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# Preemption, leverage, and financing constraints

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ABSTRACT

This paper investigates the interactions between preemptive competition and leverage in a duopoly market. We investigate both a case in which the firms have optimal financial structures, and a case in which financing constraints require firms to finance their investments by debt. Our findings are that the second mover always leaves the duopoly market before the leader, although the leader may exit before the follower's entry. The leverage effects of debt financing can increase the value of a firm and accelerate investment, even in the presence of preemptive competition. Notably, financing constraints can delay preemptive investment and improve firm values in preemptive equilibrium. Indeed, the leader's high leverage due to financing constraints can lower the first-mover advantage and weaken preemptive competition. Especially with strong first-mover advantage, the financing constraint effects can dominate the leverage effects. These findings are almost consistent with the empirical evidence, which shows that high leverage leads to competitive disadvantage and mitigates product market competition.



## 1. Introduction

Since the seminal paper of Brander and Lewis (1986), a number of papers have investigated the interactions between financial structure and product market competition. Although these papers have developed a variety of static models (e.g., Faure-Grimaud, 2000; Fulghieri & Nagarajan, 1996; Povel & Raith, 2004), few models capture the dynamic interactions of financial structure with preemptive entry into a market. This paper develops a dynamic model to describe these interactions.

Our model builds on the literature covering real option game models, such as Grenadier (1996), Huisman (2001), and Pawlina and Kort (2006). We consider two symmetric firms that compete for first-mover advantage in a new market. The entry into the market is accompanied by irreversible capital expenditures. Firms can enter the market at an arbitrary time and access debt financing upon market entry. Suppose that one of the firms, denoted as the "leader", enters the market earlier than the other, denoted as the "follower". The leader can collect monopoly rents before the follower's entry, but it cannot optimally delay market entry. On the other hand, the follower loses monopoly rents, but it maintains the option to enter the market at the optimal time. Considering the trade-off, in equilibrium the leader enters the market with timing at which the first-mover advantage is offset by the follower's option value.

A main difference from the previous studies on real option games is that our model allows firms to use debt financing. By this, we examine the interactions between a firm's leverage and preemptive entry. For instance, in the airline and retailing industries, the leverage is much higher than the average over all industries, and preemptive competition is severe (e.g., Fulghieri & Nagarajan, 1996; Harris & Raviv, 1991). Our model with leverage will better fit these industries than will previous models that do not account for the use of leverage.

Our analysis of the model yielded several key results. First, we find that the last in, first out (LIFO) scenario holds in a duopoly. This is mainly because the leader's entry trigger is much lower than the follower's entry trigger, which makes the leader's debt issuance much lower than the follower's debt issuance. Although the leader with lower leverage can survive longer, the leader forgoes higher interest tax shields. Our result is consistent with MacKay and Phillips (2005), who empirically show that leverage of new entrants is likely to be higher than that of incumbents. The LIFO scenario is also consistent with empirical findings that high debt tends to lead to disadvantage in product market competition (e.g., Chevalier, 1995a, 1995b; Phillips, 1995).

Second, we show that the leverage effects remain unchanged even if one takes account of preemptive competition. Indeed, compared to the unlevered case, the entry triggers (firm values) become lower (higher) in preemptive competition with optimal capital structure. The leverage

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effects have been shown in the investment timing models of Hennessy (2004), Mauer and Sarkar (2005), and Sundaresan and Wang (2007b), but they focus on a monopoly. We ensure the robustness of the leverage effects even in the presence of preemptive competition.

In addition to analyzing firms with optimal capital structure, we consider financially constrained firms in which investment costs must be financed by debt issuance. This case approximates firms that have no cash reserves and cannot use external equity financing due to the high costs. Notably, we show that financing constraints can delay preemptive investment and improve firm values in equilibrium. The intuition is as follows. The financing constraints cause the leader to be highly leveraged, while increasing the value of the follower's option to wait for the leader's exit. Thus, the constraints reduce firms' incentive to move first, alleviating preemptive condition.

The financing constraint effects can happen with a modest level of first-mover advantage and greatly increase with strengthening of the first-mover advantage. When the financing constraint effects dominate the leverage effects, the preemptive entry trigger can be later than that of the unlevered case. Although the financing constraint effects in preemptive competition have yet to be tested rigorously, there are several findings related to the predictions. For instance, empirical evidence indicates that higher leverage can soften product market competition (e.g., