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# INVESTMENT DECISIONS AND FINANCIAL LEVERAGE UNDER A POTENTIAL ENTRY THREAT

## Abstract:

This study examines investment and financing decisions of a pioneering firm and agency costs of debt in the presence of an entry threat by a potential competitor. It demonstrates that the over-investment problem demonstrated by Mauer and Sarkar (2005) remains in the presence of the potential entry threat. In addition, it demonstrates that when the pioneering firm increases leverage, a potential competitor expedites its market entry. Furthermore, high leverage creates the potential for inducing the competitor to enter the market in a downturn and exposing the pioneering firm to a risk of forced bankruptcy. Therefore, the potential entry threat hinders the pioneering firm from debt financing, and thus mitigates agency conflicts between shareholders and bondholders over investment decisions.

## Keywords:

Investment; leverage; Agency costs; Entry threats; Real options

**JEL Classification:** G31, G32, G33

# 1 Introduction

When managements aim to maximize shareholders' value, debt financing causes agency conflicts in corporations and thus destroys firm value, distorting investment and financing decisions. Jensen and Meckling (1976) demonstrate that when managements maximize the value of firm's equity, debt financing causes an asset substitution problem that they are induced to undertake excessively risky investments at the expense of their bondholders. Myers (1977) demonstrates a debt-overhung problem that debt financing induces managements acting in shareholders' interest to forego investing in positive NPV projects because part of the investment value is transferred to bondholders at the expense of their shareholders. After these two seminal studies, studies of corporate finance devote much attention to examine how agency conflicts between shareholders and bondholders affect investment and financing decisions.[1]

Furthermore, theoretical studies of corporate finance develop real options models by employing a contingent claims method and progressively examine interactions between investment and financing decisions under shareholder-bondholder conflicts of interest and the magnitude of agency costs of debt. These studies provide significant insights and understandings regarding interactions between investment and financing decisions and the effects of shareholder-bondholder conflicts of interest over managerial decisions under dynamic and uncertain environment of economy.[2] However, these studies assume that a firm permanently operates as a monopolist, and thus effects on investment and financing decisions of potential competitors' entry threats remain unexplored.

[1] Hariss and Ravivi (1991) provide an excellent survey of the literature on capital structure and see them for other studies of corporate finance that examine agency conflicts created by debt financing.

[2] Mello and Persons (1992) examine levered firm's decisions regarding abandonment, suspension and resumption of a mining operation and quantify the agency costs created by outstanding debts of the firm. Leland (1998) examines interactions between a switching decision of project risk and a restructuring policy of debt financing and quantifies the agency costs of debt. Mauer and Ott (2000) examine a levered firm's decision to expand its production capacity, optimal capital structure, and the agency costs of debt. Childs et al. (2005) examine the impact of a recapitalization policy of debt financing and a degree of asset substitution of an investment opportunity on investment decisions and agency costs of debt. Mauer and Sarkar (2005) examine investment and financing decisions on an investment opportunity and demonstrate that debt financing induces over-investments under shareholder-bondholder conflicts of interest and creates the agency costs of debt. Titman and Tsyplakov (2007) examine agency costs of debt and cross-sectional and time-series characteristics of leverage ratios by developing a continuous time model where a firm dynamically chooses its investment scale and restructures its capital structure over time. Hirth and Uhrig-Homburg (2010) examine the impact of firm's internal funds on investment decisions, financial leverage choice and agency costs of debt and demonstrate that financial leverage can induce over-and under-investments and firm's internal funds work to mitigate the agency costs of debt. Sarkar (2011) examines investment and financing decisions, optimal capital structure, and agency costs of debt by developing a real options model where a firm possessing an expansion opportunity chooses the expansion timing, financial leverage prior to the expansion, and scale of debt financing for the expansion. Sundaresan et al. (2015) develop a real options model where a firm possesses a collection of investment opportunities and sequentially expands scale of existing assets with debt recapitalization and examine the effects of the number of the investment opportunities on sequential investment decisions, debt financing and default policies, and optimal leverage choice.

A strand of the literature on real options has examined investment decisions on market entry and exit in the presence of competitors. Dixit and Pindyck (1994) develop a real options model where two identical firms that share an investment opportunity decide the investment timing with strategic considerations for a competitor's decision and derive equilibrium investment strategies for market entry. The study has been extended to examine the strategic investment decisions under uncertainty in various model settings.[3] These studies enrich the existing models of real options by encompassing competitor's market entry and exit decisions and demonstrate the impact of strategic considerations for the competitor's decisions on firm's own market entry and exit decisions under uncertainty. However, except for Lambrecht (2001) and Zhdanov (2008), no study explores interactions between strategic investment and financing decisions in a competitive industry. [4]

This study attempts to fill a gap between two strands of the literature on real options by presenting a model based on studies of Lambrecht (2001), Mauer and Sarkar (2005), and Zhdanov (2008). It examines an investment decision and financial leverage choice of a pioneering firm under a circumstance where the firm is exposed to a potential entry threat by a competitor after launching a new product.

In the model presented by this study, the pioneering firm has succeeded in developing a product and now plans to undertake an investment to launch it. The investment costs are raised with equity and debt financing. The firm anticipates that a competitor enters the market to sell a substitute product in the future. Therefore, the investment and financing decisions for the pioneering firm are subject to agency conflicts between shareholders and bondholders and strategic considerations to the competitor’s investment decision.

The model demonstrates that debt financing induces the pioneering firm to expedite the investment decision when the manager maximizes equity value rather than total firm value in the presence of conflicts of interest between shareholders and bondholders. This

[3] Kulatilaka and Perotti (1998) examine the strategic investment decisions on a production costs reduction in a duopoly. Grenadier (2000) examines preemptive competition of real estate development in a duopoly and demonstrates equilibrium outcomes of the investment pattern. Joaquin and Butler (2000), Joaquin and Khanna (2001), Shackleton, Tsekrekos, and Wojakowski (2004), and Pawlina and Kort (2006) examine the impacts of heterogeneous characteristics between competing firms regarding production cost structures, production capacities, future operating profitability and the scale of investment costs on the strategic investment decisions. Lambrecht and Perraudin (2003) examine the preemptive investment strategy to monopolize the market under the assumption that firms face asymmetric information on competitor's investment costs. Weeds (2002) examines the strategic decisions on R&D investment. Nielsen (2002) examines the impact of market externality on strategic investment decisions. Pennings (2004) examines the relationship between the investment decisions on market entry and choices on product quality in a duopoly. Bayer (2007) examines the timing of strategic predatory behavior under imperfect competition. Carlson et al. (2014) examine interrelations between dynamics of firm's own and competitor's systematic risks and their investment decisions on capacity expansion and contraction in a duopoly.

[4] Lambrecht (2001) examines the impact of debt financing on market entry and liquidation decisions in a duopoly. Zhdanov (2008) extends a study of Lambrecht (2001) and derives the leader's and the follower's equilibrium strategies for market entry, debt financing, and default decisions.

over-investment problem is consistent with the result demonstrated by Mauer and Sarkar (2005) where a firm undertakes an investment with debt financing in the absence of potential entry threats. The model also demonstrates that when the pioneering firm increases financial leverage, a potential competitor expedites its market entry. Furthermore, high leverage has the potential for inducing the potential competitor to enter the market in a downturn and exposing the pioneering firm to a risk of forced bankruptcy. Therefore, the potential entry threat hinders the pioneering firm from debt financing, and thus decreases the agency costs arising from conflicts of interest between shareholders and debtholders over the investment decision.

This study contributes to the literature on real options by presenting a real options model that considers agency conflicts between shareholders and bondholders and strategic consideration for competitors' investment decisions and examining investment and financing decisions under a potential entry threat. Mauer and Ott (2000) and Mauer and Sarkar (2005) incorporate agency conflicts between shareholders and bondholders into a real option model and examine investment and financing decisions of a monopolist and the magnitude of agency costs of debt. Lambrecht (2001) and Zhdanov (2008) incorporate choices of financial leverage into a model of strategic real options and examine the impact of strategic consideration to competitor's market entry, exit, and debt financing decisions on firm's investment and financing decisions. This study fills a gap between these two strands of studies on real options that examine investment and financing decisions in a monopoly and that in a duopoly. It provides an insight into interrelations between investment decisions, financial leverage choices, and agency costs of debt in the presence of potential entry threats.

# 2 The Model

## 2.1 Assumptions

There are a pioneering firm and a potential competitor in this model. The pioneering firm plans an investment to launch a new product. The potential competitor finds an investment opportunity to produce a substitute with a probability $p$ after the pioneering firm launches its product. The pioneering firm knows that a competitor emerges and enters the market in the future with a probability $p$ .

The pioneering firm generates earnings at each point in time $t$ after it undertakes the investment. It earns $x_t - f$ as a monopolist until the potential competitor enters the market. The variable $x_t$ represents firm's revenue in a monopoly. The future revenue is uncertain and depends on economic and industry conditions. The model assumes that $x_t$ follows a geometric Brownian motion:

$$dx_t = \mu x_t dt + \sigma x_t dw_t \quad (1)$$

where $dw_t$ is a standard Winner process, $\mu$ is the expected growth rate of firm's revenue

in a monopoly, $\sigma$ is the volatility rate of firm's revenue in a monopoly, and $\mu$ and $\sigma$ are constant over time. The parameter $f$ represents fixed costs for their productions.

After the potential competitor enters the market to produce a substitute, the pioneering firm and the potential competitor earn $\pi x_t - f$ in a duopoly. The parameter $\pi$ represents a ratio of revenue in a duopoly relative to revenue in a monopoly under a given value of $x_t$ and $0 < \pi < 1$. It implies that competition in a duopoly decreases the firm's revenue ratio from $1$ to $\pi$ under the same economic and industry conditions. In addition, the potential competitor earns $x_t - f$ as a monopolist after the pioneering firm leaves the market first in a downturn.

The pioneering firm needs investment costs $I$ to launch its product. The investment costs are raised with equity and debt financing. It is assumed that the debt security has no maturity and pays a constant coupon $b$ until the firm declares to default on a debt. If the firm defaults on the coupon payment, bondholders liquidate the firm's assets and receive the value of the unlevered firm net of liquidation costs. The liquidation costs are given by a ratio of the unlevered firm value, which is represented by $l$. The shareholders have their discretion to default on the coupon payment, and thus adopt a default policy that maximizes the value of the equity. The model also assumes that the pioneering firm is not allowed to restructure its capital structure after the investment.

The potential competitor also needs investment costs $I$ to begin its production. For the purpose of making the model tractable, the potential competitor is assumed to be an unlevered firm, so the investment costs are raised with equity financing. The firm's shareholders have their discretion to liquidate the firm's operation, and thus adopt a liquidation policy that maximizes the value of the equity.

The model assumes that all earnings are taxed. The rate of corporate tax are expressed as $g$. It also assumes that all investors are risk neutral. The rate of return on a risk-free asset is $r$, which is constant over time and $r > \mu$.

## 2.2 Valuation in the absence of a potential entry threat

### 2.2.1 Equity and debt values of a monopolist

This subsection considers equity and debt values of a firm after the investment to launch a new product under the assumption that the firm faces no entry threat by a potential competitor. This event occurs with a probability $1-p$. In this event, the firm permanently monopolizes the market until it abandons its operation. Therefore, the equity and debt values of the firm are derived by following Mauer and Sarkar (2005). The equity value in the absence of a potential competitor $S(x_t)$ is expressed as follows:

$$S(x_t)=\begin{cases}(1-g)\left(\frac{x_t}{r-\mu}-\frac{f}{r}-\frac{b}{r}\right)+\left(\frac{(1-g)(f+b)}{(1-\gamma)r}\right)\left(\frac{x_t}{\underline{x}(b)}\right)^{\gamma} & if\ x_t\geq \underline{x}(b)\\ 0 & if\ x_t<\underline{x}(b)\end{cases} \quad (2)$$

and

$$\gamma=\frac{1}{2}-\frac{\mu}{\sigma^2}-\sqrt{\left(\frac{1}{2}-\frac{\mu}{\sigma^2}\right)^2+\frac{2r}{\sigma^2}} \quad (3)$$

where $\underline{x}(b)$ represents a default threshold. When $x_t$ reaches $\underline{x}(b)$, the firm decides to default on coupon payment. Therefore, the equity value becomes $0$ at $\underline{x}(b)$. The default threshold derives from the value matching and smooth pasting conditions, which guarantee that the equity value becomes 0 at $\underline{x}(b)$ and the default policy maximizes $S(x_t)$. It is expressed as follows:

$$\underline{x}(b)=\frac{-\gamma(r-\mu)}{(1-\gamma)r}(f+b) \quad (4)$$

The debt value in the absence of a potential competitor $D(x_t)$ is expressed as follows:

$$D(x_t)=\begin{cases}\frac{b}{r}+\left((1-l)U(\underline{x}(b))-\frac{b}{r}\right)\left(\frac{x_t}{\underline{x}(b)}\right)^{\gamma} & if\ x_t\geq \underline{x}(b)\\ (1-l)U(x_t) & if\ x_t<\underline{x}(b)\end{cases} \quad (5)$$

The equation indicates that when the firm defaults on coupon payment $b$ at $\underline{x}(b)$, bondholders liquidate the firm' assets and receive the unlevered firm value net of bankruptcy costs $(1-l)U(\underline{x}(b))$. The unlevered firm value in the absence of a potential competitor $U(x_t)$ is expressed as follows:

$$U(x_t)=\begin{cases}(1-g)\left(\frac{x_t}{r-\mu}-\frac{f}{r}\right)+\left(\frac{(1-g)f}{(1-\gamma)r}\right)\left(\frac{x_t}{\underline{x}}\right)^{\gamma} & if\ x_t\geq \underline{x}\\ 0 & if\ x_t<\underline{x}\end{cases} \quad (6)$$

where $\underline{x}=\underline{x}(0)$. It represents a liquidation threshold for the unlevered firm. It also derives from the value matching and smooth pasting conditions, which guarantee that the unlevered firm value becomes 0 at $\underline{x}(0)$ and the liquidation policy maximizes $U(x_t)$.

