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Why did the Dutch East India Co. outperform the British East India Co.?
—A theoretical explanation based on the objective of the firm and limited liability—

Tetsuya Shinkai
School of Economics, Kwansei Gakuin University
Takao Ohkawa
Faculty of Economics, Ritsumeikan University
Makoto Okamura
Faculty of Economics, Hiroshima University and Ritsumeikan University
Kozo Harimaya
Faculty of Business Administration, Ritsumeikan University

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SCHOOL OF ECONOMICS

KWANSEI GAKUIN UNIVERSITY

1-155 Uegahara Ichiban-cho
Nishinomiya 662-8501, Japan

Why did the Dutch East India Co. outperform the British East India Co.? —A theoretical explanation based on the objective of the firm and limited liability—-*

Tetsuya Shinkai[†] Takao Ohkawa[‡] Makoto Okamura[§]
Kozo Harimaya[¶]

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Abstract

We examine the relationship between the objective of a monopolist and limited liability. We establish that the owners of a monopolistic firm are better off to choose profit maximization rather than sales maximization under both unlimited and limited liability. This is consistent with the fact that the Dutch East India Company, whose objective was profit maximization, was better off in the seventeenth century than the British East India Company, whose objective was sales maximization. We also show that a monopolist should choose to organize as a limited liability entity regardless of its objective.

Keywords: limited liability, firm objective, managerial incentives, monopoly
JEL classification: G32, L13, L12

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†Corresponding Author: School of Economics, Kwansei Gakuin University, 1-115, Uegahara Ichiban-cho, Nishinomiya 662-8501, Japan, E-mail: shinkai@kwansei.ac.jp, Fax: +81-798-51-0944

‡Faculty of Economics, Ritsumeikan University

§Faculty of Economics, Hiroshima University and Ritsumeikan University

¶Faculty of Business Administration, Ritsumeikan University

1 Introduction

Modern large companies typically have separate ownership and management, which was observed by Berle and Means (1932), and limited liability.

Separating ownership and management allows firms to commit to actions besides maximizing profits. Some empirical evidence implies that such firms do not necessarily maximize profits. For example, Amihud and Kamin (1979) support "Baumol (1958)'s hypothesis that revenue maximizing is more prevalent among oligopolistic, management-controlled firms."

Limited liability system is one of the most valuable inventions and institutions in history in our modern capitalistic society. Today, most large firms in developed market economies are limited liability companies. In some of these firms, managerial compensation is not very dependent on firm performance as measured by profit. In the economics literature, Brander and Lewis (1986) argue that an oligopolistic product market is linked to the financial structure and show that limited liability may commit a leveraged firm to output more aggressively. These arguments in the literature have only been applied to an oligopolistic market[1].

Historically, separation of ownership and management and limited liability were necessary for European countries that traded with the Indies in the sixteenth and seventeenth centuries. This trading required large funds because merchants who wanted to trade with the East had to send many ships to take goods back and forth, hire many seamen and military personnel to defend the goods from piracy, and supply the ships with food and water for a twelve-month voyage. In addition, shipwrecks were likely because navigation was underdeveloped, safe sea routes were still unknown, and pirates were a threat. The merchants who stayed in their native countries could not directly control and manage trade activity in the East Indies.

The East India Companies in Dutch and England, established early in the seventeenth century, were the original corporations, which today are an important type of limited liability organization[2]. In those days, the East India Companies in the Netherlands and England obtained exclusive trade rights with the countries of the Indies. In this sense, each firm acted as a monopolist in each market. The Dutch East India Company dominated long-distance commerce in seventeenth century, and the British East India Company inherited its mantle in the eighteenth century. These two companies with very different institutional origins and philosophies battled each other for global trade

[1] Shinkai, Ohkawa, Okamura and Harimaya (2012) examine the effect of limited liability on strategic delegation in a Cournot duopoly with demand uncertainty. This paper explores the same effect in a monopoly.

[2] Bernstein (2008) describes in chp.9 p.223, "Dutch citizens would consider it just as natural to own a fractional share in trading vessels to Baltic or Spice Islands." In Israel (1989) p.22, "One Amsterdam shipowner, at his death in 1610, left shares in twenty-two ships, consisting of one-sixteenth shares in thirteen vessels, one thirty-second shares in seven,...and a one twenty-eighth share."

supremacy for two hundred years[3]. The former company's structure reflected the divisions within the United Provinces[4], so the Dutch government was inclined to act in the interest of the whole nation and control the management of the company. The Dutch company sent a governor-general with full authority over all of the company's officers to Indonesia. The British East India Company was even more decentralized, however, and acted less as a trading company than as a guild. It allowed each of its members to trade on his account, owning only the ships in common with other members[5]. Bernstein (2008) also describes the behavior of the employees of the British East India Company, "the employee of the East India Company treated its ships as their own, transporting large amounts of trade goods for their accounts to and from Asia." From these historical facts, the objective of the Dutch East India Company was likely to maximize profits, whereas the British East India Company tried to maximize sales since the employee of it transported large amounts of trade goods not only for the company's but their own accounts to and from Asia.

The aim of this paper is to build a simple economic model to describe these limited liability companies in their historical context and theoretically analyze the behavior of these two different types of monopolists.

