E-commerce retail and reverse factoring: A newsvendor approach

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Abstract: This study builds a theoretical model to examine how supply chain finance (SCF) services using fintech can ease e-commerce suppliers’ capital constraints. Despite the innovation in the logistics industry during the Fourth Industrial Revolution and the acceleration of e-commerce in the post-COVID era, small e-commerce enterprises may fail to grow owing to their budget constraints. Reverse factoring is believed to ease such suppliers’ capital constraints. We analyze the effect of reverse factoring using the capital-constrained newsvendor model, and we consider the impacts of additional funding from SCF services. Our results show that SCF services reduce e-commerce suppliers’ orders and, thus, alleviate their budget constraints. This finding suggests that the discount factor of reverse factoring should be higher to ease small suppliers’ budget constraints and allow the e-commerce industry to grow sustainably.

Keywords: E-commerce retail; FinTech; Newsvendor model; Small enterprise; Supply chain finance

JEL Classification: M21; O12; O16

1. Introduction
In the logistics industry, digital transformations using fintech and information technologies have
improved the efficiency of online-to-offline connections in the retail industry (Einav, Levin, Popov, and Sundaresan, 2014; Jolivet and Turon, 2019; Ko, Lee, and Ryu, 2018; Lehmacher, Betti, Beecher, Gromemeier, and Lorenzen, 2017; Park and Ryu, 2022). Additionally, e-commerce transaction volumes are increasing as contactless transactions continue to grow following the COVID-19 pandemic (Moretto and Caniato, 2021). Nanda, Xu, and Zhang (2021) show that e-commerce and digitalization in the retail industry have accelerated since the COVID-19 pandemic. This substantial growth in retail orders increases the likelihood of unexpected short-term demand spikes. E-commerce suppliers may not be able to effectively respond to this increasing demand owing to their budgets as it can take several months for them to receive payments. They incur high opportunity costs as a result of delayed payments when their working capital is insufficient (Jin, Luo, and Zhang, 2018; Zhao, Wu, Liang, and Dolgui, 2015). If additional orders are delayed because of a lack of working capital, the associated additional gains are likely to be missed. Delays in the payment process may also delay delivery, which can negatively affect a supplier’s corporate reputation (Matsa, 2011). Numerous small businesses participate in e-commerce, and they need financial services, such as bank financing or trade credit, to provide sufficient working capital (Binh, Jhang, Park, and Ryu, 2020; Park, Jo, and Ryu, 2021).

The adoption of supply chain finance (SCF) is a potential solution to this problem. Traditional discussions of supply chain management (SCM) focus on optimizing logistics rather than financial processes. However, as the importance of financial management increases, financial supply chain management (FSCM) is being actively discussed (Dekkers, de Boer, Gelsomino, de Goeij, Steeman, Zhou, Sinclair, and Souter, 2020). FSCM refers to the minimization of financial costs in a supply chain. SCF is a way to achieve FSCM; it mainly refers to the financial services used to rapidly provide working capital to supply chain participants to enhance supply chain efficiency. The payment system is especially important for adjusting a supply chain to improve its financial performance through cash flow optimization (Qin, Han, Wei, and Xia, 2020; Wu, Wang, Xu, and Chen, 2019).

Reverse factoring (RF), that is, the reverse process of factoring, is expected to be the most efficient form of SCF for easing e-commerce suppliers’ budget constraints (Grüter and Wuttke, 2017). In RF, capital is supplied through a sales credit transfer. A factoring company contracts with an e-commerce platform (henceforth, an e-retailer) that is highly creditable and likely to pay trade receivables. The factoring company proposes a financing option for small suppliers, including the timing of payments and discount rate for accounts receivable. Suppliers sign contracts based on their cash flows and receive a certain level of discounted accounts receivable before the expiration date. Therefore, RF involves a collaboration between a buyer, which is typically a large enterprise, and a factoring company to provide credit to suppliers. Thus, small suppliers are relatively free from credit risk and can reduce the costs of their procedures. The development of fintech has made RF easier in the e-commerce context.

This study theoretically analyzes the effect of RF activation on e-commerce suppliers. RF
activation enables e-commerce suppliers to raise additional capital in the short term. Consequently, suppliers will consider this ability when seeking long-term loans and will borrow relatively small amounts, lowering the interest rates on their loans. Thus, RF activation benefits suppliers by reducing their total interest costs.

