Supply Chain Finance: The Operational Benefits

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Motivation

• As business expands (e.g., globalization), working capital is tight within its supply chains
• Financial institutes use Supply Chain Finance (SCF) to provide short-term credit to optimize working capital for both seller and buyer
• In the US, SCF is defined as Reverse Factoring
  – Buyer (with better credit rating) helps seller to obtain cheaper finance than under factoring—seller sells its receivables
• In China, SCF also includes Inventory Finance
  – Seller (with better credit rating) helps buyer to obtain (cheaper) finance by committing to buyback excess inventory
Reverse Factoring (payment guarantee)

Inventory Finance (buyback)

Upstream

Downstream
Practice Example

- A Chinese commercial bank provides Difference Repurchase (DR) contract to car dealers with car maker buys back unsold cars (difference) at time $T$, where $[0,T]$ is the sales period
  1. Dealer sets order quantity and pays deposit to the bank, usually 30-40% of total cost (at time 0)
  2. Bank issues commercial draft to car maker with maturity time $T$ (at time 0)
  3. Car maker sends cars to the dealer and certificates to the bank (at time 0)
  4. Dealer redeems certificates after sales during $(0,T)$
  5. Car maker buys back unsold cars and collects money from bank (at time $T$)
An Example (wholesale price=$10k, retail price=$15k, dealer’s initial wealth=$200k)

- **Trade credit**
  - Car maker sends 100 cars (of cost $1M) to a dealer
  - Dealer sells for a month
  - If 100 sold
     - Dealer earns $500k profit, pays car maker in full
     - Car maker receives $1M
  - If 30 sold
     - Dealer earns 0, pays $450k+200k (< $1M)
     - Car maker receives $650k

- **DR (SCF)**
  - Dealer pays 30% deposit of $300k, bank issues car maker commercial draft of $1M
  - Car maker sends 100 cars to dealer and the car certificates to bank
  - If 100 sold
     - Dealer earns $500k profit, pays bank $700k (in addition to deposit)
     - Car maker receives $1M
  - If 30 sold
     - Dealer earns $150k profit, pays bank 0
     - Car maker buys back 70 unsold and pays $700k to bank, receiving $300k net
Research Question

• It’s known SCF provides unique financial benefits to core enterprises in supply chains
  – Improved on-book financial performances and affordable finance to their small supply chain partners (upstream and downstream)
• Any operational benefits? Earn more profit?
• How should supplier choose financing schemes, internal finance (trade credit) or SCF?
Single-Period Model I: Trade Credit

- 1-supplier (big, principle) and 1-retailer (small and capital constrained, agent)
- Supplier: sets wholesale price $w_t$ (paid at the end)
- Retailer: set order quantity $q$, responding to $w_t$
  - Initial wealth $\eta$
  - Face uncertain demand $D$
  - Sell at unit price $p$ (sales volume=$\min\{D,q\}$)
  - Holding cost and salvage value are assumed 0
  - Payment of $w_tq$ with probability $\beta$ (assumed binary, pay or no pay, independent of its revenue earned)
Model I: Trade Credit

Step 1: Retailer sets optimal order quantity $q^*(w_t)$

$$\max_{q \geq 0} \pi_r(q|w_t) = \frac{1}{1 + r_r} \{ pE[D \wedge q] - \beta E[w_tq \wedge (\eta(1 + r_r) + pD)] \}.$$ 

Step 2: Supplier sets optimal $w^*_t$, knowing retailer’s $q^*(w_t)$

$$\max_{w_t \in \left(\frac{c(1+r_s)}{\beta}, p\right)} \pi_s(w_t) = \frac{\beta}{1 + r_s} \left[ \eta(1 + r_r) + p \int_{0}^{d_t^*(w_t)} \tilde{F}(x) dx \right] - cq^*(w_t).$$

Supply chain’s profit evaluated at time $T$ (rather than time $0$) is:

$$\pi_c = \pi_r + \pi_s = pE[D \wedge q] - c(1 + r_s)q.$$
Model II: SCF (DR)

1. 1-supplier (big, principle), 1-retailer (small and capital constrained, agent), and 1 bank
2. Bank: requires deposit of $\alpha w_d q$ from retailer
3. Supplier: sets wholesale price $w_d$ (paid by bank)
   - Payment of $w_d(q-S)$ to bank
4. Retailer: set order quantity $q$, responding to $w_d$
   - Initial wealth $\eta$ (must be enough to pay deposit $\alpha w_d q$)
   - Face uncertain demand $D$
   - Sell at unit price $p$ (sales volume $S=\min\{D,q\}$)
   - Payment of $w_d S$
Model II: DR

Step 1: Retailer sets optimal order quantity \( q^*(w_d) \)

\[
\max_{q \leq \frac{\eta}{\alpha w_d}} \pi_r(q|w_d) = \frac{1}{1 + r_r} \left\{ (p - w_d)E[D \land q] + \alpha w_d q (1 + r_f) \right\} - \alpha w_d q.
\]

Step 2: Supplier sets optimal \( w^*_d \), knowing retailer’s \( q^*(w_d) \)

\[
\max_{w_d \in (c(1+r_s), \frac{p}{1+\alpha(r_r-r_f)})} \pi_s(w_d) = \frac{1}{1 + r_s} E [w_d (D \land q^*(w_d))] - cq^*(w_d).
\]

Bought back inventory has no value!
(consistent with the Trade credit model)
Model III: Reverse DR