John, Senbet, Sundaram, and Woodward (2005) examine the product market choices of a monopolist that is organized as a limited liability firm and discuss the relationship between limited liability and market power. Under limited liability, if the total revenue resulting from the realized market is higher than the total costs, then the monopolist is able to pay the factors of production and make profits; on the other hand, if the total revenue from the realized market is less than the total cost, the monopolist can declare bankruptcy with no liability. They showed that a risk-neutral monopolist facing uncertain demand with constant returns to scale technology produces more output, yielding higher expected profits, when limited liability permits a costless exit. They do not discuss different firm objectives in their research on the relationship between limited liability and the market power of a monopolist.

Therefore, in this paper, we consider a two-stage monopoly market with demand uncertainty under both unlimited and limited liability. In the first stage, the shareholders of a monopoly can choose their objective by designing either a profit maximization or a sales maximization incentive scheme for the manager[6]. In the second stage, the manager

[3]Bernstein, W. (2008), pp.215-216.

[4]Bernstein (2008, p.220) says "The only national political institution in United Provinces in Netherlands for two centuries when the Union of Utrecht established the northern provinces in revolt against Spain was the State General, which is considered as the Dutch government."

[5]Ibid. p.225. The decentralization of the British East India Company also made it more susceptible to corruption than the Dutch India Company.

[6]In this paper, we do not assume that the owners of a monopolistic firm can choose between limited liability and unlimited liability. Ohkawa, Shinkai, Okamura, and Harimaya (2012) endogenize the oligopolistic firms' choice of organizational form in the first stage, and these firms then compete in a Cournot fashion in the second stage.

of the firm chooses her output quantity. We explore the relationship between the objective of the monopolist and limited liability.

In the next section, we describe the structure of our model. In section 3, we consider a monopoly in which the owners of the firm can choose either profit maximization or sales maximization before the manager of their firm chooses the output of the firm in the second stage under unlimited liability. In section 4, we consider the same two-stage decision process under limited liability. In section 5, we evaluate the equilibrium of the entire game from a social welfare perspective. The final section gives concluding remarks.

2 The Model

We consider a monopoly with additive demand uncertainty in which a monopolist produces and supplies a good with an identical constant return to scale technology. Under limited (unlimited) liability, we assume that the shareholders of the monopolistic firm are (not) protected by limited liability effects. The manager of the firm chooses output to maximize expected profit (sales) when the owners of their firm choose 'profit maximization' ('sales maximization) as their objective, similar to the Dutch East India Company (British East India Company).

The shareholders can ask for debt D from outside investors if the equity capital is not sufficient for finance production. According to Brander and Lewis (1986), the debt holders are residual claimants in case of bankruptcy. Hence, the shareholders of the firm do not care about returns in the bad state; they are only concerned with returns in the good state. When the firm takes on debt, it is more inclined to follow strategies that provide more returns in the good state and fewer returns in the bad state. That is, we say that *the firm is protected by the limited liability effect of debt financing.* The limited liability effect induces the firm to assume more risk. As Brander and Lewis (1986) show, the behavior of a leveraged firm is more aggressive than that of an unleveraged firm. In this paper, we consider *the objective choice effect in addition to this limited liability effect* in a monopoly.

The demand function is assumed to have additive uncertainty and to be inverse linear

$$p = a + \widetilde{z} - Q = a + \widetilde{z} - q, \tag{1}$$

where a denotes the magnitude of the market and $\widetilde{z}$ is a uniformly distributed random variable with support $[-\overline{z}, \overline{z}]$, $a - \overline{z} > 0$ and with probability density function

$$\begin{aligned} \phi(z) &= \frac{1}{2\overline{z}}, \text{ for } z \in [-\overline{z}, \overline{z}] \\ &= 0, \quad \text{otherwise.} \end{aligned} \tag{2}$$

From (2), we observe that $\widetilde{z}$ has mean 0 and variance $\frac{1}{3}\overline{z}^2$. We also assume that the monopolist has a linear cost function

$$C(q) = cq, a > c > 0.$$

We assume that $c = 1$. Here, we make a key assumption in our analysis of a leveraged monopolist under limited liability. That is, we assume that the firm is financially constrained and must finance all or part of its variable costs by borrowing from its investors or banks, following Povel and Raith (2004). Most of the debt contract literature assumes, as in as Brander and Lewis (1986), that a firm or an entrepreneur must finance a fixed start-up or project cost. In these papers, the equilibrium output and debt level of each firm are not derived explicitly because of the nonlinearity of the reaction function of each firm, as described in the analysis of the Brander-Lewis framework[7]. Povel and Raith (2004), however, consider a Cournot duopoly in which one of the firms is financially constrained and must finance all or part of its variable costs by borrowing from an investor and the other firm is not financially constrained[8]. Under their assumptions, each firm's choice of output uniquely determines its level of debt, making our analysis more tractable. We thus assume in this paper that the debt level of the monopolist is a linear variable cost function of its output under limited liability. We take the debt assumed by the monopolist as endogenous. The monopolist takes on debt only to finance its production. That is,

$$D = cq = q.$$

The expected profit of the monopolist is defined as

$$\pi(q, \widetilde{z}) = R(q, \widetilde{z}) - C(q) = (a + \widetilde{z} - q - 1)q. \tag{3}$$

Because the revenue of the monopolist ($R(q, z) = (a + z - q - 1)q$) is increasing in z, we can define the repayment function under limited liability as $r \equiv \min\{R(q, z), D\}$ for any given realized value z of $\widetilde{z}$:

$$\begin{aligned} r &= R(q, z), \text{ if } -\overline{z} \leq z < \widehat{z} \\ &= D = q, \quad \text{if } \overline{z} \geq z \geq \widehat{z}, \end{aligned} \tag{4}$$

[7] In the Brander-Lewis framework, R^i (the gross profit function) is assumed to depend on the outputs q_i and q_j and the random shock $\widetilde{z}_i$ with support $[-\overline{z}, \overline{z}]$. For example, see Franck and Pape (2008).