We contribute to the literature in several ways. First, we newly extend the newsvendor model to RF in e-commerce and show that RF can reduce small e-commerce suppliers’ budget constraints. Second, through comparative static analyses, we show that a higher RF discount factor can improve a supplier’s financial condition when the market demand is expected to be sufficiently large. Third, we provide managerial implications for the sustainable e-commerce industry. Our results suggest that a high discount factor is sufficiently helpful for small e-commerce suppliers during the Fourth Industrial Revolution and in the post-COVID era, when the e-commerce industry is growing. We also show that in this current environment of growth, small e-commerce suppliers can benefit when fintech companies suggest effective SCF solutions.

The remainder of this paper is organized as follows. Section 2 explains the concept of SCF and suggests that RF provides suitable SCF for small businesses. We also review the related literature in Section 2. Section 3 presents the design of a newsvendor model with RF. Section 4 presents and discusses the results through comparative static analyses. Finally, Section 5 concludes the paper.

2. Research Background

2.1. Reverse Factoring

In academia, SCF has been discussed since 2008, and it has recently drawn keen attention (Xu, Chen, Jia, Brown, Gong, and Xu, 2018). Traditionally, discussions of SCM focus on optimizing logistics processes rather than on optimizing financial processes. However, as the importance of financial management increases, FSCM is being more actively discussed. In general, FSCM and SCF share similar concepts, but FSCM is slightly more comprehensive. FSCM refers to minimizing costs across the financial processes that result from logistics processes in the supply chain. SCF is a means of achieving FSCM and mainly refers to the financial services used to rapidly provide working capital to supply chain participants to enhance supply chain efficiency.

SCF systems can be categorized into the systems of accounts receivable and those of accounts payable, depending on which participant leads the financial process. SCF for accounts receivable typically takes the form of invoice finance and factoring, whereas SCF for accounts payable takes the form of RF. In invoice finance, a supplier facing budget constraints takes the lead in the financial process to find an investor. This process is conceptually similar to factoring, in which a supplier obtains financing by transferring discounted accounts receivable to a factoring company. RF refers to the reverse process. In RF, as in factoring, capital is supplied through a sales credit transfer, but in the case of RF, the factoring company leads the financial process. The RF process proceeds as
A factoring company contracts with a buyer, that is, a highly creditable e-retailer that is likely to pay trade receivables by the due date. The factoring company proposes a financing option, including the timing of payments and discount rate for accounts receivable, to suppliers doing business with the platform. Suppliers sign contracts based on their cash flows and receive a certain level of discounted accounts receivable before the expiration date (Herath, 2015). Figure 1 illustrates the structure of RF.

The agent proposing the contract assumes the contract’s risk. In factoring services, a small supplier with relatively high credit risk borrows credit from a large company. In principle, the supplier has no repayment burden because the buyer repays the loan when the accounts receivable mature. However, if the buyer does not repay the loan, the financial institution exercises its right to reimbursement, and the supplier must repay the loan secured on behalf of the buyer. Thus, the supplier not only forfeits its sales amount but also incurs losses up to the amount of discounted credit sales. In other words, factoring led by small suppliers faces the problem that these suppliers assume the risks of financial contracts in the case of reimbursement requests.

Conversely, under RF, factoring companies lead contracts and assume the risk accordingly. Thus, the buyer’s bankruptcy risk is not transferred to the small supplier. Additionally, RF can create economies of scale in large-scale funding contracts. Factoring processes are complicated for small businesses and, thus, are less accessible. Small businesses handle small amounts of funds through factoring, meaning that the benefits may not outweigh the costs. RF makes it easier for suppliers to obtain factoring benefits because one buyer can manage the factoring services of multiple suppliers.

Recent developments in fintech have made RF easier for small suppliers than ever before. Fintech facilitates the movement of capital online, improves suppliers’ ability to handle online financial transactions, and reduces the cost of small capital movements. These improvements enable RF, which involves numerous small capital movements. Payoneer is a typical fintech company that
provides RF services to assist small businesses in e-commerce. The company collaborates with several e-retailers to provide RF services to suppliers that enter these platforms. These services greatly help ease e-commerce suppliers’ budget constraints and boost their businesses. Payoneer’s services are expected to reduce capital costs for suppliers facing capital constraints, especially as the Fourth Industrial Revolution increases the importance of short-term funding. Thus, this study analyzes the positive effects of RF activation on suppliers facing budget constraints.

2.2. Literature Review
Several studies examine whether SCF benefits businesses. Pfohl and Gomm (2009) adopt a game-theoretic approach to demonstrate that SCF can optimize capital costs by mitigating the information asymmetry between borrowers and financial institutions in the case of incomplete information. Wuttke, Blome, Heese, and Protopappa-Sieke (2016) also construct a game-theoretic model of SCF services to mathematically derive a company’s optimal payments and payment timing. Bougheas, Materu, and Mizen (2009) use an inventory management model to analyze the benefits of SCF. They show that buyers have incentives to provide trade credit to their suppliers. SCF takes various forms, depending on the funding source. Thus, some studies compare the efficiencies of different capital suppliers. Lee and Rhee (2010) further consider inventory financing costs in their SCM analysis, using a mathematical model to demonstrate that supplying capital through supply chain participants’ credit is more efficient than doing so through financial institutions.