## 2.3 Valuation in the presence of a potential entry threat

### 2.3.1 Values of equity, debt, and unlevered firm in a duopoly

By following Lambrecht (2001), this subsection derives equity and debt values of the pioneering firm and an unlevered firm value of the potential competitor in a duopoly. As Lambrecht (2001) demonstrates, the values of equity and debt in a duopoly depend on whether a firm leaves a market earlier or later than a competitor and the firm with higher coupon leaves a market first in default on its debt. Therefore, under the assumptions of the present model, the pioneering firm leaves the market first in default on coupon payment and the unlevered potential competitor stays the market as a monopolist.

Considering this outcome, the equity value of the pioneering firm $S_d(x_t)$ is expressed as follows:

$$S_d(x_t)=\begin{cases}(1-g)\left(\frac{\pi x_t}{r-\mu}-\frac{f}{r}-\frac{b}{r}\right)+\left(\frac{(1-g)(f+b)}{(1-\gamma)r}\right)\left(\frac{x_t}{\underline{x}_d(b)}\right)^{\gamma} & if\ x_t \geq \underline{x}_d(b)\\ 0 & if\ x_t < \underline{x}_d(b)\end{cases} \quad (7)$$

where $\underline{x}_d(b)$ represents a default threshold. When $x_t$ reaches $\underline{x}_d(b)$, the pioneering firm decides to default. Therefore, the equity value becomes $0$ at $\underline{x}_d(b)$. The default threshold derives from the value matching and smooth pasting conditions, which guarantee that the equity value becomes 0 at $\underline{x}_d(b)$ and the default policy maximizes $S_d(x_t)$. It is expressed as follows:

$$\underline{x}_d(b)=\frac{-\gamma(r-\mu)}{(1-\gamma)\pi r}(f+b) \quad (8)$$

The debt value of the pioneering firm $D_d(x_t)$ is expressed as follows:

$$D_d(x_t)=\begin{cases}\frac{b}{r}+\left((1-l)U_d(\underline{x}_d(b))-\frac{b}{r}\right)\left(\frac{x_t}{\underline{x}_d(b)}\right)^{\gamma} & if\ x_t \geq \underline{x}_d(b)\\ (1-l)U_d(x_t) & if\ x_t < \underline{x}_d(b)\end{cases} \quad (9)$$

The equation indicates that when the firm defaults on its coupon payment $b$ at $\underline{x}_d(b)$, bondholders liquidate the firm's assets and receive the unlevered firm value net of bankruptcy costs $(1-l)U_d(\underline{x}_d(b))$. The unlevered firm value in the duopoly $U_d(x_t)$ is expressed as follows:

$$U_d(x_t)=\begin{cases}(1-g)\left(\frac{\pi x_t}{r-\mu}-\frac{f}{r}\right)+\left(\frac{(1-g)f}{(1-\gamma)r}\right)\left(\frac{x_t}{\underline{x}_d}\right)^{\gamma} & if\ x_t \geq \underline{x}_d\\ 0 & if\ x_t < \underline{x}_d\end{cases} \quad (10)$$

where $\underline{x}_d=\underline{x}_d(0)$, which represents a liquidation threshold for the unlevered firm in a duopoly. It derives from the value matching and smooth pasting conditions, which guarantee that the unlevered firm value becomes 0 at $\underline{x}_d$ and the liquidation policy maximizes $U_d(x_t)$.

The value of the unlevered potential competitor is expressed as follows:

$$V_d(x_t)=\begin{cases}(1-g)\left(\frac{\pi x_t}{r-\mu}-\frac{f}{r}\right)\\ \quad +\left(U(\underline{x}_d(b))-(1-g)\left(\frac{\pi \underline{x}_d(b)}{r-\mu}-\frac{f}{r}\right)\right)\left(\frac{x_t}{\underline{x}_d(b)}\right)^{\gamma} & if\ x_t \geq \underline{x}_d(b)\\ U(x_t) & if\ x_t < \underline{x}_d(b)\end{cases} \quad (11)$$

This equation indicates that when $x_t$ reaches $\underline{x}_d(b)$, the pioneering firm leaves the market first in default on its coupon payment and the potential competitor becomes a monopolist. The unlevered firm value of a monopolist $U(x_t)$ is given by equation (6).

### 2.3.2 Market entry of a potential competitor

This subsection considers the investment decision for the potential competitor under the condition that a levered pioneering firm operates as a monopolist. The investment decision is characterized as exercising an option of the investment because the potential competitor has discretion to decide when to enter the market. The model needs to consider two situations in which the potential competitor is induced to enter the market in order to derive the investment decision and the value of the investment. One situation is the same as the previous studies of strategic real options. The potential competitor enters the market when the market develops large enough to make profits in a duopoly. The other situation emerges when the pioneering firm is highly levered. High leverage expedites default of the pioneering firm in a duopoly. The potential competitor is induced to enter the market and take over a monopoly position in a downturn if the market entry can immediately force the high levered pioneer to go bankrupt. Considering these two situations, the investment decision and the value of the investment option depend on an amount of coupon payment of the pioneering firm. The value of the investment option is expressed as follows:

$$C(x_t) = \begin{cases} L_1 x_t^{\beta} + L_2 x_t^{\gamma} & if\ b \le \bar{b} \\ L_3 x_t^{\beta} + L_4 x_t^{\gamma} & if\ b > \bar{b} \end{cases} \tag{12}$$

and

$$\beta = \frac{1}{2} - \frac{\mu}{\sigma^2} + \sqrt{\left(\frac{1}{2} - \frac{\mu}{\sigma^2}\right)^2 + \frac{2r}{\sigma^2}} \tag{13}$$

where $\bar{b}$ represents a level of coupon payment above which the potential competitor is induced to force the pioneering firm to go bankrupt in a downturn and becomes a monopolist.

