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Endogenous Determination of the Liability Rule in Oligopolistic Markets*

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Abstract

We address the following question: Why do most large firms select limited liability as their business organizational form in the real world? We construct a two-stage game. In the first stage, each of the oligopolistic firms chooses its business organizational form, while in the second stage, each behaves in a Cournot fashion. The following conclusions are established. (1) Even if an unlimited liability firm is viable, all firms become limited liability entities in equilibrium. (2) The equilibrium industry configuration, where all firms become limited liability entities, achieves efficiency in the second-best sense.

Keywords: business organizational form, limited liability, unlimited liability, Cournot oligopoly

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1 Introduction

In nearly all developed, capitalistic economies, a majority of the large companies undertake limited liability while only a small minority of partnerships undertake unlimited liability as a form of business organization. According to the National Tax Agency (2012), there were 6872 companies in Japan in FY2010 with capital greater than 1 billion yen, 6222 of which had limited liability (6212 corporations, 10 companies with limited liability), only 3 had unlimited liability (none with general partnerships, 3 with limited partnerships), and 647 other business organizations. According to the Monopolkommission (2012, p. 124), in 2010, the Germany's 100 largest companies consisted of 80 limited liability entities (67 corporations, 7 limited liability companies, 6 Societas Europaea (European companies)), 13 unlimited liability entities (0 general partnership, 11 limited partnerships, 2 limited partnerships by shares), and 7 other business organizations. Spulber (2009, pp. 264-65) reported that corporations earn nearly 85% of the total revenues of all firms (including partnership and sole proprietorship) per year; however, their share of the number of total firms is roughly 19% in the United States. [1] This implies that large American companies primarily adopt corporations as their business organizational form.

This study raises the question as to why nearly all business entities, especially large-size corporations, choose limited liability as a form of their business organization. No theoretical article has addressed this issue to our knowledge; however, numerous articles deal with the relationship between financial structure and product market competition. [2] This study focuses on the two types of business organization: (1)a limited liability entity and (2) an unlimited liability entity. It examines which form of business organization do quantity-setting oligopolists select under an extended and modified version of the Brander and Lewis (1986) model.

A two-stage game is constructed: In the first stage, each of the firms simultaneously and

[1] There are three main financial structure: corporation, partnership, and sole proprietorship in the United States. Corporation only adopts limited liability. See Spulber(2009, p. 264) in detail.

[2] For example, Brander and Lewis (1986); Showalter (1995); Hughes, Kao, and Mukherji (1998); Wanzenried (2003); and Franck and Le Pape (2008) have studied oligopolistic competition. See Neff (2003) for a detailed survey of related articles.

independently chooses to be either an entity with limited liability or an entity with unlimited liability. In the second stage, each firm engages in Cournot competition. We determine that when an unlimited liability entity is viable, each firm adopts entities with limited liability as a form of business organization, and an industry consisting of entities with limited liability is socially optimal.

The rest of the paper is organized as follows: Section 2 presents our model. In Section 3, we examine the endogenous determination of the form of business organization. Section 4 addresses the optimal industry structure determining the forms of business organization, and finally, section 5 presents concluding remarks.

2 The Model

We consider an industry with $N(\geq 2)$ risk-neutral firms. N is assumed to be fixed. Each firm produces a homogeneous product. Firm $i(=1, ..., N)$'s cost function is $c(q_i) = cq_i$, where c is the constant marginal cost, and q_i is a firm i's quantity supplied. Each firm assumes a linear inverse demand function with uncertainty [3] :

$$p = p(z; Q) = a + z - Q \tag{1}$$

where p is the market price, a represents a demand parameter, $Q(= \sum_{i=1}^{N} q_i)$ is the total output, and z is a random variable uniformly distributed in the interval $[-\bar{z}, \bar{z}]$ with a density function,

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

A two-stage game is constructed: In the first stage, each firm simultaneously yet independently chooses either a limited liability organizational form labeled L or an unlimited liability organizational form labeled U. In the second stage, each firm competes *à la* Cournot in the product market.