However, these analyses in the previous studies do not sufficiently consider the supplier’s budget constraint, whereas the following recent studies do. Dada and Hu (2008) incorporate newsvendor models, which are primarily used to analyze inventory control, into their analysis of SCF. They expand existing newsvendor models by incorporating budget constraints and suggest a capital-constrained newsvendor (CCNV) model. After the pioneer work of Dada and Hu (2008), many researchers utilize the CCNV model for supplier’s budget constraints. Chen and Cai (2011) and Chen (2015) use the CCNV model to determine which supply chain participants can most efficiently provide SCF to suppliers facing budget constraints. Both studies suggest that credit from participants inside the supply chain—rather than credit from financial institutions, such as banks—is more efficient for suppliers. Yan and Sun (2013) manipulate the CCNV model to confirm that suppliers facing budget constraints can benefit from an SCF system. Huang, Fan, and Wang (2019) compare optimal operational strategies for an SCF system comprising a buyer, a supplier, and a third-party logistics firm (3PL) depending on the supplier’s capital constraint. They show that the supply chain’s profit can be Pareto improved through 3PL financing services. Accordingly, we extend the CCNV model with RF services, and we analyze the effect of RF on e-commerce suppliers’ budget constraints.
3. Model Design

3.1. Capital-constrained newsvendor model

In this section, we extend the CCNV model by considering additional financing from RF services. In the CCNV model, a capital-constrained newsvendor obtains financing from a bank. A supplier (S), whose budget is constrained to \( B \), determines an order quantity \( Q \) considering the market demand \( D \), which is a random variable. We assume that the product has a short life cycle. Thus, if the market demand is less than the order quantity, the supplier should discard unsold goods. The market demand follows a failure distribution function \( F(.) \), which represents the probability that the market demand is less than the order quantity \( F(Q) \equiv P[D \leq Q] \). \( f(.) \) is the probability density function of the market demand \( f(.) = F'(.) \) on \( R^+ \). \( F(.) \) is an increasing function on the domain \([0,\infty]\), where \( F(0) = 0 \) and \( F(D) \rightarrow 1 \) as \( D \rightarrow \infty \). The survival function is the probability that the supplier can sell all of its inventory because the order quantity is less than the demand \( S(Q) = 1 - F(Q) = P[D > Q] \). \( S(.) \) is a decreasing function on the domain \([0,1]\), where \( S(0) = 1 \) and \( S(D) \rightarrow 0 \) as \( D \rightarrow \infty \). The failure rate is defined as \( h(Q) = f(Q)/S(Q) \), meaning that \( Q \) is the marginal order quantity at which failure occurs. Following Buzacott and Zhang (2006), we assume that the market demand follows an increasing failure rate (IFR) distribution because larger orders are more likely to exceed the realized demand \( h'(Q) > 0 \). For simplicity, the market price equals one, and the cost of ordering a product is \( c \in [0,1] \). The supplier’s revenue is \( \min\{D,Q\} \), and the cost is \( cQ \). Without additional funding, the supplier’s order amount cannot exceed the budget \( B \). Thus, the supplier’s problem without any additional funding is:

\[
\max_{Q \geq B/c} E[\pi_S] = E[\min\{D,Q\} - cQ] \\
= E[D|D \leq Q] \cdot Pr[D \leq Q] + E[Q|D > Q] \cdot Pr[D > Q] - cQ \\
= \int_0^Q Df(D)dD + Q \cdot S(Q) - cQ \\
= \int_0^Q S(D)dD - cQ 
\]

The optimal order quantity of a capital-constrained newsvendor without financing can be derived using the Karush-Kuhn-Tucker (KKT) conditions.

\[
Q_0^* = \begin{cases} 
\frac{B}{c}, & \text{if } cQ = B \\
\hat{Q}_0, & \text{if } cQ < B 
\end{cases} \quad \text{where } \hat{Q}_0 = S^{-1}(c) 
\]

At the optimum, the order quantity is a decreasing function of the order cost and is not affected by the budget constraint, except at the corner solution.