[8] As Povel and Raith (2004) state in their paper, "internal funds" refers the firm's own funds that it can use to pay for variable production costs, $w_0 \equiv r_0 - F$, where r_0 and F denote the firms' retained earnings and fixed costs, respectively. Cleary et al. (2007) show that $w_0 < 0$, that is, *"negative internal funds"* are empirically relevant using 20 years of annual Compustat data, so we can expect that a firm must finance variable costs in this case.

where $\widehat{z}$ is defined as

$$D = q = (a + \widehat{z} - q)q = R(q, \widehat{z}).$$

$$\widehat{z} = -(a - q - 1). \tag{5}$$

Following the assumption of Brander and Lewis (1986) for $\widehat{z}$, we assume that[9]

$$-\overline{z} < \widehat{z} < \overline{z}. \tag{6}$$

We assume the following to guarantee a positive output and a positive margin in equilibrium.

[**Assumption 1**]
$2(a-1) > \overline{z} > \frac{1}{2}(a-1)$ and $a > 2$.

3 A Monopoly under Unlimited Liability

We consider a monopoly in which the owners choose an objective of profit maximization or sales maximization in the first stage and the manager chooses the output in the second stage under *unlimited liability*. That is, the owners are faced with a two-stage decision problem under additive demand uncertainty.

We consider the decision problem in stage 2. Given that the owners of the monopolist chose profit maximization, we have an equilibrium in the monopoly.

From (3), the first order condition is given by

$$\frac{\partial R(q, z)}{\partial q} = a - 2q - 1 = 0. \tag{7}$$

From (7) and (1), we can easily obtain each firm's output, total output, and expected price at the equilibrium

$$\begin{aligned} q^{UP} &= \frac{1}{2}(a-1), \\ Ep^{UP} &= E[a + \widetilde{z} - q^{UP}] = \frac{1}{2}(a+1), \end{aligned} \tag{8}$$

where the superscript "UP'' of q denotes that the objective of the monopolist is profit maximization under unlimited liability.

By (1) and (3), we have

[9]This assumption guarantees that $\widehat{z}$, the break-even realized value of $\widetilde{z}$, at which the expected net profit (sales) of the firms after full repayment D exists between the closed interval $[-\overline{z}, \overline{z}]$.

$$\begin{aligned}\pi^{UP} &= EPS^{UP} = E[(p^{UP}-1)q^{UP}] = (q^{UP})^2 = \frac{1}{4}(a-1)^2, && (9)\\ ECS^{UP} &= \frac{1}{2}E[(a+\widetilde{z}-p^{UP})q^{UP}] = \frac{1}{2}(q^{UP})^2 = \frac{1}{8}(a-1)^2, \\ ESS^{UP} &= EPS^{UP} + ECS^{UP} = \frac{3}{8}(a-1)^2, && (10)\end{aligned}$$

where PS, CS, and SS denote producer surplus, consumer surplus, and social surplus, respectively.

Next, given that the owners of the monopolist choose sales maximization, a simple calculation provides us with the monopoly equilibrium. The monopolist maximizes its expected sales (revenue),

$$ER^{US} = \max_q E[(a+\widetilde{z}-q^{US})q^{US}],$$

where the superscript "*US*" of q denotes that the objective is *sales maximization* under *unlimited liability*.

The first order condition is

$$a - 2q^{US} = 0. \quad (11)$$

From (11) and (1), we can easily obtain the output of the monopoly, and the expected price at the equilibrium

$$\begin{aligned}q^{US} &= \frac{1}{2}a, \\ Ep^{US} &= E[a+\widetilde{z}-q^{US}] = \frac{1}{2}a. && (12)\end{aligned}$$

From (1) and (3), we have[10]

$$\begin{aligned}\pi^{US} &= EPS^{US} = (Ep^{US}-1)q^{US} = \frac{1}{2}(\frac{1}{2}a-1)a = \frac{1}{4}a(a-2), && (13)\\ ECS^{US} &= \frac{1}{2}E[(a+\widetilde{z}-Ep^{US})q^{US}] = \frac{1}{2}(q^{US})^2 = \frac{1}{8}a^2, \\ ESS^{US} &= EPS^{US} + ECS^{US} = \frac{1}{8}a(3a-4). && (14)\end{aligned}$$

From the above equalities, we can derive the following proposition.

[10] To guarantee positive expected profit, we assume that $a > 2$.

Proposition 1 A monopolist produces more in the US equilibrium than in the UP equilibrium. Consequently, the expected price in the former equilibrium is lower than in the latter one, the monopolist in the former earns less than the monopolist in the latter, and the expected consumer and social surplus in the former are larger than in the latter. Formally, if $a > 2$ and $2 < t$, then

$q^{US} > q^{UP}$, $Ep^{US} < Ep^{UP}$, $E\pi^{UP} > E\pi^{US}$, $ECS^{UP} < ECS^{US}$, and $ESS^{UP} < ESS^{US}$.

