^*)^2$ and $\widehat{q} = c'(e_s^*)(e_s^*)^2 + \widehat{\varepsilon}$, we have $\widehat{q} - q^* = \widehat{\varepsilon}$, and the realized profit becomes:

$$T(min\{q^* + \widehat{\varepsilon},\ q^*\}) + p^I \max\{0,\ \widehat{\varepsilon}\} - c(e_s^*) + (L_s - c'(e_s^*)e_s^*),$$

where $p^I \max\{0, \widehat{\varepsilon}\}$ represents the revenue from the inventory if realized shock $\widehat{\varepsilon}$ is higher than 0.

Let ε^* be the critical value for $\widehat{\varepsilon}$ to satisfy the indifferent condition for solvency:

$$T(min\{q^*+\widehat{\varepsilon},\ q^*\}) + p^I \max\{0,\ \widehat{\varepsilon}\} - c(e_s^*) + (L_s - c'(e_s^*)e_s^*) = (1+r_s)L_s, \tag{2}$$

where $(1+r_s)L_s$ is the repayment to the commercial bank. Given the distribution of ε, the supplier's default risk is given by $\Pr(\widehat{\varepsilon} < \varepsilon^*)$, which is $F(\varepsilon^*)$ by definition.

However, since the supply chain is directed in the sense that if the downstream retailer defaults, the upstream supplier will not receive the compensation $T(.)$, so the supplier will default, too. But it is not true for the other way round. Hence the supplier's total default probability is:

$$G(\mu^*) + (1 - G(\mu^*))F(\varepsilon^*).$$

That is, the supplier will default if (i) the retailer defaults and cannot pay the compensation; (ii) In the case where the retailer remains solvent, the received compensation is not enough to cover the effort and capital costs and repay the money to the bank (i.e., $F(\varepsilon^*)$). This probability is also higher than $F(\varepsilon^*)$ as it can be rewritten as $F(\varepsilon^*) + G(\mu^*)(1 - F(\varepsilon^*))$, which is greater than $F(\varepsilon^*)$. The extra risk $G(\mu^*)(1 - F(\varepsilon^*))$ measures the risk contagion from the downstream retailer. Alternatively, the upstream supplier has higher default risk as $G(\mu^*) + (1 - G(\mu^*))F(\varepsilon^*) > G(\mu^*)$.

Proposition 2 *(i) The upstream supplier has higher default risk than the retailer; (ii) The risk contagion from the downstream retailer is* $G(\mu^*)(1 - F(\varepsilon^*))$.

4.3 Stage Two

In the second stage, the commercial bank decides whether to lend L_s and L_r to the supplier and the retailer, respectively. We consider two schemes: separate lending and joint lending where the supplier uses the procurement contract to borrow money from the bank.

4.3.1 Separate Lending

We first discuss the decisions under separate lending. Since the commercial bank cannot observe the supplier and retailer's effort and capital decisions, we assume for simplicity that the historical effort and capital levels for the both supplier and retailer are the same and

equal to e^0 and k^0. For separate lending, the commercial bank has independent evaluation about the supplier's revenue, which we simplify as $R(Eq(e^0, k^0))$, where the expectation is taken over the distribution of ε. We assume that the commercial bank also believes that the random terms ε and μ are distributed according to $F(.)$ and $G(.)$, respectively.

First, the bank perceives that the supplier's expected payoff is

$$R(Eq(e^0, k^0, \varepsilon)) - c(e_s) + (L_s - k_s). \tag{3}$$

The bank will lend L_s to the supplier if

$$R(Eq(e^0, k^0, \varepsilon)) - c(e^0) + (L_s - k^0) - (1 + r_s)L_s \geq 0.$$

Let ε^0 be the critical value of random term such that

$$R(e^0 k^0 + \varepsilon^0) - c(e^0) + (L_s - k^0) - (1 + r_s)L_s = 0.$$

Thus, under separate lending, the perceived probability of default is when $\varepsilon < \varepsilon^0$, which is denoted as $F(R, \varepsilon^0)$.

There can be two types of mistakes for the bank. First, even when the compensation scheme is known and hence $R(\cdot)$=$T(\cdot)$ and if the historical effort and capital levels (e^0 and k^0) are smaller than the optimal effort and capital levels (e_s^* and k_s^*), the critical value of random term will be higher under separate lending (i.e., $\varepsilon^* < \varepsilon^0$). This is the conventional *credit rationing* problem,[8] whose probability is measured by $F(R, \varepsilon^0) - F(\varepsilon^*)$.

Second, as we have demonstrated, the supply chain is a directed network and there will be risk contagion from downstream retailer. So, contrary to the credit rationing problem, even when the compensation scheme is known (i.e., $R(\cdot)$=$T(\cdot)$), there can be a chance that the supplier's default risk is underestimated because the risk contagion $G(\mu^0)(1 - F(\varepsilon^0))$ is not considered by the commercial bank.