If the supplier can raise more funds, it can order more goods. The supplier can obtain loans.
from the bank (BK). The bank adjusts the interest rate \((r)\) to maximize its expected profits, given the supplier’s order quantity. Under the supplier’s budget constraint, the supplier borrows \(cQ - B\) at interest rate \(r\) and repays \((cQ - B)(1 + r)\) at maturity. If the revenue realized in the future is less than the redemption amount, the supplier goes bankrupt and repays only the realized revenue. We assume that the bank sets the interest rate first and the supplier then chooses the order quantity, which represents a Stackelberg game. Thus, we first solve the supplier’s problem and then solve the bank’s problem by considering the optimal order quantity.

Equation (3) describes the supplier’s bank financing problem. Here, \(X^+ = \max \{X, 0\}\).

\[
\max_Q E[\pi_S] = E[(\min(D, Q) - R^+) - \min(B, cQ)] = \int_R^Q S(D)dD - \min(B, cQ),
\]

where \(R^+ = (cQ - B)^+(1 + r)\). \(\quad (3)\)

If the budget is sufficiently large, that is, \(B \geq c\hat{Q}_0\), the supplier’s problem in equation (3) becomes the problem in equation (1). Thus, we now consider the condition in which the budget is small \((B < c\hat{Q}_0)\). In this case, the supplier’s bank financing problem is:

\[
\max_{Q < \frac{B}{c}} E[\pi_S] = E[(\min(D, Q) - R)^+ - B] = \int_R^Q S(D)dD - B, \text{ where } R = (cQ - B)(1 + r). \quad (4)
\]

By manipulating the KKT conditions, we can obtain the optimal order quantity of a capital-constrained newsvendor with bank financing as follows:

\[
Q^*_1 = \begin{cases} \frac{B}{c}, & \text{if } S^{-1}(c(1 + r)) \geq \frac{B}{c} \\ \hat{Q}_1, & \text{if } S^{-1}(c(1 + r)) < \frac{B}{c} \end{cases}
\]

where \(S(\hat{Q}_1) - S \left( (c\hat{Q}_1 - B)(1 + r) \right) \cdot c(1 + r) = 0. \quad (5)\)

At the optimum, the supplier obtains a loan from the bank when \(S^{-1}(c(1 + r)) < \frac{B}{c}\). This condition implies that when the supplier takes a loan from the bank, the order cost is \(c(1 + r)\). It follows that the upper bound of the interest rate is \(\bar{r} = \left\{ S \left( \frac{B}{c} \right) - c \right\} / c\). The second-order condition of the optimal order quantity can be calculated as follows:

\[
\text{s.o.c: } \frac{\partial^2 E[\pi_S]}{\partial Q^2} \bigg|_{Q=\hat{Q}_1} = -f(\hat{Q}_1) + f(\hat{R}_1) \cdot \{c(1 + r)\}^2 = S(\hat{Q}_1)[-h(\hat{Q}_1) + h(\hat{R}_1) \cdot c(1 + r)] < 0.
\]

Since \(c(1 + r) < S(\frac{B}{c}) < 1\), \(\hat{Q}_1 > \hat{R}_1\), and demand follows the IFR distribution, \(h(\hat{Q}_1) > h(\hat{R}_1)\).
\(c(1 + r)\) (Buzacoot and Zhang, 2004). Thus, the second-order condition on the optimal quantity holds, indicating that \(\hat{Q}_1\) maximizes \(E[\pi_S]\).

The bank expects revenue equal to the smaller of the supplier’s realized revenue and the repayment amount and pays a cost equal to the present value of the repayment amount. The bank chooses the interest rate by considering the supplier’s optimal choice (\(\hat{Q}_1\)). Thus, the bank’s problem can be written as follows:

\[
\max_{0 \leq r \leq \hat{r}} E[\pi_B|Q=\hat{Q}_1] = E[\min\{\min\{D, \hat{Q}_1\}, \hat{R}_1\}] - \frac{\hat{R}_1}{1+r} = \int_0^{\hat{R}_1} S(D)dD - \frac{\hat{R}_1}{1+r},
\]

where \(\hat{R}_1 = (c\hat{Q}_1 - B)(1+r)\) and \(\tilde{r} = \frac{s_B}{c}\).

