Post-Bankruptcy Product Market Prospects and Strategic Debt Placement

Jing Yang *

California State University, Fullerton

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*Assistant Professor of Finance, California State University at Fullerton, Fullerton, CA92831. Email: jyang@fullerton.edu.

What Affects the Strategic Function of Debt
in the Product Market Competition?

ABSTRACT

I develop a strategic debt model that characterizes the interactions between the limited liability effect and the deep pocket effect in the product market competition. It incorporates not only the pre-bankruptcy product market, which is usually the focus of the conventional strategic debt models, but also the post-bankruptcy product market, which is commonly ignored. I find that although a firm might obtain a better current product market position though rasing a strategic debt, it might alternatively obtain a better future product market position if it constrains the current use of debt and achieves a longer stay in the market. The two adverse effects of debt generate an equilibrium debt that is lower than predicted by the conventional strategic debt models. In addition, the strategic placement of debt is impacted by traditional capital structure factors, such as financially constraint (+), investment risk (+), reorganization possibility (+), and asset liquidity (-). My model can justify several empirical findings that are difficult to explain by existing capital structure theories.

JEL classification: G32, E23

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1 Introduction

In this paper, I develop a simple Cournot model that integrates two opposite effects of strategic debt, the limited liability effect and the deep pocket effect, on the product market competition. This model allows me to reexamine the strategic functions of debt, hopefully in a more thorough way than traditional strategic debt models (that focus on either the limited liability effect or the deep pocket effect) can do. Built upon this model, I also investigate the impacts of traditional capital structure determinants on the strategic debt placement. Given the importance of strategic debt in growing industries (Graham and Harvey, 2001), my findings might shed lights on the capital structure decisions in these industries.

The impact of debt on product market competition has been an unresolved issue in the capital structure literature for decades. The major debate is on whether or not a strategic placement of debt can help a firm improve its product market position. The theoretical conflicts exist mainly between the limited liability theory (Brander and Lewis,1986, and Maksimovic, 1988, and so on), and the deep pocket theory (Fudenberg and Tirole, 1986, Poitevin, 1989, Bolton and Scharfstein, 1990, and Faure-Grimaud, 1986, and so on). The limited liability theory argues that, given the convexity of equity payoff, a debt commitment might induce aggressive productions when the shareholders see a greater chance of risk shifting, which may strengthen its market position. The deep pocket theory, however, argues that a higher leverage might signal greater vulnerability, hence induce tougher rivalries, worsening the market position. The existing empirical evidence so far has also been mixed, with some industries in favor of the deep pocket effect (such as the supermarket industry in Chevalier, 1995, and Khanna and Tice, 2000), and some in favor of the limited liability effect (such as the telecommunications industry in Leach, Moyen and Yang, 2006).

In this paper, I reexamine this issue based upon a two-run production model that is extended from the one-run production model in Brander/Lewis (1986) (hereforth BL). My leverage and first-run production story resembles that in BL, however, I also incorporate a second-run production story that characterizes the post-bankruptcy product market. I find that although a firm might obtain a better current product market position though rasing strategic debt, it might alternatively obtain a better future product market position if it constrains the current use of debt and stays longer in the market. The two controversial effects of debt generate an equilibrium debt level that is lower than predicted in BL, and higher than predicted in the deep pocket theory. My simple benchmark model can be easily extended to show the impacts of traditional capital structure determinants, such as financial slack, volatility, asset uniqueness, growth opportunities, etc., on the strategic placement of debt. They insert impacts on strategic debt mainly through affecting the strengths of the limited liability effect and the deep pocket effect.[1]

This study is linked to a rich literature. In addition to the main literature on the strategic functions of debt, it is also associated with the literature on how a bankruptcy event affects the rest of the industry. Lang and Stulz (1992) report that a bankruptcy announcement might incur contagion effects on industrial peers (mainly the negative information spillover on them, causing industrial wide stock price drop, input cost increase and capital cost increase), as well as competitive effects on competitors (such as a larger market share, and a reputation advantage in the product market). By focusing on the competitive effects of a bankruptcy, I ignore the contagion effects in my model, but I understand that the existence of contagion effects might reduce firms' incentive to fight hard against a levered rival, strengthening the strategic function of debt.

By incorporating several realisms into my model, I also link my study to some literature that focus on some particular aspects of the strategic debt placement. For instance, my extended model that

[1]Note that I borrow the word "deep pocket effect" from literature to describe the predatory rivalry towards a debt increase, but it is not exactly the same as originally described in literature (such as Fudenberg and Tirole, 1986). The original deep pocket theory focuses on a firm's predatory reaction to its more-financially constrained rival's issuance of debt, where debt is purely for financing, and it is usually applied to the competition between well developed incumbents and financially constrained entrants. Here I focus on the strategic placement of debt, where debt is solely for rivalry deterrence as in BL. I argue that even though the levered firm might not have financial needs for debt, to make the limited liability induced predatory threat creditable, this firm needs to convince the rivals that it does have possibility to default and shift the risk. I find that as long as the default is possible, a predatory reaction might still occur from the unlevered or less levered peers, who will have incentives to drive the levered firm into bankruptcy and capture the greater market shares.

addresses the impact of intra-industrial asset transferability, is related to Schleifer and Vishny (1992). They model a situation in which when a firm goes bankrupt, its industrial peers, the major potential buyers of its assets, might concurrently experience distress. Therefore when a firm's asset is less liquid, its debt will have a higher bankruptcy cost, causing a positive link between asset liquidity and industry average leverage. My model examines asset liquidity from a different perspective: a greater asset liquidity will reduce a firm's production cost upon its rival's bankruptcy, hence increase its incentive to fight, weakening the strategic function of debt. In this sense, I predict a negative relation between asset liquidity and debt.

My another extended model that addresses the impact of reorganization probability, is related to Hunsaker (1999). She compares BL's limited liability effect under two different bankruptcy codes: Chapter 7 (liquidation) and Chapter 11 (reorganization). She finds that inconsistent with BL (which implicitly assumes a Chapter 7 code), a debt placement under a Chapter 7 code will induce a tougher rivalry, against the strategic function of debt; while a debt increase under a Chapter 11 code will induce a softer rivalry, in accord with the strategic function of debt. My model generates a similar prediction based on a different rationale: a greater reorganization possibility will abate the chance of a monopoly through predatory rivalries against levered competitor, hence strengthen the strategic function of debt.

In this paper, I consider a three-period model with two firms competing in the product market. Like in BL, the two firms decide on their leverage ratios in the first period, then choose their optimal capacities and first-run production sizes, and conduct corresponding investments and productions in the second period. Also like in BL, the market demand is uncertain when firms make their financial and initial investment decisions. In the second-run investment/production, which is excluded in BL, I assume that the market uncertainty disappears, hence no strategic recapitalization incurs after the original debt is paid. The survivals will then choose optimal second-run investment/production sizes and conduct new investments/productions. The incentive to force the highly levered firm into bankruptcy hence itself can grab a larger second-run market share, will make the less levered firm more predatory in the first-run market.

The rest of the paper is structured as follows. Section 2 describes the construction and the solving for the benchmark model. Section 3 extends the benchmark model into several ways and show the impacts of several traditional capital structure determinants on strategic debt. Section 4 discusses the testable implications of my model and their connections to the existing empirical evidence. Section 5 concludes.

2 Benchmark Model

I consider two risk neutral firms (F_i and F_j) in three periods ($t \in [0, 1]$, $t \in [1, 2]$, and $t \in [2, 3]$), in a simple setting that resembles that in BL. Like BL, I assume that both firms have accessibility to the debt markets, but to concentrate on the strategic role of debt, I ignore any non-strategic need of debt (such as financing) in my model. In other words, both firms are not financially constrained, and the only incentive to raise debt is to improve a firm's product market position, if this strategic function of debt does exist. Also like BL, I assume that if a firm goes bankrupt, it can file for Chapter 7 only, that is, liquidation, but there is no post-bankruptcy asset flow from the bankrupt firm to its survived rival.

Figure 1 illustrates the time line for the benchmark game. At $t = 0$, firm F_i and firm F_j choose the sizes of their debt, D_i and D_j, respectively, where both debts are due at $t = 2$. At $t = 1$, knowing their own debts and the rivals' debts, firms choose their initial investment capacities, denoted as q_{1i} and q_{1j}, then conduct their first-run productions. Each firm's second-run production at $t = 2$ is contingent on its survival after paying off its debt. I assume that the marginal cost of building additional capacity is the same as that of building the initial capacity, hence there is no point for a firm to built excess capacity in the first-run before knowing whether it can survive later and if survive, its optimal capacity in the second run.[2] Note that the products generated in one period will be sold in the next period, hence when

[2]If the capacity adjustment cost is higher than the original capacity cost, firms will have incentives to build excess capacity at the earlier stage. However, given the focus of my study, modifying my model to incorporate this possibility will not change the main outcomes, but rather make the math more complicated.

firms choose q_{1i} and q_{1j}, the decisions are made under their imperfect information on what the market demand level will be in the next period. Following the tradition, I use a linear and downward-sloped price function to define market demand: $p(q_i, q_j) = a + \tilde{z} - b(q_i + q_j)$. Note that a is the base demand; $\tilde{z}$ is the market shock that remains unknown to the public (until $t = 2$) except for its probability distribution function $\tilde{z}\tilde{\ }\Phi[Z_L, Z_U]$; b is the price elasticity to supply; r is the marginal capacity/investment cost; and finally, l is the marginal production cost (including labor cost). For simplicity, I assume that a, b, r and l are industry-specific parameters that are homogeneous across firm. To prevent a negative price, I also assume that a is much larger than l, r and b.

At $t = 2$, demand shock is realized at level z, products are sold, and debts are due. Each firm pays back its debt from of its first-run profit, resulting into four possible situations in the second-run: 1) going bankrupt already; 2) co-surviving and duopolizing the market with the rival; and 3) being the sole survivor and the monopolist. Upon its survival, a firm will decide on whether or not to expand its production size in the new run, and build necessary capacity if an expansion is optimal. The production sizes in the second-run are q_{2i} and q_{2j}, respectively. Given the demand shock already realized, and the only function of debt as deterring competition through risk-shifting, there is no point for firms to reissue debt in the second run when the market risk has disappeared.

Finally, at time $t = 3$, new products are sold, new revenues are realized, and the game ends. Table 1 summarizes all the possible outcomes and the corresponding production sizes. T1, T2, T3, T4, T5, T6, T7 and T8 are the indexes for outcomes (see Figure 1), each matching a survival result and expansion decision. For $f = i, j$, q_{1i} is firm F_f's first-run production size, q_{2i}^{me}, q_{2i}^{mn}, q_{2i}^{de}, q_{2i}^{dn} are its second-run production sizes that correspond to the following four situations, respectively: (1) monopoly with an expansion; (2) monopoly without an expansion; (3) duopoly with an expansion; and (4) duopoly without an expansion.

Terminal Node	Firm F_i	Firm F_j
T1	Monopoly with an expansion: $\{q_{1i},\, q_{2i}^{me}\}$	Default: $\{q_{1j},\, -\}$
T2	Monopoly without an expansion: $\{q_{1i},\, q_{2i}^{mn}\}$	Default: $\{q_{1j},\, -\}$
T3	Duopoly with an expansion: $\{q_{1i},\, q_{2i}^{de}\}$	Duopoly without an expansion: $\{q_{1j},\, q_{2j}^{dn}\}$
T4	Duopoly with an expansion: $\{q_{1i},\, q_{2i}^{de}\}$	Duopoly with an expansion: $\{q_{1j},\, q_{2j}^{de}\}$
T5	Duopoly without an expansion: $\{q_{1i},\, q_{2i}^{dn}\}$	Duopoly with an expansion: $\{q_{1j},\, q_{2j}^{de}\}$
T6	Duopoly without an expansion: $\{q_{1i},\, q_{2i}^{dn}\}$	Duopoly without an expansion: $\{q_{1j},\, q_{2j}^{dn}\}$
T7	Default: $\{q_{1i},\, -\}$	Monopoly with an expansion: $\{q_{1j},\, q_{2j}^{me}\}$
T8	Default: $\{q_{1i},\, -\}$	Monopoly without an expansion: $\{q_{1j},\, q_{2j}^{mn}\}$

Table 1 Outcomes and Production Sizes

Through the whole procedure, each firm will sequentially make the following decisions: the leverage decision at $t = 0$; the initial capacity/production decision at $t = 1$; and upon survival, the expansion/production decision at $t = 2$. I solve the model with backward induction, starting with the expansion/production decision at $t = 2$. The discussions will be focused on firm F_i, while symmetric analyses can be conducted on firm F_j.

2.1 Sequential Decisions

2.1.1 At $t = 2$: Second-run Expansion/Production Decision

If a firm survives from the earlier stages, it will decide at this stage on its optimal second-run production quantity and the necessary capacity expansion level to accommodate the production. Given the conditions in the earlier stages sunken, and debts already paid off, the firm's current goal is to maximize its second-run production/investment profit, which is the net addition in its firm/equity value.[3] Its objective function, however, depends on the rival's survival outcome.