The constants $L_1$ and $L_2$ are obtained by the following two value matching conditions:

$$L_1(x_e(b))^{\beta} + L_2(x_e(b))^{\gamma} = V_d(x_e(b)) - hI \tag{14}$$

and

$$L_1(\underline{x}_m^*(b))^{\beta} + L_2(\underline{x}_m^*(b))^{\gamma} = 0 \tag{15}$$

The first condition indicates that the value of the investment option on the left-hand side becomes the net present value of the investment in a duopoly $V_d(x_e(b)) - hI$ at the

investment threshold $x_e(b)$. This is because the potential competitor enters the market when $x_t$ reaches $x_e(b)$. This investment threshold is obtained as a solution that satisfies the following smooth pasting condition under a given coupon payment $b$:

$$\frac{\partial C(x_t)}{\partial x_t}\Big|_{x_t=x_e(b)} = \frac{\partial V_d(x_t)}{\partial x_t}\Big|_{x_t=x_e(b)} \tag{16}$$

This condition guarantees that it is the optimal investment decision that maximizes the value of the investment option for the potential competitor to enter the market when $x_t$ reaches $x_e(b)$. The second condition indicates that the option becomes worthless at $\underline{x}_m^*(b)$ where the pioneering firm decides to go bankrupt in a monopoly. This default threshold $\underline{x}_m^*(b)$ is characterized as a solution of a maximization problem regarding the equity value of the pioneering firm in a monopoly, which is demonstrated later. The constants $L_1$ and $L_2$ are expressed as follows:

$$L_1 = \frac{(V_d(x_e(b)) - hI)(\underline{x}_m^*(b))^{\gamma}}{(x_e(b))^{\beta}(\underline{x}_m^*(b))^{\gamma} - (x_e(b))^{\gamma}(\underline{x}_m^*(b))^{\beta}} \tag{17}$$

and

$$L_2 = \frac{-(V_d(x_e(b)) - hI)(\underline{x}_m^*(b))^{\beta}}{(x_e(b))^{\beta}(\underline{x}_m^*(b))^{\gamma} - (x_e(b))^{\gamma}(\underline{x}_m^*(b))^{\beta}} \tag{18}$$

The constants $L_3$ and $L_4$ are also obtained by the following two value matching conditions:

$$L_3(x_e(b))^{\beta} + L_4(x_e(b))^{\gamma} = V_d(x_e(b)) - hI \tag{19}$$

and

$$L_3(\underline{x}_d(b))^{\beta} + L_4(\underline{x}_d(b))^{\gamma} = U(\underline{x}_d(b)) - hI \tag{20}$$

The first condition is identical to the previous value-matching condition in Equation (14). The second condition indicates that the value of the investment option becomes net present value of the investment in a monopoly at $\underline{x}_d(b)$ where the pioneering firm decides to go bankrupt in a duopoly. It implies that if the potential competitor enters the market at $\underline{x}_d(b)$, the pioneering firm is immediately forced to go bankrupt in a duopoly and thus the potential competitor becomes a monopolist. The constants $L_3$ and $L_4$ are expressed as follows:

$$L_3 = \frac{(V_d(x_e(b)) - hI)(\underline{x}_d(b))^{\gamma} - (U(\underline{x}_d(b)) - hI)(x_e(b))^{\beta}}{(x_e(b))^{\beta}(\underline{x}_d(b))^{\gamma} - (x_e(b))^{\gamma}(\underline{x}_d(b))^{\beta}} \tag{21}$$

and

$$L_4 = \frac{-(V_d(x_e(b)) - hI)(\underline{x}_d(b))^{\beta} + (U(\underline{x}_d(b)) - hI)(x_e(b))^{\gamma}}{(x_e(b))^{\beta}(\underline{x}_d(b))^{\gamma} - (x_e(b))^{\gamma}(\underline{x}_d(b))^{\beta}} \tag{22}$$

The debt coupon $\bar{b}$ must satisfy the following condition:

$$L_1(\underline{x}_d(\bar{b}))^{\beta} + L_2(\underline{x}_d(\bar{b}))^{\gamma} = U(\underline{x}_d(\bar{b})) - I \quad (23)$$

The left-hand side of this condition represents the value of the investment option at $\underline{x}_d(\bar{b})$ under the assumption that the potential competitor forgoes to force the pioneering firm to go bankrupt in a duopoly by entering the market at $\underline{x}_d(\bar{b})$ in a downturn . The right-hand side represents net present value of a monopoly that the potential competitor receives by entering the market at $\underline{x}_d(\bar{b})$. This condition implies that if the pioneering firm limits its coupon payment below $\bar{b}$ , the potential competitor has no incentive to force the pioneering firm to go bankrupt at $\underline{x}_d(\bar{b})$ by entering the market in a market downturn.

### 2.3.3 Values of equity and debt in a monopoly

This subsection demonstrates the values of equity and debt for the pioneering firm in a monopoly. The value of the equity in a monopoly $S_m(x_t)$ is expressed as follows:

$$S_m(x_t) = \begin{cases} S_d(x_t) & if\ x_t > x_e(b) \\ (1-g)\left(\frac{x_t}{r-\mu} - \frac{f}{r} - \frac{b}{r}\right) + M_1 x_t^{\beta} + M_2 x_t^{\gamma} & if\ \underline{x}_m(b) \le x_t \le x_e(b) \\ 0 & if\ x_t < \underline{x}_m(b) \end{cases} \quad (24)$$

where $\underline{x}_m(b)$ represents the default threshold where the pioneering firm decides to go bankrupt and it is expressed as follows:

$$\underline{x}_m(b) = \begin{cases} \underline{x}_m^*(b) & if\ b \le \bar{b} \\ \underline{x}_d(b) & if\ b > \bar{b} \end{cases} \quad (25)$$

where $\underline{x}_m^*(b)$ represents the optimal default threshold that maximizes the value of the equity in a monopoly. If $b \le \bar{b}$ , the potential competitor has no incentive to force the pioneering firm to go bankrupt by entering the market in a downturn. Therefore, the pioneering firm's shareholders choose the optimal default policy. Otherwise, the potential competitor is induced to enter the market at $\underline{x}_d(b)$ and thus the pioneering firm is immediately forced to go bankrupt in a duopoly. Equation (24) indicates that the value of the equity in a monopoly becomes $0$ when $x_t$ reaches $\underline{x}_m(b)$ because the pioneering firm goes bankrupt in default on its debt. Equation (24) also indicates that the value of the equity in a monopoly becomes the value in a duopoly $S_d(x_t)$ when the potential competitor enters the market at $x_e(b)$.