(6)

The optimal interest rate can be derived as follows:

\[
r_1^* = \begin{cases} 
0, & \text{if } \Gamma(0) < 0 \\
\hat{r}_1, & \text{if } \Gamma(\hat{r}_1) > 0, \text{ where } \Gamma(r) = \frac{(c\hat{Q}_1-B)}{c(1+r)} + \frac{\partial \hat{Q}_1}{\partial r}, \hat{r}_1 = \frac{s_B}{c}, \text{ and } \hat{r}_1 \text{ implies } \Gamma(\hat{r}_1) = 0. 
\end{cases}
\]

(7)

At the interior solution of the interest rate (\(r_1^* = \hat{r}_1\)), \(\frac{(c\hat{Q}_1-B)}{c(1+r)} + \frac{\partial \hat{Q}_1}{\partial r} \bigg|_{r=\hat{r}_1} = 0. \text{ Since } \frac{(c\hat{Q}_1-B)}{c(1+r)} > 0, \frac{\partial \hat{Q}_1}{\partial r} < 0 \text{ in equilibrium. This finding implies that } \hat{Q}_1 \text{ is a monotonically decreasing function of } r. \text{ Thus, for a unique } \hat{r}_1, \text{ the CCNV model has a unique equilibrium } (\hat{Q}_1(\hat{r}_1), \hat{r}_1).\)

3.2. Reverse Factoring

This study extends the CCNV model by incorporating RF. With RF, the supplier can obtain additional funding when the realized demand exceeds the initial order quantity. We assume that the market demand is a random variable prior to the lending period. Thus, the supplier can place additional orders within that period if possible. The supplier can fund part of the realized revenue through RF. If demand is less than the order quantity, the supplier’s revenue is \(D\). However, if demand is greater than the order quantity within a period (\(D > Q\)), the supplier can obtain additional funding from the RF service. In this case, the supplier can raise additional funds up to \(\alpha Q\) and order additional goods up to \(\frac{\alpha}{\kappa}Q\), where \(\alpha\) denotes the discount factor for RF and \(\kappa\) denotes the additional order cost above \(c\) (\(c < \kappa < 1\)). \(\alpha\) is determined by the factoring company. In Figure 1, the e-retailer repays the accounts receivable to the factoring company at maturity. This result implies that \(\alpha\) is not affected by the supplier’s credit, meaning that additional orders by the supplier do not affect the RF discount rate. Thus, we assume that the RF discount factor is exogenous. If the remaining demand is less than the additional order quantity \((D - Q < \frac{\alpha}{\kappa}Q)\), the supplier’s revenue is \(D\). Otherwise, \((D - Q > \frac{\alpha}{\kappa}Q)\), and
the total revenue is \( \left(1 + \frac{a}{\kappa}\right)Q \). The supplier’s RF problem is rewritten as follows:

\[
\max_{Q \leq B/c} E[\pi_S] = E[\min \{D, Y \} - cQ] = \int_0^{Y} S(D)dD - cQ, \text{ where } Y = \left(1 + \frac{a}{\kappa}\right)Q. \tag{8}
\]

Through the KKT conditions, we obtain the optimal order quantity using reverse factoring.

\[
Q_{RF,D}^* = \begin{cases} \frac{B}{c}, & \text{if } S^{-1}\left(\frac{ck}{k+\alpha} \right) \cdot \frac{k}{k+\alpha} \geq \frac{B}{c}, \text{ where } \hat{Q}_{RF,0} = S^{-1}\left(\frac{ck}{k+\alpha} \right) \cdot \frac{k}{k+\alpha} \geq \frac{B}{c}, \\ \hat{Q}_{RF,0}, & \text{if } S^{-1}\left(\frac{ck}{k+\alpha} \right) \cdot \frac{k}{k+\alpha} < \frac{B}{c}, \end{cases}
\tag{9}
\]

If the supplier obtains financing from both the bank and RF, the supplier’s problem is

\[
\max_{Q > B/c} E[\pi_S] = E[\min \{D, Y \} - R] - B = \int_0^{Y} S(D)dD - B,
\]

where \( R = (cQ - B)(1 + r) \) and \( Y = \left(1 + \frac{a}{\kappa}\right)Q \).

\(
\tag{10}
\)

Following the same process, the optimal quantity can be calculated as follows:

\[
Q_{RF,1}^* = \begin{cases} \frac{B}{c}, & \text{if } S^{-1}\left(\frac{ck(1+r)}{k+\alpha} \right) \cdot \frac{k}{k+\alpha} \geq \frac{B}{c}, \\ \hat{Q}_{RF,1}, & \text{if } S^{-1}\left(\frac{ck(1+r)}{k+\alpha} \right) \cdot \frac{k}{k+\alpha} < \frac{B}{c}, \end{cases}
\]

where \( S\left(\left(1 + \frac{a}{\kappa}\right)\hat{Q}_{RF,1}\right) \cdot \left(1 + \frac{a}{\kappa}\right) - S\left((c\hat{Q}_{RF,1} - B)(1 + r)\right) \cdot c(1 + r) = 0. \tag{11}\)