As a Monopolist in the Second Run This occurs when firm F_j goes bankrupt after the first run. Firm F_i will then choose its second-run production size q_{2i} to maximize its expected equity addition

[3] Given a zero leverage in the second run, an addition in the firm's equity value equates that in its total firm value.

generated from a monopolistic profit E_{2i}^m, which will be

$$E_{2i}^m = \max\ \{\max_{\{q_{2i}^{me}\}}[(a+z-bq_{2i}^{me}-l)\, q_{2i}^{me} - r(q_{2i}^{me}-q_{1i})]\ (\text{s.t. } q_{2i}^{me} \geqslant q_{1i}), \tag{1}$$

$$\max_{\{q_{2i}^{mn}\}}[(a+z-bq_{2i}^{mn}-l)\, q_{2i}^{mn}]\ (\text{s.t. } q_{2i}^{mn} \leqslant q_{1i})\},$$

where $\max_{\{q_{2i}^{me}\}}[(a+z-bq_{2i}^{me}-l)\, q_{2i}^{me}-r(q_{2i}^{me}-q_{1i})]$ (s.t. $q_{2i}^{me} \geqslant q_{1i}$) is its monopolistic profit with a capacity expansion (corresponding to an optimal quantity q_{2i}^{me}, see terminal node T1), and $\max_{\{q_{2i}^{mn}\}}[(a+z-bq_{2i}^{mn}-l)\, q_{2i}^{mn}]$ (s.t. $q_{2i}^{mn} \leqslant q_{1i}$) is its optimal monopolistic profit without any capacity expansion (corresponding to an optimal quantity q_{2i}^{mn}, see terminal node T2). Whether or not expanding the capacity is based on the maximization of the monopolistic profit. Note that the market demand is already certain, with the demand shock $\tilde{z}$ realized at level z.

As One of the Duopolists in the Second Run This happens when F_j also survives after the first run. F_i will then choose its second-run production size q_{2i} to maximize its expected equity addition generated from a duopolistic profit E_{2i}^d, which will be

$$E_{2i}^d = \max\ \{\max_{\{q_{2i}^{de}\}}[\Big(a+z-b(q_{2i}^{de}+q_{2j}^{de})-l\Big)\, q_{2i}^{de} - r(q_{2i}^{de}-q_{1i})]\ (\text{s.t. } q_{2i}^{de} \geqslant q_{1i}), \tag{2}$$

$$\max_{\{q_{2i}^{dn}\}}[\Big(a+z-b(q_{2i}^{dn}+q_{2j}^{dn})-l\Big)\, q_{2i}^{dn}]\ (\text{s.t. } q_{2i}^{dn} \leqslant q_{1i})\},$$

where $\max_{\{q_{2i}^{de}\}}[\Big(a+z-b(q_{2i}^{de}+q_{2j}^{de})-l\Big)\, q_{2i}^{de}-r(q_{2i}^{de}-q_{1i})]$ (s.t. $q_{2i}^{de} \geqslant q_{1i}$) is its duopolistic profit with expansion (corresponding to an optimal quantity q_{2i}^{de}, see node T3 upon the rival's no-expansion, and node T4 upon the rival's expansion), and $\max_{\{q_{2i}^{dn}\}}[\Big(a+z-b(q_{2i}^{dn}+q_{2j}^{dn})-l\Big)\, q_{2i}^{dn}]$ (s.t. $q_{2i}^{dn} \leqslant q_{1i}$) is its optimal duopolistic profit without expansion (corresponding to an optimal quantity q_{2i}^{dn}, see node T5 upon the rival's expansion, and node T6 upon the rival's no-expansion).

The subgame equilibrium is:

Lemma 1 *Firm F_i's optimal second-run expansion/production decision rule is contingent on the level* *of its first-run capacity q_{1i}, as summarized in Table 2:*

Panel A - If $\frac{1}{2b}(a+z-l-r) \geqslant \frac{1}{3b}(a+z-l)$

	Range of q_{1i}	q_{2i}^{m*}	*Expand*^{m}*?*	q_{2i}^{d*}	*Expand*^{d}*?*
1	$(\frac{1}{2b}(a+z-l),\ +\infty)$	$\frac{1}{2b}(a+z-l)$	*No*	$\frac{1}{3b}(a+z-l)$	*No*
2	$(\frac{1}{2b}(a+z-l-r),\ \frac{1}{2b}(a+z-l)]$	q_{1i}	*No*	$\frac{1}{3b}(a+z-l)$	*No*
3	$(\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l-r)]$	$\frac{1}{2b}(a+z-l-r)$	*Yes*	$\frac{1}{3b}(a+z-l)$	*No*
4	$[\frac{1}{3b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)]$	$\frac{1}{2b}(a+z-l-r)$	*Yes*	q_{1i}	*No*
5	$(-\infty,\ \frac{1}{3b}(a+z-l-r))$	$\frac{1}{2b}(a+z-l-r)$	*Yes*	$\frac{1}{3b}(a+z-l-r)$	*Yes*

Panel B - If $\frac{1}{2b}(a+z-l-r) < \frac{1}{3b}(a+z-l)$

	Range of q_{1i}	q_{2i}^{m*}	*Expand*^{m}*?*	q_{2i}^{d*}	*Expand*^{d}*?*
1	$(\frac{1}{2b}(a+z-l),\ +\infty)$	$\frac{1}{2b}(a+z-l)$	*No*	$\frac{1}{3b}(a+z-l)$	*No*
2	$(\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l)]$	q_{1i}	*No*	$\frac{1}{3b}(a+z-l)$	*No*
3	$(\frac{1}{2b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)]$	q_{1i}	*No*	q_{1i}	*No*
4	$[\frac{1}{3b}(a+z-l-r),\ \frac{1}{2b}(a+z-l-r)]$	$\frac{1}{2b}(a+z-l-r)$	*Yes*	q_{1i}	*No*
5	$(-\infty,\ \frac{1}{3b}(a+z-l-r))$	$\frac{1}{2b}(a+z-l-r)$	*Yes*	$\frac{1}{3b}(a+z-l-r)$	*Yes*

Table 2 The Summary of the Second-run Production/Investment Decision

Proof. See Appendix. ■

2.1.2 At $t = 1$: First-run Production/Investment Decision

With backward induction, at this point, taking into account the second-run production/investment decisions solved earlier, each firm makes its first-run production/investment decision. Remember that at this point, the demand shock $\tilde{z}$ has not been realized yet. I define $\widehat{z}_i$ as the "default point" for F_i, the level of the demand shock that enables firm F_i to just payoff its debt D_i after its first-run production. Similarly, $\widehat{z}_j$ is the default point for firm F_j. The associated equations are:

$$R^i(\widehat{z}_i) = (a + \widehat{z}_i - b(q_{1i} + q_{1j}) - l - r)\, q_{1i} - D_i = 0, \tag{3}$$

$$R^j(\widehat{z}_j) = (a + \widehat{z}_j - b(q_{1i} + q_{1j}) - l - r)\, q_{1j} - D_j = 0. \tag{4}$$

Correspondingly, the competition situation in the second-run depends on the relative levels of two default points, $\widehat{z}_i$ and $\widehat{z}_j$. There are two possibilities. One is that a firm defaults earlier than its rival (that is, its default point is above its rival's default point), therefore when the market shock $\tilde{z}$ is above its own default point, this firm survives and so does its rival, and the two firms will play a duopoly game in the second-run; when $\tilde{z}$ is below its own default point, it will of course go bankrupt and get out of the market. The second possibility is the opposite: a firm defaults later than its rival firm (that is, its own default point is below its rival's default point), therefore when the market shock is above the rival's default point, both firms survive and will play a duopoly game in the second run; but when the market shock level is in between its own default point and its rival's default point, this firm will be the sole survivor and will monopolize the market in the second run; again, when $\tilde{z}$ is below its own default point, it will go bankrupt and get out of the market. A firm will solve for the optimal first-run decision in each of the two possible situations, then compare the two situations to determine its optimal move. In other words, this firm will strategically choose its first-run production/investment level to make the better situation happen.

For simplicity and without the loss of generality, for all stages earlier than $t = 2$, I consider the symmetric behaviors of the two firms, that is, either that each of both firms is not self confident, believing that it own will be the first going bankrupt (i.e., firm F_i assumes $\widehat{z_i} > \widehat{z_j}$ and symmetrically firm F_j assumes $\widehat{z_j} > \widehat{z_i}$), or that each of both firms is self confident, believing that the rival will not be the first going bankrupt (i.e., firm F_i assumes $\widehat{z_i} \leqslant \widehat{z_j}$ and symmetrically firm F_j assumes $\widehat{z_j} \leqslant \widehat{z_i}$). Note that similar symmetry is also assumed in BL.

Case "S": Not Defaulting First

In this case, each firm is confident that its has a chance to produce in the second-run if the realized demand shock z is higher than its default point. Specifically, it will continue to play a duopoly game with the rival if z is also higher than the rival's default point, but will monopolize the market if otherwise. From the earlier discussion (see Table 2), I know that the optimal second-run expansion/production level is contingent upon the range of the initial capacities q_{1i}, I hence need to analyze the problem range by range first. However, since I assume that the expansional capacity cost is the same as the original capacity cost and there is no point for a firm to hold excess capacity in the first run, intuitively, range

5 (the only range without idle capacity existing in the first-run, no matter whether a monopolistic or a duopolistic market will be formed in the second-run) should be the optimal range. Following this intuition, I discuss range 5 only. I do prove in Appendix that in a symmetric equilibrium (like in BL), the other four ranges generate corners solutions that are globally dominated by the interior solution generated from range 5.

The optimization problems are:

$$\begin{aligned}
E^S_{1i} &= \max_{\{q_{1i}\}} \int_{\widehat{z}_j}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\,q_{1i} - D_i + \Big(a+\tilde{z}-b(q^{d*}_{2i}+q^{d*}_{2j})-l\Big)\,q^{d*}_{2i} - r(q^{d*}_{2i}-q_{1i})\Big]\,d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\,q_{1i} - D_i + (a+\tilde{z}-bq^{m*}_{2i}-l)\,q^{m*}_{2i} - r(q^{m*}_{2i}-q_{1i})\right] d\Phi(\tilde{z}), \qquad (5) \\
E^S_{1j} &= \max_{\{q_{1j}\}} \int_{\widehat{z}_i}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\,q_{1j} - D_j + \Big(a+\tilde{z}-b(q^{d*}_{2i}+q^{d*}_{2j})-l\Big)\,q^{d*}_{2j} - r(q^{d*}_{2j}-q_{1j})\Big]\,d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_j}^{\widehat{z}_i} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\,q_{1j} - D_j + \big(a+\tilde{z}-bq^{m*}_{2j}-l\big)\,q^{m*}_{2j} - r(q^{m*}_{2j}-q_{1j})\right] d\Phi(\tilde{z}), \qquad (6)
\end{aligned}$$

subjected to

$$\begin{aligned}
q^{d*}_{2i} &= q^{d*}_{2j} = \frac{1}{3b}(a+\tilde{z}-l-r),\ q^{m*}_{2i} = q^{m*}_{2j} = \frac{1}{2b}(a+\tilde{z}-l-r), \\
q_{1i} &\in (-\infty,\ \frac{1}{3b}(a+\tilde{z}-l-r)) \text{ and } q_{1j} \in (-\infty,\ \frac{1}{3b}(a+\tilde{z}-l-r)).
\end{aligned}$$

Here, E^S_{1i} and E^S_{1j} are the two firms' expected payoffs if each assumes that itself will not default first. Note that in equation for E^S_{1i}, the first integral is F_i's total equity value if it duopolizes the market with the rival in the second run (when the demand shock is greater than rival's default point $\widehat{z}_j$): term $(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\,q_{1i} - D_i$ is the residual claim from the first-run, term $\Big(a+\tilde{z}-b(q^{d*}_{2i}+q^{d*}_{2j})-l\Big)\,q^{d*}_{2i} - r(q^{d*}_{2i}-q_{1i})$ is the equity addition from the second-run. The second integral in equation for E^S_{1i} is the firm's total equity value if it monopolizes the market in the second run (when demand shock is in between $\widehat{z}_j$ and $\widehat{z}_i$): term $(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\,q_{1i} - D_i$ is again the residual claim from the first-run, and term $(a+\tilde{z}-bq^{m*}_{2i}-l)\,q^{m*}_{2i} - r(q^{m*}_{2i}-q_{1i})$ is the equity addition from the second-run. Note that $r(q^{d*}_{2i}-q_{1i})$ and $r(q^{m*}_{2i}-q_{1i})$ are the capacity expansion costs under the duopoly and the monopoly situations. Firm F_j's optimization problem is similar. Both optimizations are subjected to the range constraints (for range 5) shown in Table 2 (while at this stage, the demand shock level has not been unrealized yet): $q_{2i}^{d*} = q_{2j}^{d*} = \frac{1}{3b}(a + \tilde{z} - l - r)$, $q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a + \tilde{z} - l - r)$, and q_{1i}, $q_{1j} \in (-\infty, \frac{1}{3b}(a + \tilde{z} - l - r))$.