That is, the owners of the monopolist *always* choose to maximize profits under unlimited liability.

The intuition for the proposition is clear. The *sales-maximizing* monopolist in the *US equilibrium* produces more aggressively than the *profit-maximizing* monopolist in the *UP equilibrium* because the former does not consider its costs. This output expansion in the *US equilibrium* sharply lowers the price and the expected profit relative to the *UP equilibrium.* This result about the expected profit is contrary to the result for oligopoly in Fershtman and Judd (1987). That is, the owners of the monopolist choose to maximize profits under unlimited liability even though maximizing sales is more desirable from a welfare point of view.

4 A Monopoly under Limited Liability

In this section, we consider a monopoly that follows the same decision process as in the previous section under *limited liability.* We solve a two-stage decision problem in which the owners of the firm choose either profit maximization or sales maximization in the first stage and the manager chooses the output in the second stage under limited liability.

At first, we consider a profit-maximizing monopoly. We denote a monopoly whose objective is profit maximization under *limited liability* with *superscript "LP."* We call this equilibrium "*the LP equilibrium*" hereafter. Because the monopoly under limited liability repays $r \equiv \min\{R(q,z), D\}$ for some realized value z of $\widetilde{z}$ from (4), the monopolist maximizes its expected profit after repaying its investors, that is

$$\begin{aligned}\max_q &= \textstyle\int_{-\overline{z}}^{\overline{z}} [\pi(q,z) + D - r]\phi(z)dz = \int_{-\overline{z}}^{\overline{z}} [R(q,z) - r]\phi(z)dz \\ &= \int_{\widetilde{z}^{LN}}^{\overline{z}} (a + z - q - 1)q \cdot \frac{1}{2\overline{z}} dz. \end{aligned} \tag{15}$$

The first order condition is given by

$$\frac{\partial \pi^{LP}}{\partial q} = \int_{\widehat{z}^P}^{\overline{z}} \frac{\partial}{\partial q}\left[R(q,z)-q\right]\phi(z)dz + (a+\widehat{z}^{LP}-q-1)q\cdot\frac{\partial \widehat{z}^{LP}}{\partial q}\phi(\widehat{z}^{LP})$$
$$= \int_{\widehat{z}^{LP}}^{\overline{z}} (a+z-2q-1)\frac{1}{2\overline{z}}dz(\because (5))$$
$$= \frac{1}{2\overline{z}}\frac{\left(\overline{z}-\widehat{z}^{LP}\right)}{2}\left[-q+\frac{\overline{z}-\widehat{z}^{LP}}{2}\right]=0.$$

Because $\overline{z}-\widehat{z}>0$ holds from (6), we see that $-q+\frac{\overline{z}-\widehat{z}^{LP}}{2}=0$ holds.
Substituting (5) into this equality, we see that

$$\frac{1}{2}\left(a-3q^{LP}-1+\overline{z}\right)=0, \tag{16}$$

From (16), we obtain

$$q^{LP}=\frac{1}{3}(t-1)>0, \tag{17}$$

where $t\equiv a+\overline{z}$.[11]
From (17) and (1), we see that

$$E\left[p^{LP}\right]\equiv E\left[a+\widetilde{z}-q^{LP}\right]=\frac{1}{3}(3a+1-t). \tag{18}$$

$$\widehat{z}^{LP}=-\frac{1}{3}\left(2(a-1)-\overline{z}\right). \tag{19}$$

We can show that$-\ \overline{z}<\widehat{z}^{LP}<\overline{z}$.[12]
Hence, we obtain the equilibrium net expected profit of the monopolist from (15) and (19),

$$\pi^{LP}\equiv\int_{\widehat{z}^{LP}}^{\overline{z}}(a+z-q^{LP}-1)q^{LP}\cdot\frac{1}{2\overline{z}}dz$$
$$=\frac{1}{2\overline{z}}q^{LP}\cdot\frac{1}{2}\left(\overline{z}-\widehat{z}^{LP}\right)^2(\because (16))$$
$$=\frac{1}{\overline{z}}\left(q^{LP}\right)^3=\frac{1}{27\overline{z}}(t-1)^3. \tag{20}$$

From (17) and (20), we have

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[11]The inequality holds from Assumption 1. $t=a+\overline{z}>a+\frac{1}{3}(a-1)>\frac{1}{2}(3a-1)>\frac{5}{2}>2$ holds because $a>2$.
[12]From (19),$\overline{z}-\widehat{z}^{LN}=\frac{2}{3}(a+\overline{z}-1)=\frac{2}{3}(t-1)>0$, $t>2$ and $\widehat{z}^{LN}-(-\overline{z})=\overline{z}+\widehat{z}^{LN}=\frac{4}{3}\overline{z}-\frac{2}{3}(a-1)=\frac{2}{3}(2\overline{z}-(a-1))>0$ from Assumption 1.