As in the CCNV model, the second-order condition in the case of RF can be determined using the IFR demand assumption. The second-order condition can be calculated as follows:

\[
\text{s.o.c.}\left(\frac{\partial^2 E[\pi_S]}{\partial Q^2}\right)_{Q=\hat{Q}_{RF,1}} = -f(\hat{Y}_{RF}) \cdot \left(1 + \frac{a}{\kappa}\right)^2 + f(\hat{R}_{RF}) \cdot (c(1 + r))^2
\]

\[
= S(\hat{Y}_{RF}) \cdot \left(1 + \frac{a}{\kappa}\right) \left[-h(\hat{Y}_{RF}) \cdot \left(1 + \frac{a}{\kappa}\right) + h(\hat{R}_{RF}) \cdot c(1 + r) \right] < 0. \tag{12}
\]

At the optimum, \( \hat{Y}_{RF} > \hat{Q}_{RF} > \hat{R}_{RF}, 1 + \frac{a}{\kappa} > 1, c(1 + r) < 1, \) and \( h'(\cdot) > 0 \) according to the IFR distribution assumption. Thus, the second-order condition holds, and \( \hat{Q}_{RF} \) maximizes \( E[\pi_S] \).

The bank’s problem can be rewritten as follows:
\[
\max_{0 < r < r^*} E[\pi_{BK}]_{Q=Q_{RF,1}} = E[\min\{D, \hat{Q}_{RF,1}\}, \hat{R}_{RF,1}] - \frac{\hat{R}_{RF,1}}{1+r} = \int_0^{\hat{R}_{RF,1}} S(D) dD - \frac{r^*}{1+r}
\]

where \( \hat{R}_{RF,1} = (c \hat{Q}_{RF,1} - B)(1 + r) \) and \( \hat{r} = S \left( \frac{B(\kappa + \alpha)}{ck} \right) \frac{\kappa + \alpha}{ck} - 1 \).

(13)

The bank’s problem, equation (13), is similar to equation (6) in the CCNV model, except for the upper bound or interest rate. The optimal interest rate can be calculated as follows:

\[
r_{RF,1}^* = \begin{cases} 
0, & \text{if } \Gamma(0) < 0 \\
\hat{r}_{RF,1}, & \text{if } \Gamma(\hat{r}_{RF,1}) > 0 \\
\hat{r}_{RF,1}, & \text{otherwise}
\end{cases}
\]

where \( \Gamma_{RF}(r) = \frac{c \hat{Q}_{RF,1} - B}{c(1+r)} + \frac{\partial \hat{Q}_{RF,1}}{\partial r}, \hat{r}_{RF,1} = \frac{s(B)}{c} - c, \) and \( \hat{r}_{RF,1} \) implies \( \Gamma_{RF}(\hat{r}_{RF,1}) = 0 \).

(14)

At the interior solution, \( \Gamma_{RF}(\hat{r}_{RF,1}) = \frac{(c \hat{Q}_{RF,1} - B)}{c(1+r)} + \frac{\partial \hat{Q}_{RF,1}}{\partial r} \bigg|_{r=\hat{r}_{RF,1}} = 0 \). Since \( \frac{(c \hat{Q}_{RF,1} - B)}{c(1+r)} > 0, \frac{\partial \hat{Q}_{RF,1}}{\partial r} > 0 \).

Thus, the model with RF also has a unique solution \((\hat{Q}_{RF}^{*}, \hat{r}_{RF})\).

4. Results and Discussion

4.1. Effect of Reverse Factoring

In this subsection, we compare the results of the two models and show the effects of RF. Without bank financing, the optimal order quantities are \( Q_0^* \) and \( Q_{RF,0}^* \). The two optimal values are the same \( Q_0^* = Q_{RF,0}^* = \frac{B}{c} \), except at the interior solutions. Thus, we compare the interior solutions, \( Q_0 \) and \( Q_{RF,0} \).

The first-order condition of the model with RF is:

\[
S(Y) \cdot \left( 1 + \frac{\alpha}{\kappa} \right) - c = 0.
\]

(15)

When we substitute \( \hat{Q}_0 \) into equation (15), the two values can be compared according to the following conditions:

\[
\begin{align*}
&i) \text{ If } S(Y) \cdot \left( 1 + \frac{\alpha}{\kappa} \right) - S(R) \cdot c(1+r) \bigg|_{Q=Q_0} > 0, \text{ then } Q_{RF,0} > \hat{Q}_0. \\
&ii) \text{ If } S(Y) \cdot \left( 1 + \frac{\alpha}{\kappa} \right) - S(R) \cdot c(1+r) \bigg|_{Q=Q_0} = 0, \text{ then } Q_{RF,0} = \hat{Q}_0. \\
&iii) \text{ If } S(Y) \cdot \left( 1 + \frac{\alpha}{\kappa} \right) - S(R) \cdot c(1+r) \bigg|_{Q=Q_0} < 0, \text{ then } Q_{RF,0} < \hat{Q}_0.
\end{align*}
\]