For simplicity, I assume that the demand shock $\tilde{z}$ follows a standard uniform distribution $U[0, 1]$. The marginal effect of q_{1i} on E_{1i}^S will then be:

$$\frac{dE_{1i}^S}{dq_{1i}} = \left(a - b(2q_{1i}^* + q_{1j}^*) - l\right) \frac{(\overline{z} - \widehat{z}_i)}{2\overline{z}} + \frac{(\overline{z}^2 - \widehat{z}_i{}^2)}{4\overline{z}}, \tag{7}$$

and similarly,

$$\frac{dE_{1j}^S}{dq_{1j}} = \left(a - b(2q_{1j}^* + q_{1i}^*) - l\right) \frac{(\overline{z} - \widehat{z}_j)}{2\overline{z}} + \frac{(\overline{z}^2 - \widehat{z}_j{}^2)}{4\overline{z}}. \tag{8}$$

Synthesizing the two first order conditions $\frac{dE_{1i}^S}{dq_{1i}} = 0$ and $\frac{dE_{1j}^S}{dq_{1j}} = 0$ leads to

$$q_{1i} = \frac{1}{6b}\left[2\left(a + \widehat{z}_i - l\right) + \overline{z} - \widehat{z}_j\right], \tag{9}$$

$$q_{1j} = \frac{1}{6b}\left[2\left(a + \widehat{z}_j - l\right) + \overline{z} - \widehat{z}_i\right], \tag{10}$$

or, in an alternative format,

$$\widehat{z}_i = -2\left[a - b\left(2q_{1i} + q_{1j}\right) - l\right] - \overline{z}, \tag{11}$$

$$\widehat{z}_j = -2\left[a - b\left(q_{1i} + 2q_{1j}\right) - l\right] - \overline{z}. \tag{12}$$

Together with the default definitions in equations 3 and 4, this subgame will generate an equilibrium in which the first-run quantity is a function of a firm's own debt and its rival's debt (see Appendix for the details of solving for a symmetric equilibrium). If I denote the solutions as q_{1i}^{S*} and q_{1j}^{S*}, they could be rewritten as $q_{1i}^{S*}(D_i, D_j)$ and $q_{1j}^{S*}(D_i, D_j)$. Correspondingly, the default points, denoted as $\widehat{z}_i{}^S$ and $\widehat{z}_j{}^S$, can be rewritten as $\widehat{z}_i{}^S(D_i, D_j)$ and $\widehat{z}_j{}^S(D_i, D_j)$. If the strategic role of debt in deterring competition does exists, as suggested in BL, I must have

$$\frac{dq_{1i}^{S*}}{dD_i} > 0,\ \frac{dq_{1i}^{S*}}{dD_j} < 0,\ \frac{dq_{1j}^{S*}}{dD_i} < 0 \text{ and } \frac{dq_{1j}^{S*}}{dD_j} > 0. \tag{13}$$

Correspondingly, from equations 11 and 12, I derive

$$\frac{d\widehat{z_i}^S}{dD_i} = 2b\left(2\cdot\frac{dq_{1i}^{S*}}{dD_i}+\frac{dq_{1j}^{S*}}{dD_i}\right)>0 \text{ and } \frac{d\widehat{z_j}^S}{dD_j}=2b\left(2\cdot\frac{dq_{1j}^{S*}}{dD_j}+\frac{dq_{1i}^{S*}}{dD_j}\right)>0 \tag{14}$$

(since it is reasonable to assume that a firm's output is more directly

influenced by its own debt than by its rival's debt, that is,

$$\frac{dq_{1i}^{S*}}{dD_i} > \left|\frac{dq_{1j}^{S*}}{dD_i}\right| \text{ and } \frac{dq_{1j}^{S*}}{dD_j} > \left|\frac{dq_{1i}^{S*}}{dD_j}\right|). \tag{15}$$

The strategic role of debt also leads to $\frac{d\widehat{z_i}^S}{dD_j} < 0$ and $\frac{d\widehat{z_j}^S}{dD_i} < 0$. In other words, a firm's debt placement will expand its range of bankruptcy states, while shrink its competitor's range of bankruptcy states.

Case "F": Defaulting First

This case resembles that in BL, where each firm does not consider its future monopolistic production/investment possibility. In other words, each firm assumes that itself will default earlier than its rival. My slight difference from BL is that, here, upon survival, firms may conduct two-run productions/investments rather than only one-run production/investment. With the intuitions similar as those mentioned earlier, since the expansional capacity cost is the same as the original capacity cost, there is no point for firms to hold excess capacity in the first run (like in range 5 above), a firm will expand or produce at the current capacity in the second-run production, rather than holding any idle capacity.

The optimization problems are:

$$
\begin{aligned}
E_{1i}^F &= \max_{\{q_{1i}\}} \int_{\widehat{z}_i}^{\overline{z}} \left[\left(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r\right) q_{1i} - D_i + \left(a + \tilde{z} - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\right) q_{2i}^{d*} - r(q_{2i}^{d*} - q_{1i}) \right] \\
&\quad d\Phi(\tilde{z}), && (16) \\
E_{1j}^F &= \max_{\{q_{1j}\}} \int_{\widehat{z}_j}^{\overline{z}} \left[\left(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r\right) q_{1j} - D_j + \left(a + \tilde{z} - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\right) q_{2j}^{d*} - r(q_{2j}^{d*} - q_{1j}) \right] \\
&\quad d\Phi(\tilde{z}), && (17)
\end{aligned}
$$

subjected to

$$
\begin{aligned}
{}^{d*}_{2i} &= q_{2j}^{d*} = \frac{1}{3b}(a + \tilde{z} - l - r),\ q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a + \tilde{z} - l - r), && (18) \\
q_{1i} &\in (-\infty,\ \frac{1}{3b}(a + \tilde{z} - l - r)) \text{ and } q_{1j} \in (-\infty,\ \frac{1}{3b}(a + \tilde{z} - l - r)). && (19)
\end{aligned}
$$

Here, E_{1i}^F and E_{1j}^F are the two firms' expected payoffs in this situation.

Synthesizing of the two first order conditions $\frac{dE_{1i}^F}{dq_{1i}} = 0$ and $\frac{dE_{1j}^F}{dq_{1j}} = 0$, I derive

$$
\begin{aligned}
q_{1i} &= \frac{1}{6b}\left[2\left(a + \widehat{z}_i - l\right) + \overline{z} - \widehat{z}_j\right], && (20) \\
q_{1j} &= \frac{1}{6b}\left[2\left(a + \widehat{z}_j - l\right) + \overline{z} - \widehat{z}_i\right], && (21)
\end{aligned}
$$

which take exactly the same form as in case "S", consequently generating exactly the same equilibrium as in case "S". Thus, given certain D_i and D_j, if I denote the solutions in this case as q_{1i}^{F*} and q_{1j}^{F*}, I have $q_{1i}^{F*} = q_{1i}^{S*}(D_i, D_j)$, $q_{1j}^{F*} = q_{1j}^{S*}(D_i, D_j)$, $\widehat{z}_i{}^F = \widehat{z}_i{}^S(D_i, D_j)$ and $\widehat{z}_j{}^F = \widehat{z}_j{}^S(D_i, D_j)$. The derivatives of quantities and default points with respect to debts are also the same as in case "S".

2.1.3 At $t = 0$: Leverage Decision

Finally, at the beginning stage, each firm chooses its optimal debt level, by considering its optimal first-run production/investment decision, and its optimal second-run expansion/production decision upon its survival, and maximizing its expected total firm value. In case "S" where each firm expects that the rival is the first firm going default, the optimization problems are

$$\begin{aligned}
V_{0i}^{S} &= \max_{\{D_i\}} \int_{\underline{z}}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{1i}^{*}+q_{1j}^{*})-l-r\right) q_{1i}^{*}\right] d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_j}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\right) q_{2i}^{d*} - r(q_{2i}^{d*}-q_{1i}^{*})\right] d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[(a+\tilde{z}-bq_{2i}^{m*}-l)\, q_{2i}^{m*} - r(q_{2i}^{m*}-q_{1i}^{*})\right] d\Phi(\tilde{z}),
\end{aligned} \tag{22}$$

$$\begin{aligned}
V_{0j}^{S} &= \max_{\{D_j\}} \int_{\underline{z}}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{1i}^{*}+q_{1j}^{*})-l-r\right) q_{1j}^{*}\right] d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_i}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\right) q_{2j}^{d*} - r(q_{2j}^{d*}-q_{1j}^{*})\right] d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_j}^{\widehat{z}_i} \left[\left(a+\tilde{z}-bq_{2j}^{m*}-l\right) q_{2j}^{m*} - r(q_{2j}^{m*}-q_{1j}^{*})\right] d\Phi(\tilde{z}),
\end{aligned} \tag{23}$$

subjected to

$$\begin{aligned}
q_{2i}^{d*} &= q_{2j}^{d*} = \frac{1}{3b}(a+z-l-r),\ q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a+z-l-r), \\
q_{1i}^{*} &= q_{1i}^{S*}(D_i, D_j) \text{ and } q_{1j}^{*} = q_{1j}^{S*}(D_i, D_j).
\end{aligned}$$

In case "F" where each firm expects that it is the first firm going default, the optimization problems are changed into

$$\begin{aligned}
V_{0i}^{F} &= \max_{\{D_i\}} \int_{\underline{z}}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{1i}^{*}+q_{1j}^{*})-l-r\right) q_{1i}^{*}\right] d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_i}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\right) q_{2i}^{d*} - r(q_{2i}^{d*}-q_{1i}^{*})\right] d\Phi(\tilde{z}),
\end{aligned} \tag{24}$$

$$\begin{aligned}
V_{0j}^{F} &= \max_{\{D_j\}} \int_{\underline{z}}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{1i}^{*}+q_{1j}^{*})-l-r\right) q_{1j}^{*}\right] d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_j}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\right) q_{2j}^{d*} - r(q_{2j}^{d*}-q_{1j}^{*})\right] d\Phi(\tilde{z}),
\end{aligned} \tag{25}$$

subjected to

$$\begin{aligned}
q_{2i}^{d*} &= q_{2j}^{d*} = \frac{1}{3b}(a+z-l-r),\ q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a+z-l-r), \\
q_{1i}^{*} &= q_{1i}^{F*}(D_i) = q_{1i}^{S*}(D_i) \text{ and } q_{1j}^{*} = q_{1j}^{F*}(D_j) = q_{1j}^{S*}(D_j).
\end{aligned}$$

From equation 22, with the Leibniz Integral Rule, I derive

$$\begin{aligned}\frac{dV_{0i}^S}{dD_i} &= \left(a - b(2q_{1i}^* + q_{1j}^*) - l - r\right)\frac{dq_{1i}^*}{dD_i} - bq_{1i}^*\frac{dq_{1j}^*}{dD_i} + r\left[\Phi\left(\overline{z}\right) - \Phi\left(\widehat{z}_i\right)\right]\frac{dq_{1i}^*}{dD_i} \\ &\quad + \left\{\left[\left(a + \widehat{z}_j - bq_{2i}^{m*} - l\right)q_{2i}^{m*} - r(q_{2i}^{m*} - q_{1i}^*)\right] - \left[\left(a + \widehat{z}_j - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\right)q_{2i}^{d*} - r(q_{2i}^{d*} - q_{1i}^*)\right]\right\} \\ &\quad \cdot\frac{d\widehat{z}_j}{dD_i} - \left[\left(a + \widehat{z}_i - bq_{2i}^{m*} - l\right)q_{2i}^{m*} - r(q_{2i}^{m*} - q_{1i}^*)\right]\frac{d\widehat{z}_i}{dD_i},\end{aligned} \tag{26}$$

which can be rewritten as

$$\begin{aligned}\frac{dV_{0i}^S}{dD_i} &= \left\{a - b(2q_{1i}^* + q_{1j}^*) - l - r + r\left[\Phi\left(\overline{z}\right) - \Phi\left(\widehat{z}_i\right)\right]\right\}\frac{dq_{1i}^*}{dD_i} - bq_{1i}^*\frac{dq_{1j}^*}{dD_i} \\ &\quad + \left\{\left[\left(a + \widehat{z}_j - bq_{2i}^{m*} - l\right)q_{2i}^{m*} - r(q_{2i}^{m*} - q_{1i}^*)\right] - \left[\left(a + \widehat{z}_j - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\right)q_{2i}^{d*} - r(q_{2i}^{d*} - q_{1i}^*)\right]\right\} \\ &\quad \cdot\frac{d\widehat{z}_j}{dD_i} - \left[\left(a + \widehat{z}_i - bq_{2i}^{m*} - l\right)q_{2i}^{m*} - r(q_{2i}^{m*} - q_{1i}^*)\right]\frac{d\widehat{z}_i}{dD_i}.\end{aligned} \tag{27}$$

From equation 24, again with the Leibniz Integral Rule, I derive

$$\begin{aligned}\frac{dV_{0i}^F}{dD_i} &= \left\{a - b(2q_{1i}^* + q_{1j}^*) - l - r + r\left[\Phi\left(\overline{z}\right) - \Phi\left(\widehat{z}_i\right)\right]\right\}\frac{dq_{1i}^*}{dD_i} \\ &\quad - \left[\left(a + \widehat{z}_i - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\right)q_{2i}^{d*} - r(q_{2i}^{d*} - q_{1i}^*)\right]\frac{d\widehat{z}_i}{dD_i},\end{aligned} \tag{28}$$