$$ECS^{LP} = \frac{1}{2}(q^{LP})^2 = \frac{1}{18}(t-1)^2,$$

The expected profits (losses) of the bank (investors) at the LP equilibrium are given by

$$\begin{aligned} EBP^{LP} &= E[r-D] \\ &= \frac{1}{2\overline{z}}[\int_{-\overline{z}}^{\widehat{z}^{LP}} \{(a+z-q^{LP}-1)q^{LP} - q^{LP}\}dz \\ &\quad + \int_{\widehat{z}^{LP}}^{\overline{z}} \{q^{LP} - q^{LP}\}dz] \\ &= \frac{1}{2\overline{z}} \int_{-\overline{z}}^{\widehat{z}^{LP}} \{(a+z-q^{LP}-2)q^{LP} dz \\ &= -\frac{1}{4\overline{z}} q^{LP}(\overline{z} + \widehat{z}^{LP})^2, \end{aligned} \tag{21}$$

so the expected social welfare at the LP equilibrium is given by

$$\begin{aligned} ESS^{LP} &= \pi^{LP} + ECS^{LP} + EBP^{LP} \\ &= \frac{1}{4\overline{z}}(\overline{z} - \widehat{z}^{LP})^2 q^{LP} + q^{LP} + \frac{1}{2}(q^{LP})^2 - \frac{1}{4\overline{z}} q^{LP}(\overline{z} + \widehat{z}^{LP})^2 (\because (5)) \\ &= q^{LP}(a - 1 - \frac{1}{2}q^{LP}) = \frac{1}{18}(t-1)(5(a-1) - \overline{z}). \end{aligned} \tag{22}$$

Next, we analyze a sales-maximizing monopoly under limited liability. We denote the monopoly whose objective is *sales maximization* by *superscript "LS."* Furthermore, we call the monopoly equilibrium "*the LS equilibrium.*" Although a *sales-maximizing* monopolist *has to repay all of its sales to investors when its sales less are than* D, it does not care about repayment when its sales are more than D under limited liability. That is, the monopolist repays $r \equiv \min\{R(q,z), D\}$ for some realized value z of $\widetilde{z}$ from (4). The firm maximizes net sales $\overline{R}(q,z)$, defined by

$$\begin{aligned} \overline{R}(q,z) &= R(q,z) - r = 0, \text{ if } -\overline{z} \leq z < \widehat{z}^{LS} \\ &= R(q,z), \text{ otherwise.} \end{aligned}$$

Hence, the expected sales maximization problem for the monopolist under limited liability is given by

$$
\begin{aligned}
R^{LS} &\equiv \max_q \int_{-\overline{z}}^{\overline{z}} \overline{R}(q,z)\phi(z)dz \\
& \max_q \int_{\widehat{z}^{LS}}^{\overline{z}} R(q,z)\phi(z)dz \\
&= \max_q \frac{1}{2\overline{z}} q(\overline{z}-\widehat{z}^{LS}) \frac{(2+\overline{z}-\widehat{z}^{LS})}{2} \\
&= \max_q \frac{1}{4\overline{z}} q\left\{(a+\overline{z}-q)^2-1\right\}. \qquad (23)
\end{aligned}
$$

The first order condition is

$$
\frac{\partial R^{LS}}{\partial q} = \frac{1}{2\overline{z}}\left[\frac{1}{2}\{\left(a+\overline{z}-q^{LS}\right)^2-1\} - q^{LS}\left(a+\overline{z}-q^{LS}\right)\right] = 0. \qquad (24)
$$

From (24), we then obtain the quadratic equation of q^{LS},

$$
3(q^{LS})^2 - 4tq^{LS} + t^2 - 1 = 0.
$$

This quadratic equation has two distinct real solutions,

$$
q^{LS} = \frac{1}{3}\left(2t+\sqrt{t^2+3}\right),\ \frac{1}{3}\left(2t-\sqrt{t^2+3}\right).
$$

The former root violates condition (6), that is, $\overline{z}-\widehat{z}^{LS} = a+\overline{z}-q^{LS} - 1 = t - q^{LS} - 1 = \frac{1}{3}(t-3-\sqrt{t^2+3}) < 0$.

Consequently, the equilibrium output and $\widehat{z}^{LS}$ are

$$
q^{LS} = \frac{1}{3}\left(2t-\sqrt{t^2+3}\right), \qquad (25)
$$

$$
\widehat{z}^{LS} = -\frac{1}{3}\left(3(a-1)-2t+\sqrt{t^2+3}\right). \qquad (26)
$$

Lemma 2 If $t \equiv a+\overline{z} > a > 2$ and $\overline{z} > \frac{1}{8}(2a-5+\sqrt{4a^2-4a+9})$, then $\widehat{z}^{LS}$ satisfies assumption (6).

For proof of the lemma, see the appendix.