(16)

Since \( c = S(\hat{Q}_0), S(Y) \cdot \left( 1 + \frac{\alpha}{\kappa} \right) - c \bigg|_{Q=\hat{Q}_0} = S \left( \frac{B(\kappa + \alpha)\hat{Q}_0}{\kappa + \alpha} \right) \cdot \left( 1 + \frac{\alpha}{\kappa} \right) - S(\hat{Q}_0). \) Since \( S(. \) is a
decreasing function and \( \left(1 + \frac{\alpha}{\kappa}\right) > 1, S\left(\left(1 + \frac{\alpha}{\kappa}\right)Q\right) \cdot \left(1 + \frac{\alpha}{\kappa}\right) - S(Q) = 0 \) has a unique solution, as Figure 2 shows.

**Figure 2.** Uniqueness of the solution at which \( Q_{RF,0} = \hat{Q}_0 \)

We denote this unique solution as \( \bar{Q} \) and rewrite the conditions in equation (16) as follows:

\[
\begin{align*}
\text{i)} & \quad \text{if } \bar{Q} > Q_0, \text{ then } Q_{RF,0} > \hat{Q}_0. \\
\text{ii)} & \quad \text{if } \bar{Q} = Q_0, \text{ then } Q_{RF,0} = \hat{Q}_0. \\
\text{iii)} & \quad \text{if } \bar{Q} < \hat{Q}_0, \text{ then } Q_{RF,0} < \hat{Q}_0. \\
\end{align*}
\]

(17)

With bank financing, the optimal order quantities are \( Q_1^* \) and \( Q_{RF,1}^* \). At the interior solutions \( \bar{Q}_1 \) and \( Q_{RF,1} \), the first-order condition of the model with RF is:

\[
S(Y) \cdot \left(1 + \frac{\alpha}{c}\right) - S(R) \cdot c(1 + r) = 0. 
\]

(18)

When we substitute \( \bar{Q}_0 \) into equation (15), the two values can be compared according to the following conditions:

\[
\begin{align*}
\text{i)} & \quad \text{if } S(Y) \cdot \left(1 + \frac{\alpha}{c}\right) - S(R) \cdot c(1 + r) \bigg|_{Q = \bar{Q}_1} > 0, \text{ then } Q_{RF,1} > \bar{Q}_1. \\
\text{ii)} & \quad \text{if } S(Y) \cdot \left(1 + \frac{\alpha}{c}\right) - S(R) \cdot c(1 + r) \bigg|_{Q = \bar{Q}_1} = 0, \text{ then } Q_{RF,1} = \bar{Q}_1. \\
\end{align*}
\]
If $S(Y) \cdot \left(1 + \frac{\alpha}{\kappa}\right) - S(R) \cdot c(1 + r)\bigg|_{Q=\hat{Q}_1} < 0$, then $\hat{Q}_{RF,1} < \hat{Q}_1$.  

(19)

Since $S(Y) \cdot \left(1 + \frac{\alpha}{\kappa}\right) - S(R) \cdot c(1 + r)\bigg|_{Q=\hat{Q}_1} = S\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}_1\right) \cdot \left(1 + \frac{\alpha}{\kappa}\right) - S(\hat{Q}_1)$, the conditions in equation (19) are similar to those in equation (17). Thus, a smaller $\hat{Q}$ implies that the supplier can reduce the initial order quantity and alleviate the risk that its goods are not sold.

We apply the implicit function theorem to $S\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right) \cdot \left(1 + \frac{\alpha}{\kappa}\right) = S(\hat{Q})$, and we find that $\hat{Q}$ is decreasing in $\alpha$. We denote $T = S\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right) \cdot \left(1 + \frac{\alpha}{\kappa}\right) - S(\hat{Q})$ and write:

$$
\frac{d\hat{Q}}{d\alpha} = -\frac{\partial T / \partial \alpha}{\partial T / \partial \hat{Q}}.
$$

(20)

$\partial T / \partial \hat{Q} < 0$ can be proved as follows:

$$
\frac{\partial T}{\partial \hat{Q}} = -f\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right) \left(1 + \frac{\alpha}{\kappa}\right)^2 + f(\hat{Q})
\hspace{1cm}
= S\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right) \left(-h\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right) \left(1 + \frac{\alpha}{\kappa}\right)^2 + \frac{f(\hat{Q})}{S\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right)}\right)
\hspace{1cm}
= S\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right) \left(-h\left(\left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}\right) \left(1 + \frac{\alpha}{\kappa}\right)^2 + h(\hat{Q}) \left(1 + \frac{\alpha}{\kappa}\right)\right).
$$

(21)

where $\bar{Y} = \left(1 + \frac{\alpha}{\kappa}\right) \hat{Q}$. Because of the IFR distribution assumption, $\partial T / \partial \hat{Q} < 0$ in equation (21).