The constants $M_1$ and $M_2$ in Equation (24) are obtained by the value matching conditions that assure the value of the equity to become $S_d(x_e(b))$ at $x_e(b)$ and $0$ at $\underline{x}_m(b)$. They are expressed as follows:

$$M_1 = \frac{\theta(\underline{x}_m(b))^\gamma}{(x_e(b))^\beta(\underline{x}_m(b))^\gamma - (x_e(b))^\gamma(\underline{x}_m(b))^\beta}, \quad (26)$$

$$M_2 = \frac{-\theta(\underline{x}_m(b))^\beta}{(x_e(b))^\beta(\underline{x}_m(b))^\gamma - (x_e(b))^\gamma(\underline{x}_m(b))^\beta}, \quad (27)$$

and

$$\theta = S_d(x_e(b)) - (1-g)\left(\frac{x_e(b)}{r-\mu} - \frac{f}{r} - \frac{b}{r}\right) \quad (28)$$

The value of the debt in a monopoly $D_m(x_t)$ is expressed as follows:

$$D_m(x_t) = \begin{cases} D_d(x_t) & if\ x_t > x_e(b) \\ \frac{b}{r} + N_1 x_t^\beta + N_2 x_t^\gamma & if\ \underline{x}_m(b) \le x_t \le x_e(b) \\ (1-l)U_m(x_t) & if\ x_t < \underline{x}_m(b) \end{cases} \quad (29)$$

Equation (29) indicates that the value of the debt in a monopoly becomes the value in a duopoly when $x_t$ reaches $x_e(b)$ where the potential competitor enter the market. It also indicates that bondholders receive the value of the unlevered firm net of bankruptcy costs when $x_t$ reaches $\underline{x}_m(b)$ where the pioneering firm goes bankrupt in default on its debt. The unlevered firm value $U_m(x_t)$ is expressed as follows:

$$U_m(x_t) = \begin{cases} U(x_t) & if\ b \le \bar{b} \\ U_d(x_t) & if\ b > \bar{b} \end{cases} \quad (30)$$

As explained before, if $b \le \bar{b}$, the potential competitor has no incentive to force the pioneering firm to go bankrupt by entering the market in a downturn. Therefore, the pioneering firm goes bankrupt as a monopolist at $\underline{x}_m^*(b)$ and thus its bondholders receive the unlevered firm value in a monopoly net of bankruptcy costs $(1-l)U(\underline{x}_m^*(b))$. Otherwise, the potential competitor is induced to force the pioneering firm to go bankrupt at $\underline{x}_d(b)$ by entering the market in a downturn. The market becomes a duopoly and thus the bondholders receive the unlevered firm value in a duopoly net of bankruptcy costs $(1-l)U_d(\underline{x}_d(b))$.

The constants $N_1$ and $N_2$ in Equation (29) are obtained by the value matching conditions that assure the value of the debt in a monopoly to become the debt value in a duopoly

$D_d(x_e(b))$ at $x_e(b)$ and the unlevered firm value $(1-l)U_m(\underline{x}_m(b))$ at $\underline{x}_m(b)$. They are expressed as follows:

$$N_1 = \frac{\kappa(\underline{x}_m(b))^\gamma - \lambda(x_e(b))^\beta}{(x_e(b))^\beta(\underline{x}_m(b))^\gamma - (x_e(b))^\gamma(\underline{x}_m(b))^\beta}, \quad (31)$$

$$N_2 = \frac{-\kappa(\underline{x}_m(b))^\beta + \lambda(x_e(b))^\gamma}{(x_e(b))^\beta(\underline{x}_m(b))^\gamma - (x_e(b))^\gamma(\underline{x}_m(b))^\beta}, \quad (32)$$

$$\kappa = D_d(x_e(b)) - \frac{b}{r}, \quad (33)$$

and

$$\lambda = (1-l)U_m(\underline{x}_m(b)) - \frac{b}{r} \quad (34)$$

## 2.4 Investment and financing decisions for a pioneering firm

This subsection considers the investment and financing decisions for the pioneering firm to begin its production in the presence of a potential entry threat. By following Mauer and Sarkar (2005), the investment and financing decisions are derived from a maximization problem regarding the value of the investment option. The maximization problem is formulated from two different perspectives in order to quantify agency costs of debt. One perspective is to consider first best investment and financing decisions that maximize total firm value. The other is to consider managerial investment and financing decisions that maximizes equity value.

### 2.4.1 First best decisions and total firm value maximization

First best investment and financing decisions are characterized as a set of an investment threshold and a coupon payment that maximizes the value of the investment option $W_F(x_t)$, which is expressed as follows:

$$W_F(x_t) = \left(S^p(x_F(b)) + D^p(x_F(b)) - I\right)\left(\frac{x_t}{x_F(b)}\right)^\beta \text{ for } x_t < x_F(b) \quad (35)$$

where $x_F(b)$ represents the first best investment threshold that maximizes $W_F(x_t)$ for a given coupon payment $b$. It implies that the firm that aims to maximize total firm value invests when $x_t$ reaches $x_F(b)$. For a given coupon payment $b$, this threshold must satisfy the following smooth pasting condition:

$$\frac{\partial W_F(x_t)}{\partial x_t}\Big|_{x_t = x_F(b)} = \frac{\partial S^p(x_t) + D^p(x_t)}{\partial x_t}\Big|_{x_t = x_F(b)} \quad (36)$$

This condition guarantees that the investment decision maximizes the value of the investment option from perspective of total firm value maximization for a given coupon payment $b$.

The functions $S^p(x_t)$ and $D^p(x_t)$ represent expected values of equity and debt under the condition that a potential competitor enter the market in the future with probability $p$. They are expressed as follows.

$$S^p(x_t) = pS_m(x_t) + (1-p)S(x_t) \tag{37}$$

and

$$D^p(x_t) = pD_m(x_t) + (1-p)D(x_t) \tag{38}$$

Therefore, the sum of $S^p(x_t)$ and $D^p(x_t)$ becomes total firm value of the pioneering firm.

### 2.4.2 Managerial decisions and equity value maximization

Managerial investment and financing decisions are characterized as a set of an investment threshold and a coupon payment that maximizes the value of the investment option $W_S(x_t)$, which is expressed as follows:

$$W_S(x_t) = \left(S^p(x_S(b)) - (I-K)\right)\left(\frac{x_t}{x_S(b)}\right)^{\beta} \text{ for } x_t < x_S(b) \tag{39}$$

where $x_S(b)$ represents the managerial investment threshold that maximizes $W_S(x_t)$ for a given coupon payment $b$. It implies that the firm that aims to maximize equity value invests when $x_t$ reaches $x_S(b)$. For any given coupon payment $b$, this threshold must satisfy the following smooth pasting condition:

$$\frac{\partial W_S(x_t)}{\partial x_t}\Big|_{x_t = x_S(b)} = \frac{\partial S^p(x_t)}{\partial x_t}\Big|_{x_t = x_S(b)} \tag{40}$$

This condition guarantees that the investment decision maximizes the value of the investment option from perspective of equity value maximization for a given coupon payment $b$. The variable $K$ represents the capital raised by debt financing when the pioneering firm begins its production at $x_S(b)$. As the debt is fairly valued in an efficient market, the raised debt capital $K$ at $x_S(b)$ is equal to $D^p(x_S(b))$ for any given coupon payment $b$.