Hence, we obtain the *ex ante* equilibrium expected net profit of the monopolist from (3), (26), and ((A.1))

$$\begin{aligned}
\pi^{LS} &= \int_{-\overline{z}}^{\overline{z}} [\pi(q,z) + D - r]\phi(z)dz = \int_{-\overline{z}}^{\overline{z}} [R(q,z) - r]\phi(z)dz \\
&= \int_{\widehat{z}^{LS}}^{\overline{z}} (a + z - q^{LS} - 1)q^{LS} \cdot \frac{1}{2\overline{z}} dz \\
&= \frac{1}{2\overline{z}} q^{LS} \cdot \frac{1}{2} \left(\overline{z} - \widehat{z}^{LS}\right)^2 \\
&= \frac{1}{108\overline{z}} \left(2t - \sqrt{t^2+3}\right)\left(t - 3 + \sqrt{t^2+3}\right)^2. \qquad (27)
\end{aligned}$$

From (25) and (27), we have

$$ECS^{LS} = \frac{1}{2}(q^{LS})^2 = \frac{1}{18}(2t - \sqrt{t^2+3})^2.$$

The expected profit (losses) of the bank (investors) at the LS equilibrium is given by

$$\begin{aligned}
EBP^{LS} &= E[r_{LS} - D_M] \\
&= \frac{1}{2\overline{z}}[\int_{-\overline{z}}^{\widehat{z}^{LS}} \{(a + z - q_M^{LS})q_M^{LS} - q_M^{LS}\}dz \\
&\quad + \int_{\widehat{z}^{LS}}^{\overline{z}} \{q_M^{LS} - q_M^{LS}\}dz] \\
&= \frac{1}{2\overline{z}} \int_{-\overline{z}}^{\widehat{z}^{LS}} \{(a + z - q_M^{LS} - 1)q_M^{LS} dz \\
&= -\frac{1}{4\overline{z}} q_M^{LS} (\overline{z} + \widehat{z}^{LS})^2, \qquad (28)
\end{aligned}$$

so the expected social welfare at the LP equilibrium is given by

$$\begin{aligned}
ESS^{LS} &= \pi^{LS} + ECS^{LS} + EBP^{LS} = q^{LS}(a - 1 - \frac{1}{2}q^{LS}) \qquad (29) \\
&= \frac{1}{3}\left(2t - \sqrt{t^2+3}\right)\left(a - 1 - \frac{1}{6}\left(2t - \sqrt{t^2+3}\right)\right).
\end{aligned}$$

5 Comparing the Monopoly Equilibria in Unlimited and Limited Liability

In this section, we compare the monopolist's output, expected price, and expected net profit in equilibrium under unlimited and limited liability. At first, we obtain the following proposition. See the appendix for the proof.

Proposition 3 A monopolist produces more in the LS equilibrium than in the LP equilibrium. Consequently, the expected price in the former is lower than in the latter, and the monopolist in the former earns less than the monopolist in the latter, but the expected consumer and social surplus in the former is larger than those in the latter. Formally, if $2 < t$, then $\pi^{LP} > \pi^{LS}$, $q^{LS} > q^{LP}$, $E[p^{LS}] < E[p^{LP}]$, $ECS^{LP} < ECS^{LS}$, and $ESS^{LP} < ESS^{LS}$.

The intuition of the result is straightforward. From (15) and (23), the monopolist maximizes its expected profits *after repaying* its investors for *any realized value* of z *in the LP equilibrium. In the LS equilibrium*, the monopolist maximizes its sales *after repaying its sales to investors in the bad state* ($-\overline{z} \leq z \leq \widehat{z}$), so sales are less than debt and *profits are zero.* The firm maximizes its sales *without repaying its investors in the good state* ($\widehat{z} < z \leq \overline{z}$), so its sales are more than its debt. Therefore, the monopolist in the *LS equilibrium* produces more aggressively than in the *LP equilibrium.* The firm earns less in the latter state than the former since the equilibrium price in the former is much lower than that in the latter. That is, the owners of the monopolist have *no incentive to choose to maximize sales under limited liability.*

Comparing the monopolist's output, expected price, and expected net profit derived in section 3 to those derived in section 4, we obtain the following propositions. (Please see the appendix for the proof.)

Proposition 4 (John, Senbet, Sundaram, and Woodward (2005)) Under Assumption 1, a monopolist produces more in the LP equilibrium than in the UP equilibrium. Consequently, the expected price in the former is lower than in the latter, the monopolist in the former earns more than the monopolist in the latter, and the expected consumer and social surplus in the former are larger than those in the latter. Formally, if $2 < t$, then $q^{UP} < q^{LP}$, $EP^{UP} > EP^{LP}$, and $\pi^{UP} < \pi^{LP}$ hold, and $ECS^{UP} < ECS^{LP}$ and $ESS^{UP} < ESS^{LP}$ hold.

The result of this proposition is that a limited liability profit-maximizing monopolist produces more, has a lower expected price, and earns greater expected profits than an unlimited liability profit-maximizing monopolist. This result is same as in Propositions 1 and 2 presented by John, Senbet, Sundaram, and Woodward (2005).

We can easily show the next proposition. See the appendix for the proof.

Proposition 5 Under Assumption 1, the monopolist earns the most in the LP equilibrium, the second most in the LS equilibrium, the third most in the UP equilibrium, and the least in the US equilibrium. Formally, that means $E\pi^{LP} > E\pi^{LS} > E\pi^{UP} > E\pi^{US}$ always holds.

From this proposition, we see that the owners of the monopolist are better off when they choose profit maximization than when they choose sales maximization under both unlimited and limited liability. We also see that they are better off when they choose profit maximization rather than sales maximization under limited liability in Proposition 3.

The result obtained in Proposition 3, therefore, theoretically supports the historical fact that *the Dutch East India Company, which chose profit maximization* as its objective, *earned more than the British East India Company, which chose sales maximization as its objective*, so the former *dominated long-distance commerce* in the seventeenth century. Proposition 3 also implies that it is more *desirable for the monopolist to maximize sales from a social welfare perspective* even though it maximizes profit under limited liability.