From previous discussions, I know that given certain D_i and D_j, the forms of q_{1i}^*, q_{1j}^*, $\widehat{z}_i$ and $\frac{d\widehat{z}_i}{dD_i}$ are the same in case "S" and case "F". Comparing equations 27 and 28, one difference exists between term $\left[\left(a + \widehat{z}_i - bq_{2i}^{m*} - l\right)q_{2i}^{m*} - r(q_{2i}^{m*} - q_{1i}^*)\right]$ and term $\left[\left(a + \widehat{z}_i - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\right)q_{2i}^{d*} - r(q_{2i}^{d*} - q_{1i}^*)\right]$, that is, the monopoly revenue versus the duopoly revenue in the second run. Intuitively, given the second-run optimal quantities the same (proved earlier), the monopoly revenue should be greater than the duopoly revenue. Given $\frac{d\widehat{z}_i}{dD_i} > 0$, this indicates that at any debt level D_i, the last term subtracted in the equations is greater in equation 27 than in equation 28. The term $\{[(a + \widehat{z}_j - bq_{2i}^{m*} - l)\,q_{2i}^{m*} - r(q_{2i}^{m*} - q_{1i}^*)] - \left[\left(a + \widehat{z}_j - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\right)q_{2i}^{d*} - r(q_{2i}^{d*} - q_{1i}^*)\right]\}\frac{d\widehat{z}_j}{dD_i}$, which is negative, exists only in equation 27, hence making $\frac{dV_{0i}^S}{dD_i}$ further smaller than $\frac{dV_{0i}^F}{dD_i}$. Another term, $-bq_{1i}^*\frac{dq_{1j}^*}{dD_i}$, which is positive, also exists only in equation 27, but the effect of D_i on q_{1j}^* is quite indirect, not able to beat previous effects. As a result, I have

$$\frac{dV_{0i}^S}{dD_i} < \frac{dV_{0i}^F}{dD_i}. \tag{29}$$

This means that given a certain debt level, the marginal contribution of a debt increase to the firm value will be greater in case "S" than in case "F". This will naturally lead to a lower equilibrium debt level in case "S" than in case "F", that is, $D_i^{S*} < D_i^{F*}$. I hence conclude,

Proposition 1 *A firm will use less strategic debt when it cogitates its possible monopolist status upon the rival firm's bankruptcy than when it ignores this possibility.*

Proof. As discussed above. ■

This is one of the major findings of my paper: the function of leverage to reduce the rivals' investments/productions - the limit liability effect, could be lower than predicted in BL, when a firm also takes into account the opposite deep pocket effect, that is, the less levered firm may have incentive to fight harder to grab the charming monopolistic profit. As a result, debt is not as effective as in BL in deterring competition, and correspondingly firms should use less strategic debt than predicted in BL.

3 Model Extensions

My benchmark model is constructed based on many simplifications, such as that firms have no financial constraints when debts are issued, that there are no asset flows from the bankrupt firm to its peer survivals, that reorganizations are unavailable upon default, and that investments are riskless and real options do not exist, etc. In this section, I will discuss how the benchmark results change if I relax these assumptions one by one. These extensions are interesting also because I can investigate the impacts of traditional capital structure determinants, such as financial constraints, liquidity, growth opportunities and possibility of reorganization, on the strategic placement of debt.

3.1 Financial Constraints

In this subsection, I extend the core case in the benchmark - case "S", by considering the financial constraint of the levered firm. If this constraint exists, a debt placement will have dual roles: the financial role and the strategic role, both tending to boost productions. On the other hand, the rival's incentive to fight hard against the financially constrained firm is greater since the latter is easy to be forced into bankruptcy. The two opposite effects are offsetting each other. To investigate the net effect, I modify my benchmark model by assuming that debt could relax financial constraint hence reduce investment cost. The equity value characterized in equation 5 is then changed into

$$\begin{aligned} E_{1i}^{S} &= \max_{\{q_{1i}\}} \int_{\widehat{z}_j}^{\overline{z}} \Big[\left(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r+\nu D_i\right) q_{1i} - D_i + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big) q_{2i}^{d*} - r(q_{2i}^{d*}-q_{1i}) \Big] \\ & \cdot d\Phi(\tilde{z}) + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[\left(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r+\nu D_i\right) q_{1i} - D_i + \left(a+\tilde{z}-bq_{2i}^{m*}-l\right) q_{2i}^{m*} - r(q_{2i}^{m*}-q_{1i}) \right] \\ & \cdot d\Phi(\tilde{z}), \end{aligned} \tag{30}$$

where νD_i is the investment cost drop due to the debt financing. The marginal effect of q_{1i} on E_{1i}^S, characterized in equation 7 is changed into:

$$\frac{dE_{1i}^S}{dq_{1i}} = \left(a-b(2q_{1i}^*+q_{1j}^*)-l+\nu D_i\right) \frac{(\overline{z}-\widehat{z}_i)}{2\overline{z}} + \frac{(\overline{z}^2-\widehat{z}_i{}^2)}{4\overline{z}},$$

which is higher than in equation 7, indicating that given a certain level of debt D_i, a larger q_{1i} is desired here than in the benchmark. As expected, when debt provides both financing and strategic functions, it will induce more productions than when it provides only strategic functions. In other words, $\frac{dq_{1i}}{dD_i}$ should be higher than in the benchmark model. In addition, the firm value characterized in equation 22 is changed into

$$\begin{aligned} V_{0i}^S &= \max_{\{D_i\}} \int_{\underline{z}}^{\overline{z}} \left[\left(a+\tilde{z}-b(q_{1i}^*+q_{1j}^*)-l-r+\nu D_i\right) q_{1i}^* \right] d\Phi(\tilde{z}) \\ & + \int_{\widehat{z}_j}^{\overline{z}} \Big[\Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big) q_{2i}^{d*} - r(q_{2i}^{d*}-q_{1i}^*) \Big] d\Phi(\tilde{z}) \\ & + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[\left(a+\tilde{z}-bq_{2i}^{m*}-l\right) q_{2i}^{m*} - r(q_{2i}^{m*}-q_{1i}^*) \right] d\Phi(\tilde{z}), \end{aligned} \tag{31}$$

hence equation 26 is changed into

$$\begin{aligned} \frac{dV_{0i}^S}{dD_i} &= \left(a-b(2q_{1i}^*+q_{1j}^*)-l-r+\nu D_i\right) \frac{dq_{1i}^*}{dD_i} + \nu - bq_{1i}^* \frac{dq_{1j}^*}{dD_i} + r\left[\Phi(\overline{z})-\Phi(\widehat{z}_i)\right] \frac{dq_{1i}^*}{dD_i} \\ & + \Big\{ \left[\left(a+\widehat{z}_j-bq_{2i}^{m*}-l\right) q_{2i}^{m*} - r(q_{2i}^{m*}-q_{1i}^*) \right] - \Big[\Big(a+\widehat{z}_j-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big) q_{2i}^{d*} - r(q_{2i}^{d*}-q_{1i}^*) \Big] \Big\} \\ & \cdot \frac{d\widehat{z}_j}{dD_i} - \left[\left(a+\widehat{z}_i-bq_{2i}^{m*}-l\right) q_{2i}^{m*} - r(q_{2i}^{m*}-q_{1i}^*) \right] \frac{d\widehat{z}_i}{dD_i}. \end{aligned} \tag{32}$$

It is not difficult to see that $\frac{dV_{0i}^S}{dD_i}$ is greater than in equation 26, suggesting a higher equilibrium debt level than in the benchmark model. Moreover, this effect is continuous. When the firm is more financially constrained, the effect of additional debt in reducing the constraint is more significant, reflected by a larger ν, and consequently $\frac{dV_{0i}^S}{dD_i}$ is bigger, leading to a higher equilibrium debt level. I hence conclude:

Proposition 2 *A firm cogitating its possible monopolist status upon the rival firm's bankruptcy will use more strategic debt if it is more financially constrained.*

The proposition indicates that with severer financial constraints, although a leverage induces the rival firm to fight harder due to the more significant deep pocket effect, it also provides the levered firm lower cost to produce, which turns out to dominate the first effect and ends up with a net increase in the debt level. In other words, financial constraints make debt more effective in deterring competition. This finding is important because traditional attentions are focused on the fact that financial constraint might strengthen the deep pocket effect, while I argue that it also strengthens the limited liability effect and the net result on the product market competition could be the opposite.

In addition, it is worthwhile to compare the strategic function and the non-strategic function of financial constraint on capital structure. In traditional capital structure determinants, several variables might be related to financial constraints, including free cash flow (-), financial slack (-), profitability (-) and growth (+). Based on my strategic story, these variables should affect the level of strategic debt in the following ways: free cash flow, profitability and financial flexibility negatively affect financial constraint, thus should negatively strategic debt; while growth (+) positively affects financial constraint, hence should positively affect strategic debt. In the traditional capital structure literature that focuses on the non-strategic functions of debt, free cash flow, profitability and financial flexibility positively affect debt based on agency theories (Jensen,1986, and Stulz, 1990), while these variables negatively affect debt based on information asymmetry (or, pecking order) theories (Myers and Majluf, 1984). In addition, growth opportunity negatively affects debt based on agency models (Jensen and Meckling, 1976, Stulz, 1990, and Miao, 2005). In general, the testable implications of my model are in line with information asymmetry theories, but against agency theories.

3.2 Interfirm Asset Flows

In this subsection, I extend case "S" in the benchmark model by allowing post-bankruptcy asset flows from the bankrupt firm to its survived rival. Intuitively, this will lower the rival's second-run marginal investment cost for the additional capacity. I assume this new cost as r', which is lower than the original marginal investment cost r, that is, $r' < r$.

The second-run expansion/investment results will be similar as those in the benchmark model (summarized in Lemma 1) except that variable r is replaced with r'. Intuitively, given other parameters unchanged, the survived firm/firms will produce at a higher level than in the benchmark due to the reduction in the marginal investment cost for the additional capacity, ending up with $q_{2i}^{d*} = q_{2j}^{d*} = \frac{1}{3b}(a + \tilde{z} - l - r')$ and $q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a + \tilde{z} - l - r')$. The second-run will generate a higher profit, no matter in monopoly or in oligopoly, also due to the lower marginal expansion cost.

Moving back to the first-run, the optimization problems are changed from equations 5 and 6 to:

$$\begin{aligned} E_{1i}^S &= \max_{\{q_{1i}\}} \int_{\widehat{z}_j}^{\overline{z}} \Big[(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r)\, q_{1i} - D_i + \Big(a + \tilde{z} - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\Big)\, q_{2i}^{d*} - r'(q_{2i}^{d*} - q_{1i}) \Big]\, d\Phi(\tilde{z}) \\ &\quad + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r)\, q_{1i} - D_i + (a + \tilde{z} - b q_{2i}^{m*} - l)\, q_{2i}^{m*} - r'(q_{2i}^{m*} - q_{1i}) \right] d\Phi(\tilde{z}), \qquad (33) \\ E_{1j}^S &= \max_{\{q_{1j}\}} \int_{\widehat{z}_i}^{\overline{z}} \Big[(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r)\, q_{1j} - D_j + \Big(a + \tilde{z} - b(q_{2i}^{d*} + q_{2j}^{d*}) - l\Big)\, q_{2j}^{d*} - r'(q_{2j}^{d*} - q_{1j}) \Big]\, d\Phi(\tilde{z}) \\ &\quad + \int_{\widehat{z}_j}^{\widehat{z}_i} \left[(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r)\, q_{1j} - D_j + \big(a + \tilde{z} - b q_{2j}^{m*} - l\big)\, q_{2j}^{m*} - r'(q_{2j}^{m*} - q_{1j}) \right] d\Phi(\tilde{z}), \qquad (34) \end{aligned}$$

subjected to

$$\begin{aligned} q_{2i}^{d*} &= q_{2j}^{d*} = \frac{1}{3b}(a + \tilde{z} - l - r'),\; q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a + \tilde{z} - l - r'), \\ q_{1i} &\in (-\infty,\; \frac{1}{3b}(a + \tilde{z} - l - r')) \text{ and } q_{1j} \in (-\infty,\; \frac{1}{3b}(a + \tilde{z} - l - r')), \end{aligned}$$

The marginal effect of q_{1i} on E_{1i}^S in equation 7 will be changed into:

$$\frac{dE_{1i}^S}{dq_{1i}} = \big(a - b(2q_{1i}^* + q_{1j}^*) - l - r + r'\big)\, \frac{(\overline{z} - \widehat{z}_i)}{2\overline{z}} + \frac{(\overline{z}^2 - \widehat{z}_i^{\,2})}{4\overline{z}}.$$

Given $r' < r$ and other parameters unchanged, $\frac{dE^S_{1i}}{dq_{1i}}$ will be lower than in the benchmark model, hence at any level of q_{1i} , the marginal contribution of q_{1i} to the equity value is smaller than in the benchmark model, leading to a lower equilibrium production/investment level q^*_{1i} . The fact that q^*_{1i} is increasing in the second-run expansion cost is quite intuitive: when the future expansion is more costly, a larger first-run quantity q_{1i} could save more future expansion cost hence increase more firm's equity value. However, when the future capacity expansion becomes cheaper due to the post-bankruptcy interfirm asset transactions, a lower q^*_{1i} is desired. In other words, the interfirm asset transference has a tendency to postpone production, inducing a smaller q_{1i} while a larger q_{2i} than in the benchmark situation, given the same debt level. The result indicates that $\frac{dq_{1i}}{dD_i}$ is lower, and so is $\frac{d\widehat{z}_i}{dD_i}$.