[3]The following specification is also used in Hughes, Kao, and Mukherji (1998).

3 The Equilibrium

3.1 The Second-Stage Subgame

We solve the sub-game perfect Nash equilibrium of the game by backward induction. Consider the second stage of the game. Suppose $n \in [0, N]$ firms are limited liability firms, while the remaining $m(= N - n)$ firms are unlimited liability firms in the same industry. It is neither a right nor an obligation of a limited liability firm to pay its factors of production. If a limited liability firm consistently earns non-negative realized profits, it makes full payment to its input factor. Otherwise, it may pay the factors the realized revenue, which is lesser than its total cost. According to Brander and Lewis (1986) and John *et al.* (2005), each limited liability firm maximizes its expected profit:

$$\pi_i^L = \int_{\hat{z}}^{\bar{z}} (a + z - Q - c) q_i^L \frac{1}{2\bar{z}} dz, \tag{3}$$

where $\hat{z}$ is the critical value of z; a stage at which this firm earns zero profit, that is, a break-even point

$$a + \hat{z} - Q - c = 0, \tag{4}$$

and q_i^L is the individual output of limited liability firm i. When $z \geq$ (resp. $<$)$\hat{z}$, the firm makes non-negative (resp. negative) profit. $\hat{z}$ must lie within $[-\bar{z}, \bar{z}]$. Henceforth, we assume that $a - c = 1$ for simplicity. From (4), we derive the first-order condition for expected-profit maximization

$$\begin{aligned}\frac{\partial \pi_i^L}{\partial q_i^L} &= \int_{\hat{z}}^{\bar{z}} (1 + z - Q - q_i^L) \frac{1}{2\bar{z}} dz - (1 + \hat{z} - Q) \frac{1}{2\bar{z}} \cdot \frac{\partial \hat{z}}{\partial q_i^L} \\ &= (\bar{z} - \hat{z}) \left(1 - Q - q_i^L + \tfrac{1}{2}(\bar{z} + \hat{z})\right) \frac{1}{2\bar{z}} = 0. \end{aligned} \tag{5}$$

If firm i chooses q_i such that $\bar{z} - \hat{z} = 0$, then its expected profit is null from (3). Therefore, q_i^L such that $\bar{z} - \hat{z} = 0$ is not an equilibrium individual output even if the condition $\bar{z} - \hat{z} = 0$ satisfies (5). Thus, an equilibrium individual output satisfies

$$1 - Q - q_i^L + \tfrac{1}{2}(\bar{z} + \hat{z}) = 0. \tag{6}$$

In contrast, it is both a right and an obligation of an unlimited liability firm to pay its factor of production, because owners' personal assets are not protected by a legal contract. Therefore, owners must make full payment to its input factor even if the firm earns negative realized profit. Following John *et al.* (2005), the expected profit of an unlimited liability firm j π_j^U is defined as

$$\pi_j^U = \int_{-\bar{z}}^{\bar{z}} (a + z - Q - c) q_j^U \frac{1}{2\bar{z}} dz, \tag{7}$$

where q_j^U shows the output of the unlimited liability firm j. The first-order condition for expected-profit maximization is given by

$$\frac{\partial \pi_j^U}{\partial q_j^U} = 0 : 1 - Q - q_j^U = 0. \tag{8}$$

From (4), (5), and (8), we have equilibrium individual output and equilibrium total output

$$q^L = \frac{1}{2(N+1) - n}[1 + (N + 1 - n)\bar{z}], \tag{9a}$$

$$q^U = \frac{1}{2(N+1) - n}[2 - n\bar{z}], \tag{9b}$$

$$Q = \frac{1}{2(N+1) - n}[(2N - n) + n\bar{z}]. \tag{9c}$$

To ensure the viability of an unlimited liability firm, that is, $q^U \geq 0$ for any $n \leq N$, the following assumption is derived from (9b):

Assumption 1

$\bar{z} \leq \frac{2}{N}$.

We also impose the assumption ensuring that $\hat{z}$ falls in $[-\bar{z}, \bar{z}]$.