6 Discussion and Concluding Remarks

In this article, we built a simple monopoly model in order to describe two limited liability companies, the Dutch and British East India Companies, established early in the seventeenth century. Then, we theoretically analyzed the behavior of these two different types of monopolists organized as limited liability companies.

Specifically, we consider a monopoly with additive demand uncertainty in which both types of monopolist produce and supply a homogeneous good with an identical constant return to scale technology. We consider a profit-maximizing monopoly and a sales-maximizing monopoly under both unlimited liability and limited liability. That is, in the first stage, the shareholders of a monopoly can choose the objective by designing an incentive scheme for the manager of their firm. In the second stage, the manager of the firm chooses the output quantity under both unlimited liability and limited liability. We explore the relationship between the objective of the monopolist and limited liability as one of the most valuable inventions and institutions that human beings have created in history, and we show that the owners of the monopolist are better off when they choose profit maximization rather than sales maximization under both unlimited and limited liability. This result seems to be natural and straightforward in the monopoly setting, and it gives a theoretical explanation for why the Dutch East India Company rather than the British East India Company dominated long-distance commerce in the seventeenth century. Thus, we present a result that theoretically supports the historical fact that the Dutch East India Company, which maximized profits, earned more than the British East India Company, which maximized sales. From Proposition 3, although it is more desirable for a monopolist to maximize sales from a social welfare perspective, the firm chooses to maximize profits under limited liability.

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Appendix

Proof of Lemma 2

Proof: For $\hat{z}^{LS}$ to satisfy the assumption (6), we also have from assumption 1 and (5)

$$
\begin{aligned}
\overline{z} - \widehat{z}^{LS} &= \overline{z} + (a - q^{LS} - 1) \\
&= t - 1 - \frac{1}{3}(2t - \sqrt{t^2+3}) \\
&= \frac{1}{3}\left((t-3) + \sqrt{t^2+3}\right) \quad > 0 \Leftrightarrow 6(t-1) > 0 \Leftrightarrow t > 2,
\end{aligned}
\tag{A.1}
$$

where $t \equiv a + \overline{z} > 2$.
We can also show that

$$
\begin{aligned}
\widehat{z}^{LS} - (-\overline{z}) &= \overline{z} + z^{LS} \\
&= \overline{z} + \frac{1}{3}\left(3(a-1) - 2t + \sqrt{t^2+3}\right) \\
&= \frac{1}{3}\left(3 - a + 5\overline{z} - \sqrt{(a+\overline{z})^2+3}\right) > 0 \\
&\Leftrightarrow 4\overline{z}^2 + (5-2a)\overline{z} + (1-a) > 0
\end{aligned}
$$

equivalently

$$
\overline{z} < \frac{1}{8}(2a - 5 - \sqrt{4a^2 - 4a + 9}), \frac{1}{8}(2a - 5 + \sqrt{4a^2 - 4a + 9}) < \overline{z} \tag{A.2}
$$

The lemma holds since we see that $\frac{1}{8}(2a - 5 - \sqrt{4a^2-4a+9}) < 0$ for $a > 2$.■

Proof of Proposition 3

Proof: From(17)and (25), $q^{LS} - q^{LP} = \frac{1}{3}\left(2t - \sqrt{t^2+3}\right) - \frac{1}{3}(t-1) = \frac{1}{3}((t+1) - \sqrt{t^2+3}) > 0$, since $(t+1)^2 - (t^2+3)^2 = 2(t-1) > 0$ for $t > 1$,where $t = a + \overline{z}$. So we see that $E[p^{LS}] = E[a + z - q^{LS}] = a - q^{LS} < E[p^{LP}] = E[a + z - q^{LP}] = a - q^{LP}$. We also see that $ECS^{LS} = \frac{1}{2}(\ q^{LS})^2 > ECS^{LP} = \frac{1}{2}(\ q^{LP})^{2.}$ From (20) and (27), we have
$\pi^{LP}(q^{LP}) - \pi^{LS}(q^{LS}) = \frac{1}{27\overline{z}}(t-1)^3 - \frac{1}{108\overline{z}}(2t - \sqrt{t^2+3})(t - 3 + \sqrt{t^2+3})^2$
$= \frac{1}{108z}\left(t - \sqrt{t^2+3} + 1\right)^2 \left(2t + \sqrt{t^2+3} - 4\right)$.But we know that$\left(t - \sqrt{t^2+3} + 1\right)^2 > 0$, the sign of $sign(\pi^{LP}(q^{LP}) - \pi^{LS}(q^{LS})) = sign\ (2t + \sqrt{t^2+3} - 4)$.
Since $\frac{\partial}{\partial t}(2t + \sqrt{t^2+3} - 4) = \frac{t}{\sqrt{t^2+3}} + 2 > 0$ for $t > 2 > 1$ and $2 \cdot 1 + \sqrt{1^2+3} - 4 = 0$. So $(2t + \sqrt{t^2+3} - 4) > 0 \iff t > 2$. Hence we have $\pi^{LP}(q^{LP}) > \pi^{LS}(q^{LS})$. From(29) and (22), define $F(q) \equiv q(a - 1 - \frac{1}{2}q)$. $\frac{dF(q)}{dq} = F'(q^*) = a - 1 - \frac{1}{2}q^* = 0$ and $F'(q) \gtreqless 0 \Leftrightarrow q \lesseqgtr q^* = a - 1, F''(q) = -\frac{1}{2} < 0$ for all q. We can easily show that $q^* = a - 1 > \frac{1}{3}\left(2t - \sqrt{t^2+3}\right) = q^{LS} > q^{LP}$ since we have already shown it above

and so for $a > 2$ and Assumption 1.Thus, we see that $ESS^{LS} - ESS^{LP} = F(q^{LS}) - F(q^{LP}) > 0$,since $q^* = a - 1 > q^{LS} > q^{LP}$ and $F'(q) > 0$ for $q^* > q$, thus we get the result. ■

