Incentive and Supervisory Mechanism in Inventory Financing: Risks and Moral Hazard

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Abstract. This paper investigates a bank’s incentive and supervisory mechanism to a third party logistics firm (TPL) during inventory financing. Incentive and supervisory mechanism plays two important roles in this model: to control risks and to mitigate moral hazards. Using the principal-agent model, we discover a few significant conclusions, which are helpful to enhance the bank’s enthusiasm of developing the business. In particular, we show when the SME joins the bank to design the mechanism, assistance participation is more efficient than cooperation participation in increasing the bank’s profits and inducing the TPL’s effort.

Introduction
Designing an optimal contract between banks and TPLs is one of the most important issues in inventory financing. TPLs can ensure inventories’ safety only when they are fully under supervision and control. It is the TPL that sets up the warehouse, makes sure inventories properly segregated and easily identified, marks premises, and excludes any borrower. As warehouse owner, TPLs can determine the feasibility of starting a specific inventory financing business. Therefore, it is necessary for banks to motivate TPLs through an appropriate incentive-and-supervisory contract, in which TPLs are strongly encouraged to properly administer inventories on behalf of banks.

There is a very limited study about risks and moral hazards control in inventory financing, which emphasize the role of incentive-and-supervisory contract and considers how supervision can enhance TPLs’ efforts and increase banks’ profit. He et al. (2012a, 2012b, 2013) uses the game theory method, research on the question that banks prevent TPLs and borrowing enterprises from collusion to loan. Xu et al. (2012, 2016) discuss several aspects about inventory financing, risks from TPLs are emphasized. They focus on definitions, operational modes and relationship among banks, TPLs and SMEs. With the development of internet technology and the increase of online trade, research on the contract between banks and B2B platform based on electric warehouse and electric order financing receives attention(Guo et al. 2014; Shi and Guo 2015; He and Shen 2016; Wang and Shi 2016).

Our theoretical findings are similar to Xu’s (2010) observation that incentive-and-supervisory mechanisms are more suitable than simple incentive mechanisms in inducing more effort from TPLs. However, our research is different from their paper for two aspects. First, in Xu’s research, they omit the case of SMEs joining in the activity of creating incentive and supervisory mechanisms with banks together, we consider this situation in our study. Second, we divide the way of SMEs’ participation into two categories: assistance and cooperation, and get some new findings.

Assumptions
Assume lending rate is . With the amount of loan and the period , the interest that banks get is: \( R = I \times r \times T \).

Assume there is a linear “production function”: \( w(a) = -Aa + B + D + \xi, (w \geq 0) \), wherein \( w(a) \) is inventories’ loss in the whole period, \( a \) denotes the TPL’s effort level, \( w'(a) \leq 0 \). \( A \) denotes TPL’s comprehensive ability, \( B \) denotes the loss caused by inventories’ types, For
simplicity, assume $B$ and $D$ are constant. $\xi$ denotes the loss caused by outside factors such as temperature, climate, market change etc. and is subjected to $\xi \sim N(0, \sigma^2)$ distribution.

Assume the bank gives the TPL’s rewards: $\phi = \omega_b + \beta_b (w(0) - w(a))$, $\omega_b$ denotes fixed rewards, $\beta_b (0 \leq \beta_b \leq 1)$ is share of outcome, which is proposed by the bank. $(w(0) - w(a))$ is the value of output when the TPL’s effort level is $a$. When $a$ equals to 0, $w(0) - w(a) = 0$, the 3PL gets nothing except fixed rewards.

Also assume the function of the TPL’s effort cost is: $C(a) = \frac{1}{2} ba^2$, wherein $b$ denotes cost coefficient, related to its ability

**Incentive and Incentive-and-supervisory Mechanisms with SMEs’ Participation**

In this subsection, we consider the case with SMEs joining banks to mitigate moral hazards and keep risks under control. Assume the contract proposed by SMEs is $\phi = \omega_e + \beta_e (w(0) - w(a))$, wherein $\omega_e$ denotes fixed rewards, $\beta_e (0 \leq \beta_e \leq 1)$ is output share.

**Incentive Mechanism**

Classifying SMEs’ participation methods, we discuss the mechanisms from two aspects: assistance participation and cooperation participation.

**Assistance Participation.** In this subsection, we consider the case of assistance participation. Assistance means banks negotiate with TPLs and ask them to afford parts of payment, without offering any benefit share. With assistance participation, banks’ problem becomes:

$$\overline{E \Pi_b} = \text{Max } IrT + (1 - \beta_b) Aa - \omega_b - D - B$$

(1)

$$s.t. (IR) \omega_b + \omega_e + (\beta_b + \beta_e) Aa - \frac{1}{2} ba^2 - \frac{1}{2} \rho(\beta_b + \beta_e)^2 \sigma^2 \geq v^0$$

(2)

$$(IC) \omega_b + \omega_e + (\beta_b + \beta_e) Aa - \frac{1}{2} ba^2 - \frac{1}{2} \rho(\beta_b + \beta_e)^2 \sigma^2 \geq \omega_e + (\beta_b + \beta_e) Aa' - \frac{1}{2} ba'^2$$