Assumption 2

$\bar{z} > \frac{1}{N+1}$. [4]

Because $\frac{2}{N} > \frac{1}{N+1}$ holds, the above assumptions are consistent. Direct evaluation yields the following lemma.

[4] From (4), (9c), and Assumption 1, we have $\hat{z} = Q - 1 = \frac{n\bar{z}-2}{2(N+1)-n} \leq 0$, meaning that $\hat{z} < \bar{z}$. Therefore, to guarantee that $-\bar{z} < \hat{z}$, the condition that $\bar{z} > \frac{1}{N+1}$ must hold. If $\hat{z} < -\bar{z}$ holds, the limited liability firms are essentially reduced to unlimited liability firms.

Lemma 1

Suppose Assumptions 1 and 2 hold. Then, the limited liability firm always produces greater output than the unlimited liability firm.

Equation (6) shows that marginal revenue of limited liability firm, $MR^L = a + \frac{1}{2}(\bar{z} + \hat{z}) - Q - q_i^L$ equals its marginal cost c, while (8) that that of unlimited one, $MR^U = a + \frac{1}{2} - Q - q_j^U$ is equal to c. Because $MR^L > MR^U$ for the same output level, limited liability firm behaves more aggressively than unlimited liability one.

Under Assumptions 1 and 2, expected equilibrium profit of both limited and unlimited liability firms can be written as follows.

$$\pi^L = \frac{1}{\bar{z}}(q^L)^3, \tag{10a}$$

$$\pi^U = (q^U)^2.[5] \tag{10b}$$

From (9), we obtain

$$\frac{\partial q^L}{\partial n} = \frac{1 - (N+1)\bar{z}}{(2(N+1) - n)^2}, \tag{11a}$$

$$\frac{\partial q^U}{\partial n} = \frac{2(1 - (N+1)\bar{z})}{(2(N+1) - n)^2}, \tag{11b}$$

$$\frac{\partial Q}{\partial n} = \frac{2((N+1)\bar{z} - 1)}{(2(N+1) - n)^2}. \tag{11c}$$

From (10), therefore, we have the following lemma.

Lemma 2

Suppose that Assumptions 1 and 2 hold. An increase in the number of limited liability firms n reduces the individual output of both, a limited liability firm as well as an unlimited liability one, but it enhances the total output. This implies that the aggregate output of unlimited liability firms decreases.

The limited liability firm behaves more aggressive than the unlimited liability firm as shown in Lemma 1. As the number of (aggressive) limited liability firms n increases in the industry, the competitiveness in the industry also increases.

[5] Detailed calculation is given in Appendix A.

3.2 The First-Stage Subgame

Let us return to the first stage. Anticipating equilibrium in the second stage, each firm has no incentive to change its type of financial status in the first stage. The sub-game perfect Nash equilibrium industry configuration (n^e, m^e) is defined as follows.

Definition 1

An industry configuration (n^e, m^e) is the subgame perfect Nash equilibrium if the configuration satisfies

(i) $n^e + m^e = N$ for $n^e \geq 0$ and $m^e \geq 0$,

(ii) $\pi^L(n^e, m^e) \geq \pi^U(n^e - 1, m^e + 1)$,

(iii) $\pi^U(n^e, m^e) \geq \pi^L(n^e + 1, m^e - 1)$.

From (10a), (10b), and Definition 1 we establish the following proposition.

Proposition 1

Suppose that Assumptions 1 and 2 hold. The industry configuration $(N, 0)$ is a unique Nash equilibrium.

Proof. See Appendix B.

Proposition 1 states that when both limited liability and unlimited liability firms are viable, every firm that can choose its business organizational form becomes an entity with limited liability. The reason is that a limited liability firm is more profitable than an unlimited liability firm because the former behaves more aggressively than the latter as show in Lemma 1.

Considering that all firms in the same industry are unlimited liability firms, each firm has the incentive to switch from being an unlimited liability entity to a limited liability entity; this shift permits it to be profitable by expanding its output. Therefore, the industry configuration consisting solely of unlimited liability firms is not stable. Since this shift is profitable for all unlimited liability firms in the industry, the industry configuration that includes unlimited liability firms is also unstable.