Proposition 3 *Under separate lending to the supplier, there can be two types of mistakes from bank: (i) the credit rationing problem; (ii) the risk under-estimation from downstream contagion.*

[8] Holmstrom and Tirole (1998) provided an example of credit rationing where asymmetric information lead to moral hazard problem. They pointed out that the lenders cannot observe the borrowers' behaviour implies that there is a minimum level of firm assets needed for banks to provide the loan. If a firm does not have the minimum amount of assets available, then its project will not be financed.

Next, we assume that the retailer is a core business and hence the commercial bank knows better about the retailer and both $V(\cdot)$ and $T(\cdot)$ are known by the bank. Let S^0 denote the historical expenditure on CSR activities. So, the bank perceives that the retailer's expected payoff is:

$$EV(Eq, e^0, k^0, O(S^0)) - (T(Eq) + c(e^0) + S^0) + (L_r - k^0). \tag{4}$$

The bank will lend L_r to the retailer if

$$EV(Eq(e^0, k^0), e^0, k^0, O(S^0))\text{-}(T(E(q(e^0, k^0))+c(e^0)+S^0)+(L_r\text{-}k^0)\text{-}(1+r_r)Lr \geq 0.$$

Let μ^0 be the value of random term such that

$$V(E(q(e^0, k^0))), e^0, k^0, O(S^0))\text{-}(T(E(q(e^0, k^0))+c(e^0)+S^0)+(L_r\text{-}k^0)\text{-}(1+r_r)Lr = 0.$$

Thus, under separate lending, the perceived probability of default is when $\mu < \mu^0$, which is denoted as $G(\mu^0)$.

Comparing μ^0 to μ^* in stage two, we can also conclude two types of mistakes from bank in making loans to the retailer. First, if the historical effort and capital levels (e^0 and k^0) are smaller than the optimal effort and capital levels (e_r^* and k_r^*), the critical value of random term will be higher under separate lending (i.e., $\mu^*<\mu^0$). This is the *credit rationing* problem, whose probability is measured by $G(\mu^0) - G(\mu^*)$.

Second, even when the historical effort and capital levels are equal to the optimal levels (i.e., e^0=e_r^* and k^0=k_r^*), there is an over-estimation in default risk if the supplier's historical effort and capital levels are lower than the optimal ones (i.e., $e^0 < e_s^*$ and $k^0 < k_s^*$). This is the risk contagion from upstream supplier. So, in addition to the credit rationing problem, there can be a chance that the retailer's default risk is overestimated because the risk contagion is taken into account by the commercial bank.

Proposition 4 *Under separate lending to the retailer, there can be two types of mistake from bank: (i) the credit rationing problem; (ii) the risk over-estimation from upstream contagion.*

Overall, if the historical data on the retailer and supplier's effort and capital levels are lower than the optimal ones, then there will be conventional credit rationing problems. Moreover, since the supply chain network is directed, there will be under-estimation for the supplier's perceived default risk, and contrarily there will be over-estimation for the retailer's perceived default risk.

4.3.2 Joint Lending

Under joint lending, the supplier uses the procurement contract $T(q)$ to borrow L_s from the bank, so the bank's evaluation about the supplier's revenue is $E(T(q(e,k))$. Here the procurement is well designed so that the supplier will put in the optimal effort and capital levels: e_s^* and k_s^*. However, since the retailer's effort, capital, and CSR expenditure decisions are still unknown, so we keep the same assumptions on e^0, k^0 and S^0.

The joint profit for lending $(L_s + L_r)$ is hence:

$$EV(Eq(e_s^*, k_s^*), e^0, k^0, O(S^0)) - (c(e^0) + S^0) + (L_r - k^0) - c(e_s^*) + (L_s - k_s^*). \quad (5)$$

The bank will approve this joint loan if

$$EV(Eq(e_s^*, k_s^*), e^0, k^0, O(S^0))\text{-}(c(e^0)+S^0)+(L_r\text{-}k^0)\text{-}c(e_s^*)+(L_s\text{-}k_s^*) \geq (1+r_s)L_s+(1+r_r)Lr.$$

Let μ^J be the value of random term such that

$$V(Eq(e_s^*, k_s^*), e^0, k^0, O(S^0))\text{-}(c(e^0)+S^0)+(L_r\text{-}k^0)\text{-}c(e_s^*) + (L_s\text{-}k_s^*) - [(1+r_s)L_s+(1+r_r)Lr]=0.$$

Compare this joint profit to the sum of individual profits under separate lending (equations (3) and (4)):

$$\begin{aligned} &V(Eq(e^0, k^0)), e^0, k^0, O(S^0)) + [R(Eq(e^0, k^0)) - T(Eq(e^0, k^0)] \\ &-(c(e^0) + S^0) + (L_r - k^0) - c(e^0) + (L_s - k^0) - [(1 + r_s)L_s + (1 + r_r)Lr]. \end{aligned}$$

When the compensation scheme is known and hence $R(Eq(e^0, k^0)) - T(Eq(e^0, k^0) = 0$, under joint lending, the supplier's optimal effort and capital levels are ensured by the procurement contracts, hence there will be no credit rationing problem for the supplier. By the same reason, the overestimation in default risk due to the undervalued effort and capital levels also disappears as e_s^* and k_s^* are ensured in the procurement contract.