What about the starting-stage leverage decision? The total firm value characterized in equation 22 is now changed into

$$\begin{aligned} V^S_{0i} &= \max_{\{D_i\}} \int_{\underline{z}}^{\overline{z}} \left[\left(a + \tilde{z} - b(q^*_{1i} + q^*_{1j}) - l - r\right) q^*_{1i}\right] d\Phi(\tilde{z}) \\ &\quad + \int_{\widehat{z}_j}^{\overline{z}} \left[\left(a + \tilde{z} - b(q^{d*}_{2i} + q^{d*}_{2j}) - l\right) q^{d*}_{2i} - r'(q^{d*}_{2i} - q^*_{1i})\right] d\Phi(\tilde{z}) \\ &\quad + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[(a + \tilde{z} - bq^{m*}_{2i} - l)\, q^{m*}_{2i} - r'(q^{m*}_{2i} - q^*_{1i})\right] d\Phi(\tilde{z}), \end{aligned} \tag{35}$$

and the marginal value of debt characterized in equation 27 is now changed into

$$\begin{aligned} \frac{dV^S_{0i}}{dD_i} &= \left[a - b(2q^*_{1i} + q^*_{1j}) - l - r\right] \frac{dq^*_{1i}}{dD_i} + r' \left[\Phi\left(\overline{z}\right) - \Phi\left(\widehat{z}_i\right)\right] \frac{dq^*_{1i}}{dD_i} - bq^*_{1i}\frac{dq^*_{1j}}{dD_i} \\ &\quad + \left\{\left[(a + \widehat{z}_j - bq^{m*}_{2i} - l)\, q^{m*}_{2i} - r'(q^{m*}_{2i} - q^*_{1i})\right] - \left[\left(a + \widehat{z}_j - b(q^{d*}_{2i} + q^{d*}_{2j}) - l\right) q^{d*}_{2i} - r'(q^{d*}_{2i} - q^*_{1i})\right]\right\} \\ &\quad \cdot \frac{d\widehat{z}_j}{dD_i} - \left[(a + \widehat{z}_i - bq^{m*}_{2i} - l)\, q^{m*}_{2i} - r'(q^{m*}_{2i} - q^*_{1i})\right] \frac{d\widehat{z}_i}{dD_i}. \end{aligned} \tag{36}$$

Since debt is placed solely to boost the first-run production (note that it will be paid back before any second-run production is launched), a lower equilibrium first-run production size might suggests a lower desirable debt level than in the benchmark situation. The mathematical proof is as follows. The first term $\left[a - b(2q^*_{1i} + q^*_{1j}) - l - r\right] \frac{dq^*_{1i}}{dD_i}$ is lower than in the benchmark model due to the lower marginal profit of production in the first run $\left[a - b(2q^*_{1i} + q^*_{1j}) - l - r\right]$ and the lower $\frac{dq^*_{1i}}{dD_i}$. In addition, the second term $r' \left[\Phi\left(\overline{z}\right) - \Phi\left(\widehat{z}_i\right)\right] \frac{dq_{1i}^*}{dD_i}$ is also lower due to the lower r' and the lower $\frac{dq_{1i}^*}{dD_i}$. Furthermore, the last term $-\left[\left(a + \widehat{z}_i - bq_{2i}^{m*} - l\right) q_{2i}^{m*} - r'(q_{2i}^{m*} - q_{1i}^*)\right] \frac{d\widehat{z}_i}{dD_i}$ is also lower due to the greater monopoly profit in the second run $\left[\left(a + \widehat{z}_i - bq_{2i}^{m*} - l\right) q_{2i}^{m*} - r'(q_{2i}^{m*} - q_{1i}^*)\right]$ associated with a lower expansion cost. Finally, the other two terms left in equation 36 are associated with indirect effects $\frac{dq_{1j}^*}{dD_i}$ and $\frac{d\widehat{z}_j}{dD_i}$, which should be less influential than the direct effects mentioned earlier. As a result, the net effect of D_i on the total firm value should be lower than in the benchmark model, and so should the level of the optimal debt. Following the same rationale, I can show that the effect mentioned above will be continuous on r'.

Proposition 3 *A firm cogitating its possible monopolist status upon the rival firm's bankruptcy will use less strategic debt if the inter-firm asset flows are easier.*

Proof. As discussed above. ■

This result is consistent with my argument that a strategic debt may induce the rival to fight harder to grab monopoly benefit. When the post-bankruptcy interfirm asset transaction is easier, the expansion upon monopoly is less costly, increasing the value of monopoly hence the rival's incentive to fight for the monopoly, which in turn increases the cost of a strategic debt, forcing a firm to issue less strategic debt.

In literature, the impact of asset transferability on debt has been analyzed mainly in the strategic debt studies, whereas with predictions adverse to mine. For instance, the well known Schleifer and Vishny (1992) predicts a higher industry average leverage when the interfirm asset transaction is easier, due to a greater probability of obtaining peer's bailout when the whole industry is in distress. Titman (1984) predicts that a greater uniqueness of products might discourage firms from issuing debt, with a concern that customers might avoid purchasing the products when they worry that the firm will go out of business someday. Sarig (1988) predicts that firms should use less debt when the workers' skills are less transferable. With testable implications opposite to these, my model might contribute to the literature. As I will discuss later, my prediction is consistent with several empirical evidence.

3.3 Reorganization

In this subsection, I examine the change in the benchmark result if a firm has a chance to obtain reorganization upon its bankruptcy. A simple way is to see the change if the bankruptcy code is Chapter 11 rather than Chapter 7. Focusing on case "S", where each firm assumes that it will go bankrupt no earlier than its rival, I consider three possible market conditions in the second run: (1) both firms survive; (2) the rival goes bankrupt, and the own firm survives; (3) both firms go bankrupt. Under Chapter11, the bankrupt firm will stay in the market, hence two firms still play a duopoly game in the second-run. However, a bankruptcy event will incur costs, such as the reputation loss in the product market (Lang and Stulz, 1992). I simplify this bankruptcy cost as a base demand drop from a to $a-c$ for the bankrupt firm, while assuming that the rival firm, if it survives, will enjoy a base demand increase from a to $a+c$, and the industrial base demand remains as $2a$. Note that I ignore the contagion effect of a bankruptcy to the whole industry that could cause the industrial base demand to drop. However, I assume that the industrial base demand will drop to $2(a-c)$ if both firms default (situation (3)), with each firm getting a lower base demand $a-c$, and the weaker industry is penalized by the market through an aggregate loss $2c$. With backward induction, I find that the optimal second-run expansion/production decision at $t=2$ can be summarized as follows.

Lemma 2 *Under the Chapter 11 bankruptcy code, F_i's detailed optimal second-run expansion/production decision rule is in Table 3, which is contingent on the range of F_i's first-run capacity q_{1i}. Note that q_{2i}^{a*}, q_{2i}^{b*} and q_{2i}^{c*} are the equilibrium second-run production sizes in the following three situations, respectively: (1) both firms survive; (2) the rival goes bankrupt, and the own firm survives; and (3) both firms go bankrupt. Also note that the analysis applies for case $c \geqslant r$, while other two cases, case $r-c<c<r$*

and case $c \leq \frac{r}{2}$ *can be analyzed in a similar way.*

	Range of q_{1i}
1	$(\frac{1}{3b}(a+c+z-l),\ +\infty)$
2	$(\frac{1}{3b}(a+c+z-l-r),\ \frac{1}{3b}(a+c+z-l)]$
3	$(\frac{1}{3b}(a+z-l),\ \frac{1}{3b}(a+c+z-l-r)]$
4	$[\frac{1}{3b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)]$
5	$[\frac{1}{3b}(a-c+z-l),\ \frac{1}{3b}(a+z-l-r)]$
6	$[\frac{1}{3b}(a-c+z-l-r),\ \frac{1}{3b}(a-c+z-l)]$
7	$(-\infty,\ \frac{1}{3b}(a-c+z-l-r))$

	q_{2i}^{a*}	*Expand?*	q_{2i}^{b*}	*Expand?*	q_{2i}^{c*}	*Expand?*
1	$\frac{1}{3b}(a+z-l)$	*No*	$\frac{1}{3b}(a+c+z-l)$	*No*	$\frac{1}{3b}(a-c+z-l)$	*No*
2	$\frac{1}{3b}(a+z-l)$	*No*	q_{1i}	*No*	$\frac{1}{3b}(a-c+z-l)$	*No*
3	$\frac{1}{3b}(a+z-l)$	*No*	$\frac{1}{3b}(a+c+z-l-r)$	*Yes*	$\frac{1}{3b}(a-c+z-l)$	*No*
4	q_{1i}	*No*	$\frac{1}{3b}(a+c+z-l-r)$	*Yes*	$\frac{1}{3b}(a-c+z-l)$	*No*
5	$\frac{1}{3b}(a+z-l-r)$	*Yes*	$\frac{1}{3b}(a+c+z-l-r))$	*Yes*	$\frac{1}{3b}(a-c+z-l)$	*No*
6	$\frac{1}{3b}(a+z-l-r)$	*Yes*	$\frac{1}{3b}(a+c+z-l-r)$	*Yes*	q_{1i}	*No*
7	$\frac{1}{3b}(a+z-l-r)$	*Yes*	$\frac{1}{3b}(a+c+z-l-r)$	*Yes*	$\frac{1}{3b}(a-c+z-l-r)$	*Yes*

Table 3 The Summary of the Second-run Production/Investment Decision under Chapter 11

Proof. See Appendix. ■

At $t = 1$, taking into account the second-run production/investment decisions solved earlier, each firm makes its first-run production/investment decision. Following the rationale discussed earlier, I only consider range 7 in Table 3, where no idle capacity exists in the second-run in all situations. Also, for simplicity and without the loss of generality, at all stages earlier than $t = 2$, I consider the symmetric behaviors of the two firms: each firm assumes that the rival will be bankrupt first, that is, firm F_i

assumes $\widehat{z_i} > \widehat{z_j}$ and symmetrically firm F_j assumes $\widehat{z_j} > \widehat{z_i}$. The optimization problems are:

$$\begin{aligned} E_{1i}^S &= \max_{\{q_{1i}\}} \int_{\widehat{z_j}}^{\overline{z}} \left[\left(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r\right) q_{1i} - D_i + \left(a + \tilde{z} - b(q_{2i}^{a*} + q_{2j}^{a*}) - l\right) q_{2i}^{a*} - r(q_{2i}^{a*} - q_{1i}) \right] d\Phi(\tilde{z}) \\ &\quad + \int_{\widehat{z_i}}^{\widehat{z_j}} \left[\left(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r\right) q_{1i} - D_i + \left(a + c + \tilde{z} - b(q_{2i}^{b*} + q_{2j}^{b*}) - l\right) q_{2i}^{b*} - r(q_{2i}^{b*} - q_{1i}) \right] d\Phi(\tilde{z}), \end{aligned} \tag{37}$$

$$\begin{aligned} E_{1j}^S &= \max_{\{q_{1j}\}} \int_{\widehat{z_i}}^{\overline{z}} \left[\left(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r\right) q_{1j} - D_j + \left(a + \tilde{z} - b(q_{2i}^{a*} + q_{2j}^{a*}) - l\right) q_{2j}^{d*} - r(q_{2j}^{a*} - q_{1j}) \right] d\Phi(\tilde{z}) \\ &\quad + \int_{\widehat{z_j}}^{\widehat{z_i}} \left[\left(a + \tilde{z} - b(q_{1i} + q_{1j}) - l - r\right) q_{1j} - D_j + \left(a + c + \tilde{z} - b(q_{2i}^{b*} + q_{2j}^{b*}) - l\right) q_{2j}^{b*} - r(q_{2j}^{b*} - q_{1j}) \right] d\Phi(\tilde{z}), \end{aligned} \tag{38}$$

subjected to

$$\begin{aligned} q_{2i}^{a*} &= q_{2j}^{a*} = \frac{1}{3b}(a + z - l - r),\ q_{2i}^{b*} = q_{2j}^{b*} = \frac{1}{3b}(a + c + z - l - r), \\ q_{1i} &\in \left(-\infty,\ \frac{1}{3b}(a - c + z - l - r)\right) \text{ and } q_{1j} \in \left(-\infty,\ \frac{1}{3b}(a - c + z - l - r)\right). \end{aligned}$$

Note that in equation for E_{1i}^S, the first integral is F_i's total equity payoff in situation (1), where both firms survives, and the second integral is its total equity payoff in situation (2), where the rival goes bankrupt but its own survives. For the equity value, the bankrupt situation (3) is irrelevant. The first order condition for q_{1i} will be:

$$\frac{dE_{1i}^S}{dq_{1i}} = \left(a - b(2q_{1i}^* + q_{1j}^*) - l\right) \frac{(\overline{z} - \widehat{z_i})}{2\overline{z}} + \frac{(\overline{z}^2 - \widehat{z_i}^2)}{4\overline{z}}, \tag{39}$$

which exactly equates that in the benchmark model, hence at any q_{1i} level, I prove that the marginal contribution of q_{1i} to the equity value is the same as in the benchmark model, and consequently in subgame equilibrium, the optimal production/investment level q_{1i}^* should be the same as in the benchmark model.