(3)

**Solution 1.** In the case of assistance participation and simple incentive measure, the best solution is

$$\overline{a} = \frac{A^3}{b(A^2 + b \rho \sigma^2)(1 + \beta_e)}, \quad \overline{\beta_b} = \frac{A^2}{A^2 + b \rho \sigma^2} - \frac{b \rho \sigma^2}{A^2 + b \rho \sigma^2} \beta_e,$$

$$\overline{\omega_b} = v^0 - \omega_e + (1 + \beta_e) \frac{A^4 (b \rho \sigma^2 - A^2)}{2b(A^2 + b \rho \sigma^2)^2}, \quad \overline{E \Pi_b} = IrT + \frac{A^4 (1 + \beta_e)^3}{2b(A^2 + b \rho \sigma^2)} - D - v^0 + \omega_e.$$

**Cooperation Participation.** In this subsection, we consider the case of cooperation participation, in which both SMEs and banks regard collective interest as goal when choosing strategy. Under the situation, the total fee paid to TPLs is expressed by: $\phi = (\omega_b + \omega_e) + (\beta_b + \beta_e)(w(0) - w(a))$.

In this case, banks and SMEs’ goal is to minimize $\phi + w(a)$.

With cooperation participation, banks’ problem becomes
\[
\min_{\beta_0, \omega_b, \omega_s} (\beta_0 + \beta_s - 1) Aa + \omega_b + \omega_s + D + B (i = 1, 2) \\
\text{s.t.} \omega_b + \omega_s + (\beta_0 + \beta_s) Aa - \frac{1}{2} b a^2 - \frac{1}{2} \rho (\beta_0 + \beta_s)^2 \sigma^2 \geq \nu^0
\]

(4)

(5)

(6)

\section*{Solution 2.}

In the case of cooperation participation and only incentive measure, the best solution is

\[
\alpha^* = \frac{A^2}{b (A^2 + b \rho \sigma^2)}, \quad \beta^*_s = \frac{A^2}{A^2 + b \rho \sigma^2} - \beta^*_0, \quad \omega^* = \nu^0 + \frac{A' (b \rho \sigma^2 - A^2)}{2 b (A^2 + b \rho \sigma^2)} \omega^0, \quad \Pi^* = (1 + \beta_0) Aa + \psi (x_b) - Aa, \quad B = D - \nu^0 - \omega^0
\]

\section*{Inventive-and-supervisory Mechanism}

To further reduce the risks, banks and SMEs incorporate supervision into incentive mechanisms. If so, the coefficient of production function is not a constant anymore. Assume that new production function is \(w(a) = (A + \kappa (x_b) + \psi (x_s)) Aa + B + D + \xi (w \geq 0)\). Wherein \(x_b\) and \(x_s\) are banks’ and SMEs’ monitoring level respectively. \(\kappa (x_b)\) and \(\psi (x_s)\) are coefficient of production function, positively correlated with \(x_b\) and \(x_s\) respectively. Assume banks’ monitoring cost and SMEs’ monitoring cost are \(C_b (x_b)\) and \(C_e (x_s)\), and \(C_b (x_b) \geq 0, \; C_e (x_s) \geq 0\).

\section*{Assistance Participation.}

In this section, we consider the case of incentive-and-supervisory mechanism under assistance participation, in which there is no benefit share for SMEs.

With SMEs’ assistance participation in supervision, banks’ question becomes:

\[
E \Pi^*_b = \max_{\beta_0, \omega_b, \omega_s} \left[(1 - \beta_0) A (A + \kappa (x_b) + \psi (x_s)) A a - \omega_b - D - B - C_b (x_b) \right]
\]

(7)

\[
\text{s.t.} \text{(IR):} \; \omega_b + \omega_s + (\beta_0 + \beta_s) (A + \kappa (x_b) + \psi (x_s)) a - \frac{1}{2} b a^2 - \frac{1}{2} \rho (\beta_0 + \beta_s)^2 \sigma^2 \geq \nu^0
\]

(8)

\[
\text{(IC):} \; \omega_b + \omega_s + (\beta_0 + \beta_s) (A + \kappa (x_b) + \psi (x_s)) (a - A a + \psi (x_s)) a - \frac{1}{2} b a^2 - \frac{1}{2} \rho (\beta_0 + \beta_s)^2 \sigma^2 \geq \omega_b + \omega_s + (\beta_0 + \beta_s) (A + \kappa (x_b) + \psi (x_s)) a - \frac{1}{2} b a^2 - \frac{1}{2} \rho (\beta_0 + \beta_s)^2 \sigma^2
\]

(9)

\section*{Solution 3.}

In the case of assistance participation and incentive-and-supervisory mechanisms, the best solution is

\[
\hat{\alpha} = \frac{(A + \kappa (x_b) + \psi (x_s))^3}{b \left((A + \kappa (x_b) + \psi (x_s))^2 + b \rho \sigma^2\right)} (1 + \beta_0)^3, \quad \hat{\beta} = \frac{(A + \kappa (x_b) + \psi (x_s))^3}{b \left((A + \kappa (x_b) + \psi (x_s))^2 + b \rho \sigma^2\right)} - \beta_0, \quad \hat{\omega} = \nu^0 + \frac{A' (b \rho \sigma^2 - (A + \kappa (x_b) + \psi (x_s))^3)}{2 b \left((A + \kappa (x_b) + \psi (x_s))^2 + b \rho \sigma^2\right) \omega^0}
\]

\[
E \Pi^*_b = \max \left[(1 + \beta_0) A (A + \kappa (x_b) + \psi (x_s)) A a - D - B - \nu^0 - C_b (x_b) \right]
\]

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**Cooperation Participation.** In this subsection, we consider the case of incentive-and-supervisory mechanisms under cooperation participation, and the goal function is to minimize the sum of SMEs’ and banks’ payment and inventories’ loss.