Next, we compare μ^J (joint lending) with μ^0 (separate lending). Recall that μ^0 is the value of random term such that

$$V(Eq(e^0, k^0)), e^0, k^0, O(S^0)) - (T(Eq(e^0, k^0) + c(e^0) + S^0) + (L_r - k^0) - (1 + r_r)Lr = 0.$$

In the definition of μ^J, the supplier's expected payoff is added in the above equation. Given that the bank will lend L_s, this expected payoff will be nonnegative. Hence the joint lending profit in equation (5) will be higher than the above equation. Moreover, since the optimal

effort and capital levels are secured in the procurement contract, $Eq(e^*, k^*)$ is higher than $Eq(e^0, k^0)$ in the definition of μ^J. Therefore, the critical value μ^J will be smaller than μ^0. Hence $G(\mu^J) < G(\mu^0)$, indicating that the joint default probability under joint lending (*i.e.*, $G(\mu^J)F(\varepsilon^*)$) will be smaller than the joint default probability under separate lending (i.e., $G(\mu^0)F(\varepsilon^0)$).

Proposition 5 *The joint default probability is lower under joint lending.*

As described, with joint lending, the monitoring task on the supplier's effort and capital decisions can be rendered to the retailer's procurement contract. Thus, the supplier's optimal effort and capital levels are secured, hence there will be no credit rationing problem for the supplier. For the retailer, the over-estimation in default risk (due to the undervalued effort and capital levels) also disappears. Therefore, the joint default probability is lower under joint lending.

4.4 Stage One

In the first stage, the retailer needs to determine the order q^*, which is the amount of product that maximizes the retailer's profit given the retailer's optimal effort, capital and CSR decisions: e_r^*, k_r^* and S^*. $T(q)$ is the cheapest rent to satisfy both the individual rationality (IR) and incentive compatibility (IC) constraints, where[9]

$$\begin{aligned} \textbf{IR} \quad &: \quad T(q) - c(e_s) + (L_r - k_s) \geq 0. \\ \textbf{IC} \quad &: \quad (e_s)^2 \times c'(e_s) = q, \\ &\qquad k_s = c'(e_s)e_s. \end{aligned}$$

Let $e_s^*(q)$ and $k_s^*(q)$ denote the supplier's optimal effort and capital choices satisfying the IC constraint. Substitute $e_s^*(q)$ and $k_s^*(q)$ into IR and let the IR constraint bind, i.e.,

$$T^*(q) = c(e_s^*(q)) + k_s^*(q) - L_s.$$

It is important to notice that under $T(q)$, the optimal effort and capital levels will be secured. So, under joint lending, the supplier will choose the optimal effort and capital level. Moreover, since c is increasing and convex, $T(q)$ is increasing and convex in the observable output q.

[9] The value of outside option is assumed 0.

Substitute the definition of $T^*(q)$ in the retailer's expected profit function, then the maximization problem becomes:

$$\max_q E(V(q, e_r^*, k_r^*, O(S^*))) - [c(e_s^*(q)) + k_s^*(q) - L_s] - c(e_r^*(q)) + (L_r - k_r^*(q)) - S^*(q).$$

The order q^* is chosen so that the supply chain's marginal value equals to the overall effort and capital costs and CSR expenditure.

5 Concluding Remarks

Due to the advancement in information technology, supply chain data becomes available and can be used to track enterprises' production and procurement capacities, especially for capital-constrained enterprises. Supply chain finance, which aims to diversify sources of the financially constrained enterprises and substantially improves the financial efficiency of entire supply chain, has gained much attention recently. Among the two types of SCF, trade credit financing, which allows a firm to extend its credit to an upstream or downstream partner using short-term loans, was proved by both academia and business practices to be a useful method to utilize internal capital in the supply chain. However, increasing evidence shows that many firms face trade credit losses as both trade debtor failures and creditors' bankruptcy risks increase with the size of incurred losses. Recently, several new methods have been proposed for SCF with bank credits, but none of them mentions how to solve the borrowers' moral hazard problems in SCF. These are related to the borrower's repayment abilities which are important issues in banks' loan decisions.

This paper has examined the *moral hazard problems* in supply chain financing with procurement contract (or purchase order). We show that since supply chain is an up-down directed structure, when financing with the supplier's procurement contract, the supplier's effort monitoring task can rendered to the procurement contract, which can secure the supplier's optimal effort and capital choices in production. Hence, compared to separate lending, the supplier's credit rationing problem can be mitigated, and most importantly, the banks' under-estimation on the suppliers' default risk and the over-estimation on the retailer's default risk can be decreased. Our study contributes to the literature of novel SCF schemes with bank credit by developing a theory of bank financing with procurement contract which can enhance the benefits of bank financing and mitigate the moral hazard problems. Finally, we show that the retailer's CSR expenditure can increase consumers'

brand recognition, thus when facing demand shocks arising from consumer's unexpected concerns, the retailer can better stabilize firm value.

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