Synthesizing of the two first order conditions $\frac{dE_{1i}^S}{dq_{1i}} = 0$ and $\frac{dE_{1j}^S}{dq_{1j}} = 0$ generates

$$q_{1i} = \frac{1}{6b}\left[2\left(a + \widehat{z_i} - l\right) + \overline{z} - \widehat{z_j}\right], \tag{40}$$

$$q_{1j} = \frac{1}{6b}\left[2\left(a + \widehat{z_j} - l\right) + \overline{z} - \widehat{z_i}\right], \tag{41}$$

which are also the same in the benchmark model. Implicitly, the results so far indicate that the derivatives of quantities and default points with respect to debt are the same as in the benchmark model.

Finally, at the beginning point $t = 0$, each firm chooses its debt level after incorporating its production/investment decision in the first-run and its expansion/production decision in the second-run upon its survival, to maximize its expected total firm value. Firm F_i's optimization problem is

$$\begin{aligned} V_{0i}^S &= \max_{\{D_i\}} \int_{\underline{z}}^{\overline{z}} \left[\left(a + \tilde{z} - b(q_{1i}^* + q_{1j}^*) - l - r \right) q_{1i}^* \right] d\Phi(\tilde{z}) \qquad (42) \\ &+ \int_{\widehat{z}_j}^{\overline{z}} \left[\left(a + \tilde{z} - b(q_{2i}^{a*} + q_{2j}^{a*}) - l \right) q_{2i}^{a*} - r(q_{2i}^{a*} - q_{1i}^*) \right] d\Phi(\tilde{z}) \\ &+ \int_{\widehat{z}_i}^{\widehat{z}_j} \left[\left(a + \tilde{z} - bq(q_{2i}^{b*} + q_{2j}^{b*}) - l \right) q_{2i}^{b*} - r(q_{2i}^{b*} - q_{1i}^*) \right] d\Phi(\tilde{z}) \\ &+ \int_{\underline{z}}^{\widehat{z}_i} \left[\left(a + \tilde{z} - bq(q_{2i}^{c*} + q_{2j}^{c*}) - l \right) q_{2i}^{c*} - r(q_{2i}^{c*} - q_{1i}^*) \right] d\Phi(\tilde{z}), \qquad (43) \end{aligned}$$

subjected to

$$\begin{aligned} q_{2i}^{a*} &= q_{2j}^{a*} = \frac{1}{3b}(a + z - l - r), \; q_{2i}^{b*} = q_{2j}^{b*} = \frac{1}{3b}(a + c + z - l - r), \\ q_{2i}^{c*} &= q_{2j}^{c*} = \frac{1}{3b}(a - c + z - l - r), \; q_{1i}^* = \; q_{1i}^{S*}(D_i, D_j) \text{ and } q_{1j}^* = \; q_{1j}^{S*}(D_i, D_j). \end{aligned}$$

Based on the Leibniz Integral Rule, I derive

$$\begin{aligned} \frac{dV_{0i}^S}{dD_i} &= \left\{ a - b(2q_{1i}^* + q_{1j}^*) - l \right\} \frac{dq_{1i}^*}{dD_i} - bq_{1i}^* \frac{dq_{1j}^*}{dD_i} \qquad (44) \\ &+ \left\{ \left[\left(a + \widehat{z}_j - b(q_{2i}^{b*} + q_{2j}^{b*}) - l \right) q_{2i}^{b*} - r(q_{2i}^{b*} - q_{1i}^*) \right] - \left[\left(a + \widehat{z}_j - b(q_{2i}^{a*} + q_{2j}^{a*}) - l \right) q_{2i}^{a*} - r(q_{2i}^{a*} - q_{1i}^*) \right] \right\} \\ &\cdot \frac{d\widehat{z}_j}{dD_i} - \{ \left[\left(a + \widehat{z}_i - b(q_{2i}^{c*} + q_{2j}^{c*}) - l \right) q_{2i}^{c*} - r(q_{2i}^{c*} - q_{1i}^*) \right] - [\left(a + \widehat{z}_i - b(q_{2i}^{b*} + q_{2j}^{b*}) - l \right) q_{2i}^{b*} \\ &- r(q_{2i}^{b*} - q_{1i}^*)] \} \frac{d\widehat{z}_i}{dD_i}. \end{aligned}$$

As compared to $\frac{dV_{0i}^S}{dD_i}$ in the benchmark (see equation 27), the first term is obviously larger, the second term is the same as before, the third term is insignificant as an indirect effect, and the last term is smaller in $\{\cdot\}$, suggesting that a same debt level D_i will generate a larger firm value than in the benchmark model. Thus, at equilibrium (where the firm value is maximized), the optimal debt level should be higher than in the benchmark model. Following the same rationale, I can show that the effect will be continuous on the reorganization possibility.

Proposition 4 *A firm cogitating its possible monopolist status upon the rival firm's bankruptcy will use less strategic debt if it is more likely to receive reorganization upon bankruptcy.*

Proof. As discussed above. ■

This result is consistent with the intuition generated from the benchmark model: the strategic role of debt to deter competition is weakened when the rival has an incentive to fight hard in order to grab the monopoly benefit upon the levered firm's bankruptcy. However, when the monopoly perspective disappears under the Chapter 11's "soft" regulation on the bankrupt firm, the rival's incentive to fight hard also disappears, making a firm "safe" to use a strategic debt. This result is consistent with the prediction from the strategic debt model in Hunsaker (1999): a debt increase with a Chapter 7 bankruptcy expectation will induce a tougher rivalry, while a debt increase with a Chapter 11 bankruptcy expectation will induce a softer rivalry, indicating a higher desirable debt level under a Chapter 11 code than under a Chapter 7 code. However, it is against the predictions from the agency model in Harris and Raviv (1990) that debt is negatively affected by the probability of reorganization following default.

3.4 Risky Investments and Real Options

In the real world, many investments have uncertain cash flows in the future hence leave rooms for real options. Since a debt placement will increase the equity risk, in general, the value of options such as waiting options will be more valuable, which may increase the expected value of the project, leading to a larger investment. In addition, the limited liability effect will be amplified due to more substantial risk of the underlying project. Intuitively, these will trigger greater aggressiveness from the levered firm, strengthening the strategic function of debt and increasing the equilibrium debt level. Following the same rationale, I argue that this effect is continuous, that is, when the investments are more risky and real options are more valuable, the optimal debt level should be greater, as summarized below:

Proposition 5 *A firm cogitating its possible monopolist status upon the rival firm's bankruptcy will use less strategic debt if the investment is riskier and the real options are more valuable.*

Proof. As discussed above. ■

One of the traditional capital structure determinants that relates to the level of real options is growth opportunity, which is also an estimate of financial constraint (+), as I discussed earlier. Agency models predict that growth opportunity negatively affects debt (Jensen and Meckling, 1976, Stulz, 1990, and Miao, 2005). In my strategic debt model, growth opportunity is an estimate of both investment risk/real options and financial constraints, both effects positively impacting debt. Again, my model prediction is against those from agency models. Another traditional capital structure determinant, business risk, is an acknowledged debt reducer, since a greater business risk will leave smaller space for the equityholders to tolerate financial risk. However, my strategic debt model predicts the opposite: greater business risk might increase the value of investments, hence make debt more effective and more desired in improving a firm's product market position. As I will discuss later, my prediction is consistent with several empirical evidence.

4 Discussions

The previous analyses that the strategic role of debt in deterring competition might be stronger if one of the following conditions occur:

(1) Firms are more financially constrained;

(2) Assets are more specialized and less transferrable to other firms;

(3) Firms have greater opportunities to file for reorganization upon bankruptcy;

(4) Product line investments are more risky, generating more valuable real options.

However, these conditions are sometimes conflicted with each other. For instance, firms with tight financial constraints are usually not qualified for reorganization when going bankrupt, making conditions (1) and (3) discorded. I need to synthesize all these factors to see the balance between the limit liability effect and the deep pocket effect in product market competition.

The empirical evidence documented in literature seem to suggest that the strategic role of debt is less effective in matured industries (such as the supermarket industry discussed in Chevalier, 1995, and Khanna and Tice, 2002), while more effective in quickly expanding industries (such as the telecommunication industry discussed in Leach, Moyen and Yang, 2006). Campello (2003) also finds evidence in line with the strategic role of debt when the business is in expansion, while the opposite evidence when the business is in recession. To some extent, my results can justify these findings. For instance, many quickly expanding industries are high-tech industries, where R&D activities are important, as such, assets and employees' skills are very specialized and difficult to flow to other firms, satisfying condition (2)[4]. In addition, firms in fast expanding industries are more likely to encounter financial constraints, their investments are more risky, and they are more associated with real options such as growth options, satisfying conditions (1) and (4). Whereas, with more financial constraints and business risk, firms in these industries are less likely to achieve reorganizations than those firms in more matured industries, which is against condition (3).[5] The empirical evidence that the strategic use of debt in product market competition are more favored in the fast growing industries than in the matured industries, might suggest that conditions (1), (2) and (4) are more influential than conditions (3) to the strategic debt placement.

On the other hand, my strategic debt analysis might help justify several existing empirical evidence on the impacts of these factors on capital structure that can not be explained by traditional capital structure theories especially agency theories. For instance, my model can justify the negative effects of profitability on debt found in Friend and Hasbrouck (1988), Friend and Lang (1988), Kester (1986), Titman and Wessels (1988), Graham (2000), and so on; the negative effect of free cash flow on debt

[4]Titman and Wessels (1988) use R&D/Sales and employee quit rate as proxies for the uniqueness of business, where a higher R&D/Sales or a lower quit rate indicates a greater uniqueness.

[5]I investigate the bankruptcy applications during 1990 to 2006, using the SDC Bankruptcy Data, and find that the percentage of bankrupt firms that obtained reorganizations is 81.71% in the telecommunications industry (SIC code 4800-4899), which is lower than the percentage in the supermarket industry (SIC code 5300-5399), 92.31%, and the percentage in all the industries, 84.86%.

found in Chaplinsky and Niehaus (1993); the positive effect of growth opportunities on debt found in Kester (1986); the positive effect of volatility on debt found in Kim and Sorensen (1986); and the negative impact of liquidity on debt found in Graham (2000). Some of the evidence can not be justified by any other existing theories, such as the positive impact of volatility and the negative impact of liquidity on debt, while some of the evidence can be justified by theories alternative to mine. For instance, the negative impacts of profitability and free cash flow, and the positive impact of growth opportunities on debt, can be explained also by pecking order theory, and in this sense, my theory provides complementary contributions.

5 Conclusion

In this paper, I adjoin the post-bankruptcy product market condition to the traditional pre-bankruptcy framework of strategic debt, to investigate the interplays between the two opposite effects of debt in the product market competition: the limited liability effect and the deep pocket effect. I argue that the strategic function of debt in improving a firm's product market position, namely the limited liability effect, might be over-estimated without a consideration on the monopoly prospect of the less levered rival firm and its corresponding predatory reaction toward this debt placement. I also examine the impacts of several traditional capital structure determinants on the relative strengths of these two strategic debt effects. In support of my essential idea, I find that when allowing for post-bankruptcy interfirm asset transference, a greater asset liquidity will make the monopoly status more desirable due to a lower capacity expansion cost, hence initiating a more predatory rivalry upon the debt placement and reducing the equilibrium debt level. My argument is also confirmed by a higher equilibrium debt level when the monopoly prospect is weaken, such as when there is a greater opportunity for the bankrupt firm to obtain reorganization. In addition, I argue that the strategic function of debt will be strengthened when the levered firms are more financially constrained, or when the investments are more risky and real options are more valuable. My theoretical predictions are consistent with some existing empirical evidence, which might not be justifiable through non-strategic capital structure theories or alternative strategic debt theories.