Step 1: Retailer sets optimal order quantity \( q^*(w_d) \)

\[
\max_{q \leq \frac{\eta}{\alpha w_r}} \pi_r(q|w_r) = \frac{1}{1 + r_r} \left\{ (p - w_r)E[D \wedge q] + \alpha w_r q (1 + r_f) - \gamma w_r E[(q - D)^+] \right\} - \alpha w_r q.
\]

Step 2: Supplier sets optimal \( w^*_d \), knowing retailer’s \( q^*(w_d) \)

\[
\max_{w_r \in (c(1+r_s), \frac{p}{1+\alpha(r_r-r_f)})} \pi_s(w_r) = \frac{1}{1 + r_s}E \left[ w_r \left( D \wedge q^*(w_r) \right) \right] + \gamma w_r (q^*(w_r) - D)^+] - cq^*(w_r).
\]

Equivalent to buyback at a discounted price, \((1-\gamma)w_r\)!
Model II and III (SCF)

Step 1: Retailer sets optimal order quantity $q^*(w_d)$

$$\max_{q \leq \frac{\eta}{\alpha w_r}} \pi_r(q|w_r) = \frac{1}{1 + r_r} \left\{ (p - w_r)E[D \wedge q] + \alpha w_rq(1 + r_f) - \gamma w_r E[(q - D)^+] \right\} - \alpha w_rq.$$

Step 2: Supplier sets optimal $w^*_d$, knowing retailer’s $q^*(w_d)$

$$\max_{w_r \in (c(1+r_s), \frac{p}{1+\alpha(r_r-r_f)})} \pi_s(w_r) = \frac{1}{1 + r_s} E \left[ w_r(D \wedge q^*(w_r)) + \gamma w_r(q^*(w_r) - D)^+ \right] - cq^*(w_r).$$

Supply chain’s profit evaluated at time $T$ (rather than time 0) is:

$$\pi_c = \pi_r + \pi_s = pE[D \wedge q] - c(1 + r_s)q - \alpha wq(r_r - r_f).$$

May add salvage value for excess inventory, $\pi_c$ will have an additional positive term
Interesting Results

• What type of retailer would supplier prefer to finance through Trade credit?
  – Think from two dimensions: initial wealth ($\eta$) and payment probability ($\beta$)
  – Retailer A with $\eta=500k$, $\beta=95\%$ or Retailer B with $\eta=150k$, $\beta=80\%$?
  – Answer is Retailer B!
Interesting Results

Supplier’s profit under Trade Credit with different types of retailer

![Graph showing the relationship between initial wealth and probability of payment, with different lines indicating different thresholds for profit.]
Interesting Results

• What type of retailer would supplier prefer to finance through Trade credit?
  – Prefer poor, but credible retailers
  – Insights: Since poor retailers are more likely to default (thus paying $pD+\eta$, independent of $q$), they will lower supplier’s profit margins, but order more.
  – Quantity benefit $>$ profit-margin disadvantage!
TC or SCF?

Supplier’s profit under TC/Supplier’s profit under SCF

For most types of retailer, supplier does enjoy operational benefit – a higher expected profit.

Supplier sees a big profit jump from 0!
Operational Change: Wholesale Price

Optimal wholesale price for TC vs SCF

Supplier should raise wholesale price!
Operational Change: Order Quantity

\[ \frac{q^*(TC)}{q^*(SCF)} \]

- Initial Wealth \( n \)
- Probability of Payment \( \beta \)

- Supply should expect a higher production quantity! (\( >100\% \))
- Supply should expect a lower production quantity! (\( <100\% \))
- Supply should expect a higher production quantity! (\( >200\% \))
- Supply should expect a higher production quantity! (\( 400-700\% \))
How should supplier compare TC with SCF?

• TC (direct finance)
  – Bear retailer’s default and credibility risks => indirectly bear demand risk
    • Pros: encourage a bigger order quantity
  – Supplier and retailer share demand risk

• SCF (indirect finance)
  – Shield from retailer’s default and credibility risks
    • Pros: better control of profit margin
  – Buyback excess inventory => supplier directly bear demand risk alone
Any questions?
How should supplier compare TC with SCF?

• TC (direct finance)
  – Bear retailer’s default and credibility risks => indirectly bear demand risk
    • Pros: encourage a bigger order quantity

• SCF (indirect finance)
  – Shield from retailer’s default and credibility risks
    • Pros: better control of profit margin
  – Buyback excess inventory => directly bear demand risk

• Retailer’s default risk and credibility risk have same type of effect on order quantity

\[ \text{sgn} \left( \frac{dq^*(w_t)}{d\beta} \right) = \text{sgn} \left( \frac{dq^*(w_t)}{d\eta} \right) \]
Relevant Literature

• Supplier Finance
  – Trade credit:
    • “…industries with higher dependence on trade credit financing exhibit higher rates of growth in countries with weaker financial institutions.” – Fisman and Love (2003)
    • “The retailer, if offered an optimally structured trade credit contract, will always prefer supplier financing to bank financing.” – Kouvelis and Zhao (2012)
  – Buyback contract:
    • It improves supply chain efficiency (increases the supply chain profit) and some buyback prices create win-win situation for supplier and retailer – Pasternack (1985)
Relevant Literature

• SCF

  – Buyer intermediated Finance (BIF)
    • Use JD.com (the buyer) as an example to analyze the interaction between product defect and BIF -- Tunca and Zhu (2015) working paper

  – SCF with Buy-back contracts
    • Use Cherry auto (the seller) as an example to analyze the impact of SCF on operational decisions – Tunca and Zhu (2015) working paper