## 3 Numerical Results

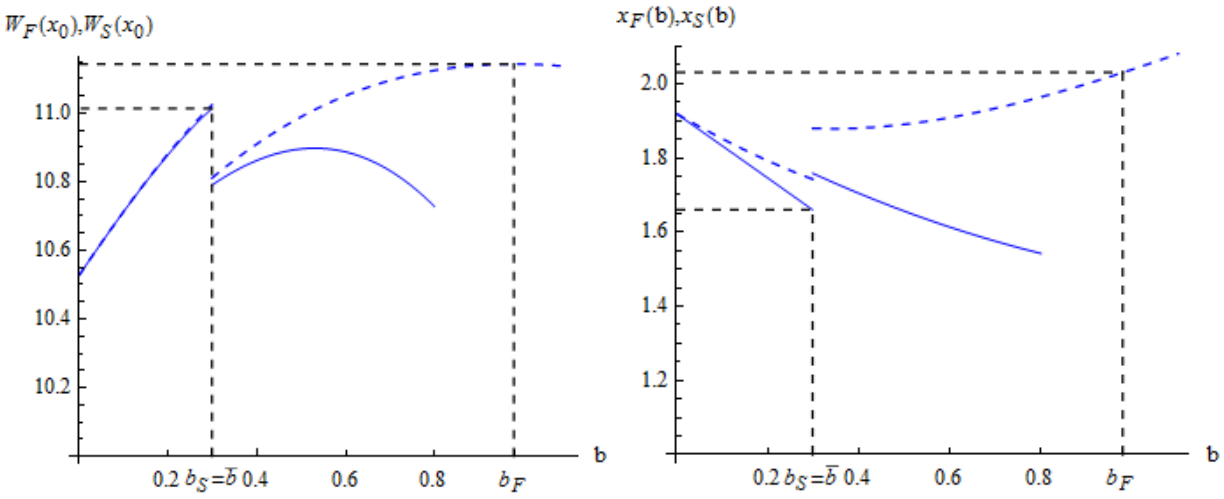
This section provides numerical results of the maximization problem on the value of investment option and demonstrates the impact of a potential entry threat on investment and financing decisions for the pioneering firm and agency costs of debt. Basic numerical values of model parameters are given as follows: $x_0 = 1$, $\mu = 0.03$, $\sigma = 0.25$, $f = 0.75$, $g = 0.3$, $I = 5$, $l = 0.35$, $r = 0.05$, $\pi = 0.5$, and $p = 1$. Except for the parameter $\pi$ and $p$,

they are obtained from Mauer and Sarkar (2005) in order to compare investment and financing decisions and agency costs of debt in the absence of a potential entry threat and those in the presence.

## 3.1 Market entry, debt financing, and agency costs of debt

With basic numerical values of model parameters, Figure 1 displays the values of the investment option as a function of coupon payment $b$ in the left figure and the investment thresholds in the right figure. In the left figure, the dotted curve demonstrates the value of the investment option that derives from the total firm value maximization problem under a given coupon payment. The solid curve demonstrates the value of the investment option that derives from the equity value maximization problem under a given coupon payment.

**Figure 1: Values of Investment option and Investment thresholds**




*Numerical values of model parameters are given as follows:* $x_0 = 1$, $\mu = 0.03$, $\sigma = 0.25$, $f = 0.75$, $g = 0.3$, $I = 5$, $l = 0.35$, $r = 0.05$, $\pi = 0.5$, *and* $p = 1$.

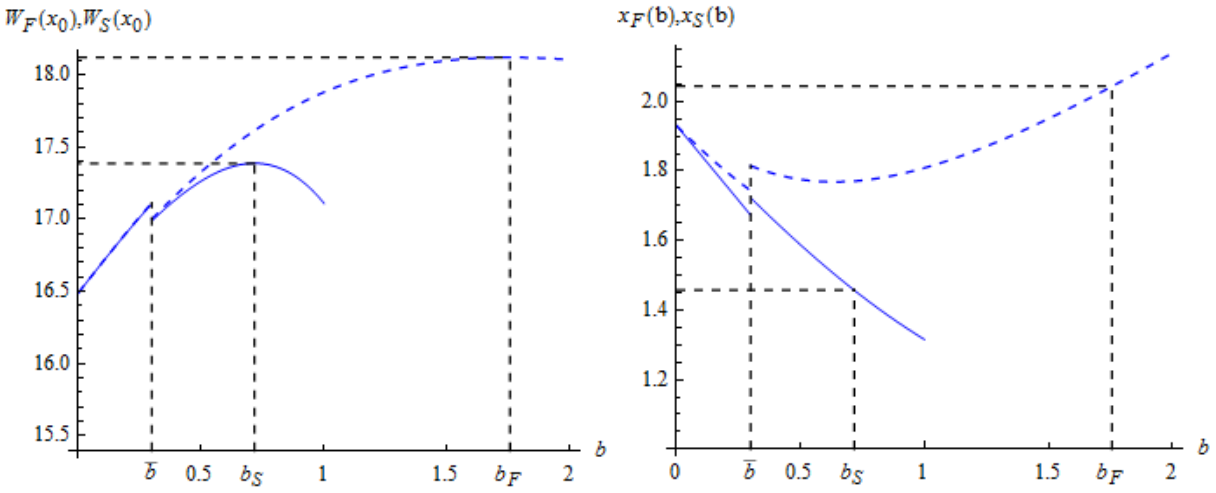
The left figure demonstrates that these values of the investment option take a highest value at $b_F$ and $b_S$, respectively. The coupon payments $b_F$ and $b_S$ represent the first best coupon payment that maximizes $W_F(x_0)$ in Equation (35) and the coupon payment that maximizes $W_S(x_0)$ in Equation (39) as a managerial choice of debt financing. The difference between two vertical lines indicates the magnitude of agency costs of debt. The agency costs arise from the consequence of managerial investment and financing decisions undertaken from perspective of equity value maximization rather than total firm value maximization.