Considering that all firms in the same industry are limited liability firms, no firm in this situation has the incentive to shift from being a limited liability entity; this shift reduces profits because of its reducing output. Thus, the industry configuration consisting solely of limited liability firms is stable.

4 Efficient Industry Configuration

In this section, we examine what constitutes a welfare-maximizing industry configuration. Now considering that n firms with limited liability and $m(=N-n)$ firms with unlimited liability coexist in the industry, we examine the second-best policy in the sense that a social planner can solely control the number of firms with limited and unlimited liability, but cannot control each firm's output decision. We construct a two-stage game: In the first stage, the social planner determines the number of limited liability firms n to maximize (expected) social surpluses. Given the liability rule, each firm engages in Cournot competition in the second stage.

The expected social surplus is defined as a sum of consumer surplus, total profits of unlimited liability firms, total profit of limited liability firms, and the social cost caused by the decision of limited liability. Because second-stage equilibrium outcomes can be regarded as a function of the number of limited liability firms n from (10), expected social surplus can be expressed as

$$\begin{aligned} W(n) = &\int_{-\bar{z}}^{\bar{z}} \left[\int_0^{Q(n)} p(s;z)ds - p(Q(n);z)Q(n) \right] \frac{1}{2\bar{z}} dz \\ &+ (N-n) \cdot \left[\int_{-\bar{z}}^{\bar{z}} \left\{ p(Q(n);z)q^U(n) - cq^U(n) \right\} \frac{1}{2\bar{z}} dz \right] \\ &+ n \left[\int_{\hat{z}}^{\bar{z}} \left\{ p(Q(n);z)q^L(n) - cq^L(n) \right\} \frac{1}{2\bar{z}} dz \right] \\ &+ n \left[\int_{-\bar{z}}^{\hat{z}} \left\{ p(Q(n);z)q^L(n) - cq^L(n) \right\} \frac{1}{2\bar{z}} dz \right]. \end{aligned} \tag{12}$$

The first-order condition for welfare maximization is given by

$$W'(n) = (a - c - Q(n)) \frac{\partial Q(n)}{\partial n} = (1 - Q(n)) \frac{\partial Q(n)}{\partial n} \tag{13}$$

from (12). [6] Because $\hat{z} = Q(n) - 1$ is the nonpositive from Assumption 1, the sign of $W'(n)$

[6] Note that welfare can be transformed into

$$W(n) = \int_{-\bar{z}}^{\bar{z}} \left[\int_0^{Q(n)} p(s;z)ds - cQ(n) \right] \frac{1}{2\bar{z}} dz.$$

Differentiating the above equation with respect to n, we can easily obtain (13).

depends on $\frac{\partial Q(n)}{\partial n}$. Because $\frac{\partial Q(n)}{\partial n} > 0$ from Lemma 2, thus, the following proposition is established.

Proposition 2

Suppose that Assumptions 1 and 2 hold. The efficient industry configuration (n^*, m^*) *is* $(N, 0)$.

Proposition 2 states that welfare is maximized when an industry configuration comprises only of limited liability entities.

In an economy with linear demand and cost functions, an increase in the total output brings about welfare improvement. As previously mentioned, a limited liability firm is more aggressive than an unlimited liability firm for its quantity setting. Now considering that all firms are unlimited liability firms, the firm's switching from unlimited liability to limited liability enhances the level of welfare; thus, when all firms become limited liability firms welfare is maximized.

Propositions 1 and 2 help establish the following proposition.

Proposition 3

The equilibrium industry configuration is efficient in the second-best sense.

5 Concluding Remarks

In the real world, most large firms select limited liability as their business organizational form. To explain this fact, we construct a two-stage game. In the first stage, each oligopolistic firm simultaneously and independently chooses to be either an entity with limited liability or an entity with unlimited liability. Each of them behaves in a Cournot fashion in the second stage. The following conclusions are established. (1) Even if an unlimited liability firm is viable, all firms select limited liability entities. (2) The equilibrium industry configuration where all firms become limited liability entities is socially efficient in the second-best sense.