Thus, the sign of $\partial \hat{Q} / \partial \alpha$ is the same as that of $\partial T / \partial \alpha$, which is calculated as

$$
\frac{\partial T}{\partial \alpha} = -f(\bar{Y}) \frac{1}{\kappa} \bar{Q} + S(\bar{Y}) \frac{1}{\kappa} = \frac{s(\bar{Y})}{\kappa} (-h(\bar{Y}) \bar{Q} + 1).
$$

(22)

The sign of $\partial T / \partial \alpha$ is determined according to the value of $1 - h(\bar{Y}) \bar{Q}$. If $1 - h(\bar{Y}) \bar{Q} > 0$, $\bar{Q}$ is increasing in $\alpha$. Conversely, if $1 - h(\bar{Y}) \bar{Q} < 0$, $\bar{Q}$ is decreasing in $\alpha$. This finding implies that if the market demand is likely to be sufficiently large, a high RF discount factor reduces the supplier’s initial order. A small initial order quantity means that the supplier’s financial risk is alleviated, thereby improving financial conditions. Without bank financing, the supplier can reserve working capital as the order volume decreases. The supplier can reduce the risk of bankruptcy when obtaining funds from the bank by reducing the loan amount.
4.2. Managerial Implications

The results of the theoretical analysis imply that if the market demand is expected to be sufficiently large, the RF discount factor should be larger to ensure the sustainable growth of the e-commerce industry. After the Fourth Industrial Revolution and the COVID-19 pandemic, online shopping order quantities have increased. Thus, the market demand for e-retailers is sufficiently large. Therefore, small suppliers using e-retailers can benefit from a higher RF discount factor. If they can finance working capital through RF with a high RF discount factor, their budget constraints can be eased, thus enabling the sustainable growth of the e-commerce industry.

The RF discount factor is not affected by the supplier’s order quantity, but rather is determined by the credit of the e-retailer contracting with the factoring company and the cost efficiency of the RF services. Thus, to increase the discount factor, either the e-retailer’s credit or the efficiency of the RF services should be increased. As the e-commerce industry grows, e-retailers grow as well. In the early stages of a business, excessive investments are often made to increase its size, but an e-retailer’s credit is highly likely to stabilize after its scale has grown to a certain extent. In other words, the discount factor may be sufficiently high because e-commerce has entered a period of stabilization after rapid growth in recent years. Recently, an increasing number of companies have offered RF services as a financial solution for small companies. They emphasize that the capital constraints on small suppliers can be alleviated through fast and efficient payment settlements; that is, the recent growth in fintech and e-commerce has increased the RF discount factor, which will help alleviate the capital constraints of small suppliers dealing with e-retailers.

5. Conclusion

This study shows that even though the e-commerce industry’s growth has accelerated during the Fourth Industrial Revolution and post-COVID era, e-commerce suppliers may not be achieving sufficient growth owing to their budget constraints. This study proposes a cutting-edge SCF service as a solution. Fintech companies are easing e-commerce suppliers’ capital constraints through RF services. Accordingly, we develop a theoretical model to analyze the effect of RF activation on e-commerce suppliers’ capital constraints by extending the CCNV model. In equilibrium, RF reduces the supplier’s order quantity, meaning that it can reduce the supplier’s capital costs through flexible capital management. Through several comparative static analyses, we show that an increase in the RF discount factor improves the supplier’s financial condition only when the market demand is sufficiently high. This result implies that in the post-COVID era, when the e-commerce industry is expected to grow, the discount factors of RF services should be higher to ensure that this growth is sustainable.

This study contributes significantly to the literature in that it extends the newsvendor
approach by considering additional funding through RF and suggests a practical implication for the e-commerce industry’s sustainable growth. However, this study is limited to a theoretical analysis because the data on fintech-based RF are insufficient. An empirical analysis of the models in this study is therefore necessary once sufficient data are available. Additionally, this study does not consider different types of RF service providers. Although RF is provided in collaboration with banks and fintech companies, it has recently been driven by peer-to-peer lending platforms. An analysis to determine which method is more efficient is also needed.

References


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