APPENDIX

A Proof for Lemma 1

As a Monopolist in the Second Run As mentioned earlier, there are two steps in solving the optimization problem characterized by equation 1. In the first step, for the optimization problem $\max_{\{q_{2i}^{me}\}}[(a+z-bq_{2i}^{me}-l)\, q_{2i}^{me}-r(q_{2i}^{me}-q_{1i})]$ (s.t. $q_{2i}^{me} \geqslant q_{1i}$), I can write firm F_i's Lagrangian as:

$$(a+z-bq_{2i}^{me}-l)\, q_{2i}^{me}-r(q_{2i}^{me}-q_{1i})+\lambda^{me}(q_{2i}^{me}-q_{1i}).$$

The Kuhn-Tucker first order conditions for q_{2i}^{me} are:

$$\begin{aligned} a+z-2bq_{2i}^{me}-l-r+\lambda^{me} &= 0 \text{ (FOC for } q_{2i}^{me}) \\ \lambda^{me} &\geq 0 \\ q_{2i}^{me} &\geqslant q_{1i} \\ \lambda^{me}(q_{2i}^{me}-q_{1i}) &= 0. \end{aligned}$$

These generate

$$\begin{aligned} q_{2i}^{me} &= \begin{cases} \frac{1}{2b}(a+z-l-r), & \text{when } \frac{1}{2b}(a+z-l-r) > q_{1i} \text{ (interior)} \\ q_{1i}, & \text{when } \frac{1}{2b}(a+z-l-r) \leqslant q_{1i} \text{ (corner)} \end{cases} \\ &= \max\ \{q_{1i}, \frac{1}{2b}(a+z-l-r)\}. \end{aligned}$$

The result is quite intuitive: it is optimal for a firm to expand only when the initial capacity q_{1i} is not large enough.

Similarly, for the optimization problem $\max_{\{q_{2i}^{mn}\}}[(a+z-bq_{2i}^{mn}-l)\, q_{2i}^{mn}]$ (s.t. $q_{2i}^{mn} \leqslant q_{1i}$), I can write firm F_i's Lagrangian as:

$$(a+z-bq_{2i}^{mn}-l)\, q_{2i}^{mn}+\lambda^{mn}(q_{1i}-q_{2i}^{mn}).$$

The Kuhn-Tucker first order conditions for q_{2i}^{mn} are:

$$\begin{aligned} a+z-2bq_{2i}^{mn}-l-\lambda^{mn} &= 0 \text{ (FOC for } q_{2i}^{mn}) \\ \lambda^{mn} &\geq 0 \\ q_{1i} &\geqslant q_{2i}^{mn} \\ \lambda^{mn}(q_{1i}-q_{2i}^{mn}) &= 0. \end{aligned}$$

These generate

$$\begin{aligned} q_{2i}^{mn} &= \begin{cases} \frac{1}{2b}(a+z-l), & \text{when } \frac{1}{2b}(a+z-l) < q_{1i} \text{ (interior)} \\ q_{1i}, & \text{when } \frac{1}{2b}(a+z-l) \geqslant q_{1i} \text{ (corner)} \end{cases} \\ &= \min\ \{q_{1i}, \frac{1}{2b}(a+z-l)\}. \end{aligned}$$

In the second step, I substitute the solutions into the profit functions $[(a+z-bq_{2i}^{me}-l)\, q_{2i}^{me}-r(q_{2i}^{me}-q_{1i})]$ and $[(a+z-bq_{2i}^{mn}-l)\, q_{2i}^{mn}]$, compare their results and see which one is higher, hence to determine the optimal expansion decision and the corresponding second-run expansion decision. The results are as follows:

Range of q_{1i}	q_{2i}^{me}	q_{2i}^{mn}	Expand?	q_{2i}^{m*}
$(\frac{1}{2b}(a+z-l),\ +\infty)$	q_{1i}	$\frac{1}{2b}(a+z-l)$	No	$\frac{1}{2b}(a+z-l)$
$[\frac{1}{2b}(a+z-l-r),\ \frac{1}{2b}(a+z-l)]$	q_{1i}	q_{1i}	No	q_{1i}
$(-\infty,\ \frac{1}{2b}(a+z-l-r))$	$\frac{1}{2b}(a+z-l-r)$	q_{1i}	Yes	$\frac{1}{2b}(a+z-l-r)$

Table 2.1 The Second-run Production/Investment Decision under Monopoly (Details)

For instance, when $q_{1i} \in (\frac{1}{2b}(a+z-l),\ +\infty)$, the optimal quantity with expansion, q_{2i}^{me}, is q_{1i}, meaning that expansion is not optimal, or, no expansion is optimal. Since the optimal quantity with no-expansion, q_{2i}^{mn}, is $\frac{1}{2b}(a+z-l)$, this must be the optimal monopoly level q_{2i}^{m*}. Similar analysis applies to the range when $q_{1i} \in (-\infty,\ \frac{1}{2b}(a+z-l-r))$, and the outcome for the range $q_{1i} \in [\frac{1}{2b}(a+z-l-r),\ \frac{1}{2b}(a+z-l)]$ is straightforward. Table 2.1 can be simplified as

Range of q_{1i}	q_{2i}^{m*}	Expand?
$(\frac{1}{2b}(a+z-l),\ +\infty)$	$\frac{1}{2b}(a+z-l)$	No
$[\frac{1}{2b}(a+z-l-r),\ \frac{1}{2b}(a+z-l)]$	q_{1i}	No
$(-\infty,\ \frac{1}{2b}(a+z-l-r))$	$\frac{1}{2b}(a+z-l-r)$	Yes

Table 2.2 The Second-run Production/Investment Decision Rule as a Monopolist

Intuitively, in the second run, "expansion" is more likely to be optimal than "no expansion" when the first-run capacity q_{1i} falls into a lower range.

As One of the Duopolists in the Second Run For the optimization problem in equation 2, following steps similar as above, I first derive

$$\begin{aligned} q_{2i}^{de} &= \max\ \{q_{1i},\ \frac{1}{3b}(a+z-l-r)\}, \\ q_{2i}^{dn} &= \min\ \{q_{1i},\ \frac{1}{3b}(a+z-l)\}. \end{aligned}$$

I then substitute this pair of production size solutions into the profit functions $[\left(a+z-b(q_{2i}^{de}+q_{2j}^{de})-l\right) q_{2i}^{de} - r(q_{2i}^{de}-q_{1i})]$ and $[\left(a+z-b(q_{2i}^{dn}+q_{2j}^{dn})-l\right) q_{2i}^{dn}]$, respectively, compare the two profits, and derive the optimal duopoly quantity q_{2i}^{d*} and the corresponding optimal expansion decision summarized in Table 2.3 .

Range of q_{1i}	q_{2i}^{d*}	Expand?
$(\frac{1}{3b}(a+z-l),\ +\infty)$	$\frac{1}{3b}(a+z-l)$	No
$[\frac{1}{3b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)]$	q_{1i}	No
$(-\infty,\ \frac{1}{3b}(a+z-l-r))$	$\frac{1}{3b}(a+z-l-r)$	Yes

Table 2.3 The Second-run Production/Investment Decision as One of the Duopolists

General Decision Rule The combination of Table 2.2 and Table 2.3 leads to a general decision rule for the second-run expansion/production, as summarized in Table 2. Thus, we prove Lemma 1.

B Subgame Equilibrium for the First-run Production/Investment in the Benchmark Model

In this section, I will show that in the symmetric equilibrium, a setting similar as in Brander and Lewis (1986), where the two firms assume that q_{i1} and q_{i2} are in the same range and finally achieve the same values, ranges 1, 2, 3, and 4 described in both Panel A and Panel B of Table 2, will generate corner solutions with q_{1i} the lower the better. As a result, the subgame equilibrium will be the interior solution for q_{1i} generated from range 5, which is the same in both panels.

Panel A -range 1

$$
\begin{aligned}
E_{1i}^S &= \max_{\{q_{1i}\}} \int_{\widehat{z_j}}^{\overline{z}} \Big[\left(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r\right)q_{1i} - D_i + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big)\, q_{2i}^{d*}\Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z_i}}^{\widehat{z_j}} \left[\left(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r\right)q_{1i} - D_i + \left(a+\tilde{z}-bq_{2i}^{m*}-l\right) q_{2i}^{m*}\right] d\Phi(\tilde{z}), \\
E_{1j}^S &= \max_{\{q_{1j}\}} \int_{\widehat{z_i}}^{\overline{z}} \Big[\left(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r\right)q_{1j} - D_j + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big)\, q_{2j}^{d*}\Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z_j}}^{\widehat{z_i}} \left[\left(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r\right)q_{1j} - D_j + \left(a+\tilde{z}-bq_{2j}^{m*}-l\right) q_{2j}^{m*}\right] d\Phi(\tilde{z}), \\
&\quad \text{Both optimizations are subjected to} \\
q_{2i}^{d*} &= q_{2j}^{d*} = \frac{1}{3b}(a+z-l),\ q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{3b}(a+z-l), \\
q_{1i} &\in \left(\frac{1}{2b}(a+z-l),\ \ +\infty\right) \text{ and } q_{1j} \in \left(\frac{1}{2b}(a+z-l),\ \ +\infty\right).
\end{aligned}
$$

The problem can be interpreted similarly as for the problem for range 5, which is characterized by equations 5 and 6. In equation for E_{1i}^S, the first integral is firm F_i's total equity payoff if it duopolizes the market with the rival in the second run, while the second term is its total equity payoff if it monopolizes the market in the second run. This range differs from range 5 in that firms will not expand in the second-run in either duopoly or monopoly market, hence there is no marginal capacity cost r for the second-run production. Another difference is that optimizations are subjected to the constraints for range 1, shown in Table 2: $q_{2i}^{d*} = q_{2j}^{d*} = \frac{1}{3b}(a+z-l)$, $q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{3b}(a+z-l)$,and q_{1i} and q_{1j} are within $(\frac{1}{2b}(a+z-l),\ \ +\infty)$.

Panel A -range 2

$$
\begin{aligned}
E_{1i}^S &= \max_{\{q_{1i}\}} \int_{\widehat{z_j}}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l \Big)\, q_{2i}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z_i}}^{\widehat{z_j}} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + (a+\tilde{z}-bq_{2i}^{m*}-l)\, q_{2i}^{m*} \right] d\Phi(\tilde{z}), \\
E_{1j}^S &= \max_{\{q_{1j}\}} \int_{\widehat{z_i}}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l \Big)\, q_{2j}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z_j}}^{\widehat{z_i}} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \left(a+\tilde{z}-bq_{2j}^{m*}-l \right) q_{2j}^{m*} \right] d\Phi(\tilde{z}), \\
&\quad \text{Both optimizations are subjected to} \\
q_{2i}^{d*} &= q_{2j}^{d*} = \frac{1}{3b}(a+z-l),\ q_{2i}^{m*} = q_{1i},\ q_{2j}^{m*} = q_{1j}, \\
q_{1i} &\in (\frac{1}{2b}(a+z-l-r),\ \frac{1}{2b}(a+z-l)] \text{ and } q_{1j} \in (\frac{1}{2b}(a+z-l-r),\ \frac{1}{2b}(a+z-l)].
\end{aligned}
$$

This range differs from range 1 only in q_{2i}^{m*}, q_{2j}^{m*} and the ranges for q_{1i} and q_{1j}.

Panel A -range 3

$$
\begin{aligned}
E_{1i}^S &= \max_{\{q_{1i}\}} \int_{\widehat{z_j}}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l \Big)\, q_{2i}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z_i}}^{\widehat{z_j}} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + (a+\tilde{z}-bq_{2i}^{m*}-l)\, q_{2i}^{m*} - r(q_{2i}^{m*}-q_{1i}) \right] d\Phi(\tilde{z}), \\
E_{1j}^S &= \max_{\{q_{1j}\}} \int_{\widehat{z_i}}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l \Big)\, q_{2j}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z_j}}^{\widehat{z_i}} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \left(a+\tilde{z}-bq_{2j}^{m*}-l \right) q_{2j}^{m*} - r(q_{2j}^{m*}-q_{1j}) \right] d\Phi(\tilde{z}), \\
&\quad \text{Both optimizations are subjected to} \\
q_{2i}^{d*} &= q_{2j}^{d*} = \frac{1}{3b}(a+z-l),\ q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a+z-l-r), \\
q_{1i} &\in (\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l-r)] \text{ and } q_{1j} \in (\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l-r)].
\end{aligned}
$$

Note that a major difference between this range and previous two ranges (range 1 and range 2) is that if the second-run is a monopoly market, additional investment cost arises to support a production that exceeds the production size in the first-run (except when q_{1i} and q_{1j} are at the upper boundary $\frac{1}{2b}(a+z-l-r)$). In addition, this range also differs from previous two ranges in q_{2i}^{m*}, q_{2j}^{m*} and the ranges for q_{1i} and q_{1j}.

Panel A -range 4

$$\begin{aligned}
E_{1i}^S &= \max_{\{q_{1i}\}} \int_{\widehat{z}_j}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big)\, q_{2i}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + (a+\tilde{z}-bq_{2i}^{m*}-l)\, q_{2i}^{m*} - r(q_{2i}^{m*}-q_{1i}) \right] d\Phi(\tilde{z}), \\
E_{1j}^S &= \max_{\{q_{1j}\}} \int_{\widehat{z}_i}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big)\, q_{2j}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_j}^{\widehat{z}_i} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \left(a+\tilde{z}-bq_{2j}^{m*}-l\right) q_{2j}^{m*} - r(q_{2j}^{m*}-q_{1j}) \right] d\Phi(\tilde{z}), \\
&\quad \text{Both optimizations are subjected to} \\
q_{2i}^{d*} &= q_{1i},\ q_{2j}^{d*} = q_{1j},\ q_{2i}^{m*} = q_{2j}^{m*} = \frac{1}{2b}(a+z-l-r), \\
q_{1i} &\in [\frac{1}{3b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)] \text{ and } q_{1j} \in [\frac{1}{3b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)].
\end{aligned}$$

This range is similar as range 3 except in the levels of q_{2i}^{m*}, q_{2j}^{m*} and the ranges for q_{1i} and q_{1j}.