Suggested directions for further research are as follows, (1) Alter the competition mode from quantity to price competition: In price competition with product differentiation, a limited liability firm may be less aggressive than an unlimited liability firm. If so, the results may change in a price-setting oligopoly. (2) Introduce institutional differences among countries: For example a general partnership, which is an unlimited liability entity, has no juridical personality in the United States whereas it does in Japan. This situation means that a general partnership may not have to pay corporate tax in the United States, although it is a mandatory payment in Japan. This difference affects the choice of either limited or unlimited liability entity.

Appendix A: The Derivation of (10)

We can transform (3) into

$$\begin{aligned}\pi^L &= \int_{\hat{z}}^{\bar{z}} (1+z-Q)q^L \frac{1}{2\bar{z}} dz \\ &= (1-Q)(\bar{z}-\hat{z})q_L \frac{1}{2\bar{z}} + \frac{1}{2}(\bar{z}^2-\hat{z}^2)q_L \frac{1}{2\bar{z}} \\ &= \frac{1}{2\bar{z}}(\bar{z}-\hat{z})q_L \left(1-Q+\frac{1}{2}(\bar{z}+\hat{z})\right). \end{aligned} \tag{A1}$$

Considering (6), we can rearrange (A1) as

$$\pi^L = \frac{1}{2\bar{z}}(\bar{z}-\hat{z})q_L^2. \tag{A2}$$

From (4) and (6), we have $q_L = \frac{1}{2}(\bar{z}-\hat{z})$. Therefore, we can transform (A2) into (10a).

We can also transform (7) into

$$\begin{aligned}\pi^U &= (1-Q)\cdot 2\bar{z}q^U \frac{1}{2\bar{z}} + (\bar{z}^2-\bar{z}^2)q^U \frac{1}{2\bar{z}} \\ &= (1-Q)q^U. \end{aligned} \tag{A3}$$

Because we obtain $q^U = 1-Q$ from (8), we can rearrange (A3) as (10b).

Appendix B: Proof of Proposition 1

Hereafter, the new variable $x \equiv \frac{1}{\bar{z}}$ is introduced. Note that $x \in (\frac{N}{2}, N+1)$ from Assumptions 1 and 2. First, we prove that $\pi^L(N,0) \geq \pi^U(N-1,1)$. Let us define $F(x) \equiv \pi^L(N,0) - \pi^U(N-1,1)$. From (10a) and (10b), we derive $F(x)$ as

$$F(x) = \frac{1}{(N+2)^3}(x+1)^3 - \frac{1}{(N+3)^2}(2x-(N-1))^2. \tag{B1}$$

We obtain from (B1):

$$\lim_{x\to-\infty} F(x) = -\infty \tag{B2a}$$

$$F\left(\frac{N}{2}\right) = \frac{1}{8} - \frac{1}{(N+3)^2} > 0, \tag{B2b}$$

$$F(N+1) = 1 - 1 = 0, \tag{B2c}$$

$$\lim_{x\to\infty} F(x) = \infty > 0. \tag{B2d}$$

Differentiating (B1) with respect to x yields

$$F'(x) = \frac{3}{(N+2)^3}(x+1)^2 - \frac{4}{(N+3)^2}(2x - (N-1)). \tag{B3}$$

From (B3), we have

$$F'(0) = \frac{3}{(N+2)^3} + \frac{4}{(N+3)^2}(N-1) > 0, \tag{B4a}$$

$$F'(N+1) = \frac{1-N}{(N+2)(N+3)} < 0. \tag{B4b}$$

Because $F(x)$ is a cubic function of x and the sign of the coefficient of x^3 is positive, $F(x) > 0$ for any $x \in (\frac{N}{2}, N+1)$ from (B2) and (B4). This means that $\pi^L(N,0) \geq \pi^U(N-1,1)$.