Proof of Proposition 4

Proof: From(8)and (17), $q^{UP} - q^{LP} = \frac{1}{2}(a-1) - \frac{1}{3}(t-1) = \frac{1}{6}(3a - 3 - 2t + 2) = \frac{1}{6}(3a - 3 - 2a - 2\overline{z} + 2) = \frac{1}{6}(a - 1 - 2\overline{z}) < 0$ from Assumption 1,where $t = a + \overline{z} > a > 2$. So we see that $E[p^{UP}] = E[a + z - q^{UP}] = a - q^{UP} > E[p^{LP}] = E[a + z - q^{LP}] = a - q^{LP}$. We also see that $ECS^{UP} = \frac{1}{2}(\ q^{UP})^2 < ECS^{LP} = \frac{1}{2}(\ q^{LP})^2$. From (9) and (20), we have

$\pi^{UP} - \pi^{LP} = \frac{1}{4}(a-1)^2 - \frac{1}{27\overline{z}}(t-1)^3 = \frac{1}{108\overline{z}}\{27\overline{z}(a-1)^2 - 4(t-1)^3\} \propto 27\overline{z}(a-1)^2 - 4(t-1)^3 = -4\overline{z}^3 - 12(a-1)\overline{z}^2 + 15(a-1)^2\overline{z} - 4(a-1)^3 \equiv g(\overline{z})$.

So we have $g(\frac{1}{2}(a-1)) = 0$, $g'(\overline{z}) = 3\,(a - 2\overline{z} - 1)\,(5a + 2\overline{z} - 5) < 0$, since $5a + 2\overline{z} - 5 = 5(a-1) + 2\overline{z} > 6(a-1)$ from Assumption 1. Hence $g(\overline{z}) < 0$ and $\pi^{UP} - \pi^{LP} < 0$ for $\overline{z} > \frac{1}{2}(a-1)$. From (10) and (22),

$ESS^{UP} - ESS^{LP} = \frac{3}{8}(a-1)^2 - \frac{1}{54\overline{z}}(t-1)^2(2(t-1) + 3\overline{z}) = \frac{1}{216\overline{z}}\{81\overline{z}(a-1)^2 - 4(t-1)^2(2(t-1) + 3\overline{z})\}$

$= \frac{1}{216\overline{z}}(a - 1 - 2\overline{z})(10\overline{z}^2 + 29\overline{z} - 8(a-1)^2) \propto -(10\overline{z}^2 + 29\overline{z} - 8(a-1)^2) \equiv h(\overline{z})$, from Assumption 1. we know that $h(\overline{z})$ is a concave quadratic function of $\overline{z}$ and $\overline{z} > \frac{1}{2}(a-1) > 0$ so we can show that $\overline{z} > \frac{1}{2}(a-1) > \frac{(a-1)}{20}(-29 + 3\sqrt{129}) > 0$, where $\frac{(a-1)}{20}(-29 + 3\sqrt{129})$ is the larger solution of the two real solutions of $h(\overline{z}) = 0$, the quadratic equation of $\overline{z}$. Hence $h(\overline{z}) < 0$ and $ESS^{UP} - ESS^{LP} < 0$, we show the result.■

Proof of Proposition 5

Proof: From (13) and (27),

$\pi^{LS} - \pi^{UP} = \frac{1}{27\overline{z}}(t-1)^3 - \frac{1}{4}(a-1)^2$
$= \frac{1}{108\overline{z}}\{4(t-1)^3 - 27\overline{z}(a-1)^2\}$
$4(a + z - 1)^3 - 27z(a-1)^2 = (4a + z - 4)\,(a - 2z - 1)^2 > 0$ for $z > \frac{1}{2}(a-1)$.

Combining the above into the results presented in Propositions 1, 3 and 4, we obtain the result.■

Authors' Information

Tetsuya Shinkai, School of Economics, Kwansei Gakuin University, 1-155 Uegahara-ichibancho, Nishinomiya 662-8501, Japan, E-mail: shinkai@kwansei.ac.jp

Takao Ohkawa, Faculty of Economics, Ritsumeikan Univeristy, 1-1-1, Nojihigashi, Kusatsu, Shiga 525-8577, Japan, E-mail: tot06878@ec.ritsumei.ac.jp

Makoto Okamura, Faculty of Economics, Hiroshima Univeristy, 1-3-2 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8511, Japan, E-mail: okamuram@hiroshima-u.ac.jp

Kozo Harimaya, Faculty of Business Administration, Ritsumeikan University, 1-1-1, Nojihigashi, Kusatsu, Shiga 525-8577, Japan, E-mail: harimaya@fc.ritsumei.ac.jp