Panel A -range 5 See equations 5 and 6.

Panel B -range 1 Exactly the same as the setting in range 1 of Panel A.

Panel B -range 2 Same as the setting in range 2 of Panel A except

$$q_{1i} \in (\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l)] \text{ and } q_{1j} \in (\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l)].$$

Panel B -range 3

$$\begin{aligned}
E_{1i}^S &= \max_{\{q_{1i}\}} \int_{\widehat{z}_j}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big)\, q_{2i}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_i}^{\widehat{z}_j} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1i} - D_i + (a+\tilde{z}-bq_{2i}^{m*}-l)\, q_{2i}^{m*} \right] d\Phi(\tilde{z}), \\
E_{1j}^S &= \max_{\{q_{1j}\}} \int_{\widehat{z}_i}^{\overline{z}} \Big[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \Big(a+\tilde{z}-b(q_{2i}^{d*}+q_{2j}^{d*})-l\Big)\, q_{2j}^{d*} \Big]\, d\Phi(\tilde{z}) \\
&\quad + \int_{\widehat{z}_j}^{\widehat{z}_i} \left[(a+\tilde{z}-b(q_{1i}+q_{1j})-l-r)\, q_{1j} - D_j + \left(a+\tilde{z}-bq_{2j}^{m*}-l\right) q_{2j}^{m*} \right] d\Phi(\tilde{z}), \\
&\quad \text{Both optimizations are subjected to} \\
q_{2i}^{d*} &= q_{2i}^{m*} = q_{1i},\ q_{2j}^{d*} = q_{2j}^{m*} = q_{1j}, \\
q_{1i} &\in (\frac{1}{2b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)] \text{ and } q_{1j} \in (\frac{1}{2b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)].
\end{aligned}$$

This range differs from range 3 in Panel A in that the second-run production will be conducted at the first-run level in either monopoly or duopoly market, hence no additional investment will occur. Further differences are in the levels of q_{2i}^{m*}, q_{2j}^{m*} and the ranges for q_{1i} and q_{1j}.

Panel B -range 4 Same as the setting in range 4 of Panel A except

$$q_{1i} \in [\frac{1}{3b}(a+z-l-r),\ \frac{1}{2b}(a+z-l-r)] \text{ and } q_{1j} \in [\frac{1}{3b}(a+z-l-r),\ \frac{1}{2b}(a+z-l-r)].$$

Panel B -range 5 Exactly the same as the setting in range 5 of Panel A.
The symmetric equilibrium solutions for q_{1i}^* and q_{1j}^* in all the ranges are summarized in Table 4.

Panel A - If $\frac{1}{2b}(a+z-l-r) \geqslant \frac{1}{3b}(a+z-l)$

Range	Range of q_{1i} and q_{1j}	Solution Feature	q_{1i}^* and q_{1j}^*
1	$(\frac{1}{2b}(a+z-l),\ +\infty)$	Corner	$\frac{1}{2b}(a+z-l)$
2	$(\frac{1}{2b}(a+z-l-r),\ \frac{1}{2b}(a+z-l)]$	Corner	$\frac{1}{2b}(a+z-l-r)$
3	$(\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l-r)]$	Corner	$\frac{1}{3b}(a+z-l)$
4	$[\frac{1}{3b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)]$	Corner	$\frac{1}{3b}(a+z-l-r)$
5	$(-\infty,\ \frac{1}{3b}(a+z-l-r))$	Interior	$\frac{1}{8b}[a+\overline{z}-l+r+\sqrt{(a+\overline{z}-l+r)^2+16bD_i}]$

Panel B - If $\frac{1}{2b}(a+z-l-r) < \frac{1}{3b}(a+z-l)$

Case	Range of q_{1i} and q_{1j}	Solution Feature	q_{1i}^* and q_{1j}^*
1	$(\frac{1}{2b}(a+z-l),\ +\infty)$	Corner	$\frac{1}{2b}(a+z-l)$
2	$(\frac{1}{3b}(a+z-l),\ \frac{1}{2b}(a+z-l)]$	Corner	$\frac{1}{3b}(a+z-l)$
3	$(\frac{1}{2b}(a+z-l-r),\ \frac{1}{3b}(a+z-l)]$	Corner	$\frac{1}{2b}(a+z-l-r)$
4	$[\frac{1}{3b}(a+z-l-r),\ \frac{1}{2b}(a+z-l-r)]$	Corner	$\frac{1}{3b}(a+z-l-r)$
5	$(-\infty,\ \frac{1}{3b}(a+z-l-r))$	Interior	$\frac{1}{8b}[a+\overline{z}-l+r+\sqrt{(a+\overline{z}-l+r)^2+16bD_i}]$

Table 4 The Summary of the First-run Production/Investment Decision

Note that in both Panel A and Panel B, the local optima are with the corner solutions: the lower first-run production, the better, except in the lowest range-range 5. Hence it is straightforward that the range 5 optimum should be the global optimum, that is,

$$
\begin{aligned}
q_{1i}^{S*} &= \frac{1}{8b}\left[a+\overline{z}-l+r+\sqrt{(a+\overline{z}-l+r)^2+16bD_i}\right], \\
q_{1j}^{S*} &= \frac{1}{8b}\left[a+\overline{z}-l+r+\sqrt{(a+\overline{z}-l+r)^2+16bD_j}\right].
\end{aligned}
$$

C Proof for Lemma 2

Under the Chapter 11 bankruptcy code, the subgame of the second-run expansion/production can be solved as the follows.

Situation (1): both firms survive

This situation resembles the duopoly situation at $t = 2$ in the benchmark model. There is no reputation loss or shift, and each firm will choose its second-run production size to maximize its expected duopolistic profit from the second-run production. Firm F_1's optimization problem is

$$
\begin{aligned}
E_{2i}^{a} = \max\ \{&\max_{\{q_{2i}^{ae}\}}[\left(a+z-b(q_{2i}^{ae}+q_{2j}^{ae})-l\right)q_{2i}^{ae}-r(q_{2i}^{ae}-q_{1i})]\ (\text{s.t. } q_{2i}^{ae}\geqslant q_{1i}), \\
&\max_{\{q_{2i}^{an}\}}[\left(a+z-b(q_{2i}^{an}+q_{2j}^{an})-l\right)q_{2i}^{an}]\ (\text{s.t. } q_{2i}^{an}\leqslant q_{1i})\},
\end{aligned}
$$

where E_{2i}^{a} is F_i's expected second-run profit, q_{2i}^{ae} is its optimal second-run production size with expansion, and q_{2i}^{an} is its optimal second-run production size without expansion. Again, whether expanding or not depends on which one generates a higher E^a_{2i}, and solving this optimization problem involves two steps. In the first step, I solve for q^{ae}_{2i} and q^{an}_{2i}, which maximize the duopolistic profit with expansion and that without expansion. The solutions are

$$\begin{aligned} q^{ae}_{2i} &= \max \ \{q_{1i}, \ \frac{1}{3b}(a+z-l-r)\}, \\ q^{an}_{2i} &= \min \ \{q_{1i}, \ \frac{1}{3b}(a+z-l)\}. \end{aligned}$$

In the second step, I substitute the two solutions into the profit functions $[\Big(a+z-b(q^{ae}_{2i}+q^{ae}_{2j})-l\Big)\, q^{ae}_{2i} - r(q^{ae}_{2i}-q_{1i})]$ and $[\Big(a+z-b(q^{an}_{2i}+q^{an}_{2j})-l\Big)\, q^{an}_{2i}]$, respectively, compare the two profits, and derive the optimal duopoly quantity q^{a*}_{2i} and the corresponding optimal expansion decision is

Range of q_{1i}	q^{a*}_{2i}	Expand?
$(\frac{1}{3b}(a+z-l), \ +\infty)$	$\frac{1}{3b}(a+z-l)$	No
$[\frac{1}{3b}(a+z-l-r), \ \frac{1}{3b}(a+z-l)]$	q_{1i}	No
$(-\infty, \ \frac{1}{3b}(a+z-l-r))$	$\frac{1}{3b}(a+z-l-r)$	Yes

Table 3.1 The Second-run Production/Investment Decision in Situation (1) under Chapter 11

Situation (2): the rival goes bankrupt and the own firm survives

This situation differs from situation (1) in that there is a base demand shift from the bankrupt firm's products to the survived firm's products due to the reputation effect. Here, if firm F_1 survives, its optimization problem is

$$\begin{aligned} E^b_{2i} = \max \ \{&\max_{\{q^{be}_{2i}\}}[\Big(a+c+z-b(q^{be}_{2i}+q^{be}_{2j})-l\Big)\, q^{be}_{2i} - r(q^{be}_{2i}-q_{1i})] \ (\text{s.t.} \ q^{be}_{2i} \geqslant q_{1i}), \\ &\max_{\{q^{bn}_{2i}\}}[\Big(a+c+z-b(q^{bn}_{2i}+q^{bn}_{2j})-l\Big)\, q^{bn}_{2i}] \ (\text{s.t.} \ q^{bn}_{2i} \leqslant q_{1i})\}, \end{aligned}$$

where E^b_{2i} is F_i's expected second-run profit, q^{be}_{2i} is its optimal second-run production size with expansion, and q^{bn}_{2i} is its optimal second-run production size without expansion. Again, whether expanding or not depends on which one generates a higher E^b_{2i}, and solving this optimization problem involves two steps. In the first step, I solve for q^{be}_{2i} and q^{bn}_{2i}, which maximize the duopolistic profit with expansion and that without expansion. The solutions are

$$\begin{aligned} q^{be}_{2i} &= \max \ \{q_{1i}, \ \frac{1}{3b}(a+c+z-l-r)\}, \\ q^{bn}_{2i} &= \min \ \{q_{1i}, \ \frac{1}{3b}(a+c+z-l)\}. \end{aligned}$$

In the second step, I substitute the two solutions into the two profit functions, compare the two profits, and derive the optimal duopoly quantity q^{b*}_{2i} and the corresponding optimal expansion decision is

Range of q_{1i}	q^{b*}_{2i}	Expand?
$(\frac{1}{3b}(a+c+z-l), \ +\infty)$	$\frac{1}{3b}(a+c+z-l)$	No
$[\frac{1}{3b}(a+c+z-l-r), \ \frac{1}{3b}(a+c+z-l)]$	q_{1i}	No
$(-\infty, \ \frac{1}{3b}(a+c+z-l-r))$	$\frac{1}{3b}(a+c+z-l-r)$	Yes

Table 3.2 The Second-run Production/Investment Decision in Situation (2) under Chapter 11

Situation (3): both firms go bankrupt

In this situation, both firms suffer a base demand loss in the product market. Firm F_1's optimization problem is

$$E_{2i}^{c} = \max\ \{\max_{\{q_{2i}^{ce}\}}[\Big(a-c+z-b(q_{2i}^{ce}+q_{2j}^{ce})-l\Big)\,q_{2i}^{ce}-r(q_{2i}^{ce}-q_{1i})]\ (\text{s.t. } q_{2i}^{ce}\geqslant q_{1i}),$$
$$\max_{\{q_{2i}^{cn}\}}[\Big(a-c+z-b(q_{2i}^{cn}+q_{2j}^{cn})-l\Big)\,q_{2i}^{cn}]\ (\text{s.t. } q_{2i}^{cn}\leqslant q_{1i})\},$$

where E_{2i}^{c} is F_i's expected second-run profit, q_{2i}^{ce} is its optimal second-run production size with capacity expansion, and q_{2i}^{cn} is its optimal second-run production size without capacity expansion. Again, whether expanding or not depends on which one generates a higher E_{2i}^{c}, and solving this optimization problem involves two steps. In the first step, I solve for q_{2i}^{ce} and q_{2i}^{cn}, which maximize the duopolistic profit with expansion and that without expansion. Their solutions are

$$\begin{aligned} q_{2i}^{ce} &= \max\ \{q_{1i},\ \frac{1}{3b}(a-c+z-l-r)\}, \\ q_{2i}^{cn} &= \min\ \{q_{1i},\ \frac{1}{3b}(a-c+z-l)\}. \end{aligned}$$

In the second step, I substitute the two solutions into the two profit functions, compare the two profits, and derive the optimal duopoly quantity q_{2i}^{c*} and the corresponding optimal expansion decision is

Range of q_{1i}	Expand?	q_{2i}^{c*}
$(\frac{1}{3b}(a-c+z-l),\ +\infty)$	No	$\frac{1}{3b}(a-c+z-l)$
$[\frac{1}{3b}(a-c+z-l-r),\ \frac{1}{3b}(a-c+z-l)]$	No	q_{1i}
$(-\infty,\ \frac{1}{3b}(a-c+z-l-r))$	Yes	$\frac{1}{3b}(a-c+z-l-r)$

Table 3.3 The Second-run Production/Investment Decision in Situations (3) and (4) under Chapter 11

The combination of Tables 3.1, 3.2 and 3.3 lead to a general decision rule for the second-run expansion/production as summarized in Lemma 2.

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Figure 1 Game Tree for the Benchmark Model