With cooperation participation in supervision, banks’ problem becomes

\[
\begin{align*}
\min_{\beta_x, \beta_y} & \quad (A + \kappa(x_i) + \psi(x_i))a + \omega_x + \omega_z + B + D - C_y(x_j) - C_z(x_j) (i = 1, 2) \\
\text{s.t.} & \quad \alpha_x + \alpha_z + (\beta_x + \beta_y)(A + \kappa(x_i) + \psi(x_i))a - \frac{1}{2} ba^2 - \frac{1}{2} \rho(\beta_x + \beta_y)^2 \sigma^2 \geq v^0
\end{align*}
\]

(10)

(11)

(12)

**Solution 4.** In the case of cooperation participation and incentive-and-supervisory mechanisms, the best solution is.

\[
\begin{align*}
\lambda_x^* &= \frac{(A + \kappa(x_i) + \psi(x_i))^2}{b\left[(A + \kappa(x_i) + \psi(x_i))^2 + b\rho \sigma^2\right]} - \alpha_x \\
\beta_x^* &= \frac{(A + \kappa(x_i) + \psi(x_i))^2}{b\left[(A + \kappa(x_i) + \psi(x_i))^2 + b\rho \sigma^2\right]} - \beta_x
\end{align*}
\]

Analysis on Results

In this section, we summarize solutions in Table 1. We use OI and IM to stand for incentive mechanisms and incentive-and-supervisory mechanisms respectively, and use letters B, C, D, E, F, G and H to stand for the following formulas respectively.

\[
\begin{align*}
B &= \frac{(A + \kappa(x_i) + \psi(x_i))^2}{(A + \kappa(x_i) + \psi(x_i))^2 + b\rho \sigma^2}, \\
C &= \frac{A^4(b\rho \sigma^2 - A^2)}{2b(A^2 + b\rho \sigma^2)}, \\
D &= \frac{(A + \kappa(x_i) + \psi(x_i))^2}{2b\left[(A + \kappa(x_i) + \psi(x_i))^2 + b\rho \sigma^2\right]} - B - D - v^0,
\end{align*}
\]

(12)

Table 1. The equilibrium solutions.

<table>
<thead>
<tr>
<th>No participation</th>
<th>Assistance</th>
<th>Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a )</td>
<td>( a^\alpha )</td>
<td>( a^\alpha (1 + \beta_x) )</td>
</tr>
<tr>
<td>( \beta_x )</td>
<td>( \beta_x^\alpha )</td>
<td>( \beta_x^\alpha' )</td>
</tr>
<tr>
<td>( \beta_y )</td>
<td>( \beta_y^\alpha )</td>
<td>( \beta_y^\alpha' )</td>
</tr>
<tr>
<td>( \omega_x )</td>
<td>( \omega_x^\alpha )</td>
<td>( \omega_x^\alpha' )</td>
</tr>
</tbody>
</table>

**Proposition 1** With SMEs’ participation, the effort level under incentive-and-supervisory mechanisms is higher than that simple incentive mechanisms.

Proposition 1 suggests the difference in TPLs’ effort level when with and without supervision. Under the same conditions, compared with the simple incentive mechanism, the incentive-and-supervision mechanism induces TPLs more effort.
Proposition 2 With SMEs’ participation, variable rewards are more effective in inducing TPL more effort.

Proposition 2 suggests that variable rewards are more efficient in inducing agents further effort and reducing moral hazards compared with fixed rewards. Proposition 1 is consistent with conclusions of most researches. This may explain why many firms opt to give their managers or employees stock option, merit pay, etc.

Proposition 3 With SMEs’ participation, assistance participation is more effective in inducing TPLs’ effort and in increasing banks’ revenues.

Proposition 3 suggests that with SMEs’ participation, assistance participation is better than cooperation participation. The comparison of banks’ revenues and TPLs’ effort level under two participation ways are shown in Table 1, banks’ revenues and TPLs’ effort level increase more quickly under assistance participation.

Conclusions

Based on the research, we reach the following conclusions: (1) variable rewards are more efficient in inducing TPLs’ effort than fixed rewards; (2) the incentive-and-supervisory mechanism induces more effort; (3) banks’ profit increases with SMEs’ participation; (4) the assistance participation is more efficient in increasing banks’ profit and making TPLs input more effort. We believe that these conclusions are not only applied to China, but also to other countries.

Acknowledgements

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Reference