The figure also demonstrates that both solid and dotted curves are shifted downward at $\bar{b}$. The downward shift derives from the fact that the potential competitor enters the market in a downturn and thus the pioneering firm is forced to go bankrupt if $b \geq \bar{b}$. It indicates that high leverage above $\bar{b}$ creates the possibility of forced bankruptcy and puts additional bankruptcy costs on the firm. As the figure shows, for the basic numerical values of model parameters, the pioneering firm is not exposed to the risk of the forced bankruptcy under managerial investment and financing decisions but under first best investment and financing decisions.

In the right figure, the dotted curve demonstrates the first best investment threshold $x_F(b)$ that maximizes the value of the investment option from perspective of total firm value. It derives from the smooth pasting condition in Equation (36) for the first best coupon payment $b_F$. The solid curve demonstrates the investment threshold $x_S(b)$ that maximizes the value of the investment option from perspective of equity value. The investment threshold $x_S(b_S)$ represents the optimal investment threshold for the manager of the pioneering firm. It derives from the smooth pasting condition in Equation (40) for the coupon payment $b_S$. The figure demonstrates that the managerial investment threshold $x_S(b_S)$ is lower than the first best investment threshold $x_F(b_F)$. It indicates an over-investment problem that the manager pursuing shareholders' interest expedites its investment decision. In addition, the figure demonstrates that both solid and dotted curves are shifted upward at $\bar{b}$. This is because when the coupon payment exceeds $\bar{b}$, the potential competitor has an incentive to enter the market in a downturn and thus the manager of the pioneering firm delays its investment decision to mitigate the possibility of facing forced bankruptcy.

Figure 2 also displays the values of the investment option as a function of coupon payment $b$ in the left figure and the investment thresholds in the right figure. The numerical value of the model parameter regarding the probability of potential competitor's emergence changes from $p = 1$ to $p = 0.5$ in the figure. Other numerical values of the model parameters are the same as those in Figure 1.

**Figure 2: Values of Investment option and Investment thresholds**




*Numerical values of model parameters are given as follows:* $x_0 = 1$, $\mu = 0.03$, $\sigma = 0.25$, $f = 0.75$, $g = 0.3$, $I = 5$, $l = 0.35$, $r = 0.05$, $\pi = 0.5$, *and* $p = 0.5$.

Comparison with Figures 1 and 2 demonstrates the impact of a potential entry threat on investment and financing decisions for the pioneering firm. In Figure 2, the coupon payments $b_F$ and $b_S$ increase and $b_S$ also exceeds $\bar{b}$ because the possibility that a potential competitor enters the market in the future decreases. This result derives from the fact that the risk of forced bankruptcy in a downturn decreases and the pioneering firm is allowed to increase debt financing that provides the value of an additional tax shield of debt. In addition, the right figure indicates that when the risk of the forced bankruptcy decreases, the investment threshold $x_S(b_S)$ decreases by larger extent than the first best investment decision $x_F(b_F)$. This means that the manager aiming to maximize shareholders' value significantly expedites its investment decision when potential entry threats recede. This is because the conflict between shareholders and bondholders over the investment decision deteriorates as the manager increases debt financing under a distant potential entry threat. As a result, the agency costs of debt in Figure 2 are larger than that in Figure 1.

Table 1 provides numerical results regarding the first best and managerial investment and financing decisions. In the table, the probability of potential competitor's emergence $p$ takes $1$, $0.5$, and $0$. Potential entry threats recede when the probability decreases. The pioneering firm undertakes the investment as a monopolist in the absence of a potential entry threat if $p = 0$. Table 1 displays the first best and managerial investment thresholds and coupon payments, and the coupon payment above which a potential competitor is induced to enter the market in a downturn. The table demonstrates that when the potential entry threat recedes, the manager expedites the investment decision

and increases coupon payment. This result is consistent with the result of comparison with Figures 1 and 2. It also demonstrates the over-investment problem that the manager aiming to maximize equity value expedites its investment decision relative to the first best decision in both presence and absence of the potential entry threat. This result means that the over-investment problem in a monopoly that demonstrated by Mauer and Sarkar (2005) still exists under a potential entry threat.

**Table 1: Impact of potential entry threats on investment and financing decisions**

| Probability of competitor's emergence | Investment threshold | | Coupon payment | | | Bankruptcy threshold | |
|---|---|---|---|---|---|---|---|
| | $x_F(b_F)$ | $x_S(b_S)$ | $b_F$ | $b_S$ | $\bar{b}$ | $\underline{x}_m(b_F)$ | $\underline{x}_m(b_S)$ |
| $p=1$ | 2.03 | 1.66 | 0.98 | 0.30 | 0.30 | 0.77 | 0.32 |
| $p=0.5$ | 2.04 | 1.46 | 1.76 | 0.72 | 0.30 | 1.11/0.56 | 0.65/0.33 |
| $p=0$ | 1.86 | 1.20 | 2.92 | 0.85 | - | 0.81 | 0.35 |

*Numerical values of model parameters are given as follows:* $x_0=1$, $\mu=0.03$, $\sigma=0.25$, $f=0.75$, $g=0.3$, $I=5$, $l=0.35$, $r=0.05$, *and* $\pi=0.5$.

Table 2 displays the values of the investment option, agency costs of debt, and leverage ratio. They are calculated by using numerical results of the maximization problems. Table 2 demonstrates that the values of the investment option decrease when the probability of potential competitor's emergence increases. This is because revenue of the pioneering firm decreases in the future when the competitor enters the market. It also demonstrates that agency costs and leverage ratio decrease when the probability of potential competitor's emergence increases. As shown by Table 1, the manager decreases coupon payments and expedites its investment decision to mitigate possibility of forced bankruptcy in a downturn when the probability of potential competitor's emergence increases. As a result, leverage ratio decreases when $p$ increases. When coupon payments decrease, agency conflicts between shareholders and bondholders over investment decisions are mitigated. Therefore, the agency costs of debt decrease when $p$ increases. The results indicate that potential entry threats work to hinder firms from debt financing and have the potential for mitigating agency conflicts between shareholders and debtholders over corporate policies.

**Table 2: Impact of potential entry threats on agency costs of debt and leverage ratio**

| Probability of competitor's emergence | Option values | | Agency costs (%) | Leverage ratio (%) | |
|---|---|---|---|---|---|
| | $W_F(x_0)$ | $W_S(x_0)$ | $\frac{W^F(x_0)-W^S(x_0)}{W^S(x_0)}$ | $\frac{D^p(x_F)}{S^p(x_F)+D^p(x_F)}$ | $\frac{D^p(x_S)}{S^p(x_S)+D^p(x_S)}$ |
| $p=1$ | 11.14 | 11.01 | 1.18 | 44.76 | 19.89 |
| $p=0.5$ | 18.11 | 17.39 | 4.21 | 50.77 | 33.38 |
| $p=0$ | 26.47 | 24.19 | 9.41 | 65.62 | 38.94 |

*Numerical values of model parameters are given as follows:* $x_0=1$, $\mu=0.03$, $\sigma=0.25$, $f=0.75$, $g=0.3$, $I=5$, $l=0.35$, $r=0.05$, *and* $\pi=0.5$.