Next, we prove that $\pi^U(n,m) < \pi^L(n+1, m-1)$. We define $G(x) \equiv \pi^U(n,m) - \pi^L(n+1, m-1)$. From (10a) and (10a), we derive $G(x)$ as

$$G(x) = \frac{1}{(2(N+1)-n)^2}(2x-n)^2 - \frac{1}{(2N+1-n)^3}(x+(N-n))^3. \tag{B5}$$

From (B5), we derive

$$\lim_{x\to-\infty} G(x) = \infty, \tag{B6a}$$

$$G(N+1) = 1 - 1 = 0, \tag{B6b}$$

$$\lim_{x\to\infty} G(x) = -\infty. \tag{B6c}$$

Differentiating (B5) with respect to x yields

$$G'(x) = \frac{4}{2(N+1-n)^2}(2x-n) - \frac{3}{(2N+1-n)^3}(x-(N-n))^2. \tag{B7}$$

From (B7), we have

$$G'(0) < 0, \tag{B8a}$$

$$G'(N+1) = \frac{1}{(2(N+1)-n)(2N+1-n)}(2(N-1)-n) > 0. \tag{B8b}$$

$G(x)$ is a cubic function of x, and the sign of the coefficient of x^3 is negative. Therefore, if $G(\frac{N}{2}) < 0$, then $G(x) < 0$ for any $x \in (\frac{N}{2}, N+1)$ from (B6) and (B8).

We show that $G(\frac{N}{2}) < 0$. From (B5), we have

$$G\left(\frac{N}{2}\right) = \frac{(2N+1-n)^3(N-n)^2 - (\frac{3}{2}N-n)^3(2(N+1)-n)^2}{(2(N+1)-n)^2(2N+1-n)^3}. \tag{B9}$$

We define the numerator of (B9) as a function of n, which is denoted by $H(n)$. Because $sgn(G(\frac{N}{2})) = sgn(H(n))$, we examine the sign of $H(n)$ for any $n \in [0, N]$. We calculate $H(0)$ and $H(N)$ as follows.

$$H(0) = N^2[(2N+1)^3 - \tfrac{27}{2}N(N+1)^2] = -N^2\left[\tfrac{11}{2}N^3 + 15N^2 + \tfrac{15}{2}N - 1\right] < 0, \tag{B10a}$$

$$H(N) = -\tfrac{1}{8}N^3(N+2)^2 < 0. \tag{B10b}$$

Differentiating $H(n)$ with respect to n and arranging term yields

$$\begin{aligned} H'(n) =& -((2N+1)-n)^2(N-n)((7N+2)-5n) \\ &+ (\tfrac{3}{2}N-n)^2(2(N+1)-n)((9N+3)-5n) \\ =& -(n^2-2(2N+1)n+(2N+1)^2)(5n^2-2(6N+1)n+N(7N+2)) \\ &+ \left(n^2-3Nn+\tfrac{9}{4}N^2\right)(5n^2-(19N+13)n+6(N+1)(3N+1)). \end{aligned} \tag{B11}$$

From (B11), we calculate $H'(0)$ and $H'(N)$

$$H'(0) = N^2(18 - \tfrac{25}{2}N) - \tfrac{3}{2}N - 2 < 0, \tag{B12a}$$

$$H'(N) = \tfrac{1}{4}N^2(N+2)(4N+3) > 0. \tag{B12b}$$

Because (B11) shows that $H'(n)$ is a cubic function of n and that the coefficient of n^3 is $-(2N+1) < 0$, (B12) implies that a critical value $\tilde{n}$ such that $H'(\tilde{n}) = 0$ uniquely exists in the interval $[0, N]$. Therefore, we have

$$H'(n) \leq 0 \quad \text{for any } n \in [0, \tilde{n}], \tag{B13a}$$

$$H'(n) > 0 \quad \text{for any } n \in [\tilde{n}, N]. \tag{B13b}$$

From (B10) and (B13), therefore, we obtain $H(n) < 0$ for any $n \in [0, N]$, which means that $G(\frac{N}{2}) < 0$.

Thus, we establish $\pi^U(n,m) < \pi^L(n+1, m-1)$, because $G(x) < 0$ for any $x \in (\frac{N}{2}, N+1)$.

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