## 4 Conclusions

This study examines an investment decision and financial leverage choice of a pioneering firm under a circumstance where the firm is exposed to a potential entry threat after a new product is launched. It demonstrates that financial leverage creates the over-investment problem that the manager pursing equity value maximization expedites its investment decision relative to the first best decision. This result is consistent with the result demonstrated by Mauer and Sarkar (2005) in the absence of potential entry threats. It also extends their work by examining the impact of a potential entry threat on managerial investment and financing decisions and agency costs of debt. It demonstrates that agency costs of debt decrease when the probability of potential competitor's emergence increases. This is because a potential competitor expedites its market entry when the pioneering firm increases financial leverage in the presence of the potential entry threat. In addition, high leverage creates the potential for inducing the competitor to enter the market in a downturn and exposing the pioneering firm to a risk of forced bankruptcy. Therefore, the potential entry threat hinders the pioneering firm from debt financing, and thus mitigate the agency conflicts between shareholders and debtholders over corporate investment decisions.

This study abstracts preemptive competition for market entry and debt financing of a potential competitor from the analysis for the purpose of examining the impact of a potential entry threat on the magnitude of agency costs of debt in a tractable model. Lambrecht (2001) and Zhdanov (2008) consider these factors in their models and examine characteristics on equilibrium investment patterns and optimal capital structure of two competitive firms in a duopoly. It will be a promising avenue for a future research to explore interrelations between these factors and the magnitude of agency costs.

## References

Bayer, C. (2007). Investment Timing and Predatory Behavior in a Duopoly with Endogenous Exit. *Journal of Economic Dynamics and Control*. 31, pp. 3069-3109.

Carlson, M., Dockner, E. J., Fisher, A., and Giammarino, R. (2014). Leaders, Followers, and Risk Dynamics in Industry Equilibrium. *Journal of Financial and Quantitative Analysis*. 49, pp. 321-349.

Childs, P. D., Mauer, D. C., and Ott, S. H. (2005). Interactions of Corporate Financing and Investment Decisions: The Effects of Agency Conflicts. *Journal of Financial Economics*. 76, pp. 667-690.

Dixit, A. K., and Pindyck, R. S. (1994). *Investment under Uncertainty*. Princeton, NJ: Princeton University Press.

Grenadier, S. R. (2000). Option Exercise Games: the Intersection of Real Options and Game Theory. *Journal of Applied Corporate Finance*. 13, pp. 99-107.

Harris, M., and Raviv, A. (1991). The Theory of Capital Structure. *Journal of Finance*. 46, pp. 297-355.

Hirth, S., and Uhrig-Homburg, M. (2010). Investment Timing, Liquidity, and Agency Costs of Debt. Journal of Corporate Finance. 16, pp. 243-258.

Jensen, M., and Meckling, W. (1976). Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure. *Journal of Financial Economics*. 4, pp. 305-360.

Joaquin, D. C., and Butler, K. C. (2000). Competitive Investment Decisions: A Synthesis. In: M. J. Brennan, and L. Trigeorgis eds., *Project Flexibility, Agency, and Competition*, 1 st ed. New York, NY: Oxford University Press., pp. 324-339.

Joaquin, D. C., and Khanna, N. (2001). Investment Timing Decisions under Threat of Potential Competition: Why Firm Size Matters. *Quarterly Review of Economics and Finance*. 41, pp. 1-17.

Kulatilaka, N., and Perotti, E. C. (1998). Strategic Growth Options. *Management Science*. 44, pp. 1021-1031.

Lambrecht, B. (2001). The Impact of Debt Financing on Entry and Exit in a Duopoly. *Review of Financial Studies*. 14, pp. 765-804.

Lambrecht, B., and Perraudin, W. (2003). Real Options and Preemption under Incomplete Information. *Journal of Economic Dynamics and Control*. 27, pp. 619-643.

Leland, H. E. (1994). Corporate Debt Value, Bond Covenants, and Optimal Capital Structure. *Journal of Finance*. 49, pp. 1213-1252.

Leland, H. E. (1998). Agency Costs, Risk Management, and Capital Structure. *Journal of Finance*. 53, pp. 1213-1243.

Mauer, D. C., and Ott, S. H. (2000). Agency Costs, Underinvestment, and Optimal Capital Structure: The Effect of Growth Options to Expand. In: M. J. Brennan, and L. Trigeorgis eds., *Project Flexibility, Agency, and Competition*, 1 st ed. New York, NY: Oxford University Press., pp. 151-179.

Mauer, D. C., and Sarkar, S. (2005). Real Options, Agency Conflicts, and Optimal Capital Structure. *Journal of Banking and Finance*. 29, pp. 1405-1428.

Mello, A. S., and Parsons, J. E. (1992). Measuring the Agency Costs of Debt. *Journal of Finance*. 47, pp. 1887-1904.

Myers, S. C. (1977). Determinants of Corporate Borrowing. *Journal of Financial Economics*. 5, pp. 147-175.

Nielsen, M. J. (2002). Competition and Irreversible Investments. *International Journal of Industrial Organization*. 20, pp. 731-743.

Pawlina, G., and Kort, P. M. (2006). Real Options in an Asymmetric Duopoly: Who Benefits from Your Competitive Disadvantage? *Journal of Economics and Management Strategy*. 15, pp. 1-35.

Pennings, E. (2004). Optimal Pricing and Quality Choice When Investment in Quality is Irreversible. *Journal of Industrial Economics*. 52, pp. 569-589.

Sarkar, S. (2011). Optimal Expansion Financing and Prior Financial Structure. International Review of Finance. 11, pp. 57-86.

Shackleton, M. B., Tsekrekos, A. E., and Wojakowski, R. (2004). Strategic Entry and Market Leadership in a Two-player Real Options Game. *Journal of Banking and Finance*. 28, pp. 179-201.

Sundaresan, S., Wang, N., and Yang, J. (2015). Dynamic Investment, Capital Structure, and Debt Overhang. *Review of Corporate Finance Studies*. 4, pp. 1-42.

Weeds, H. (2002). Strategic Delay in a Real Options Model of R&D Competition. *Review of Economic Studies*. 69, pp. 729-747.

Titman, S., and Tsyplakov, S. (2007). A Dynamic Model of Optimal Capital Structure. *Review of Finance*. 11, pp. 401-451.

Zhdanov, A. (2008). Optimal Capital Structure in a Duopoly. Available at SSRN: https://ssrn.com/abstract=862564 or http://dx.doi.org/10.2139/ssrn.862564.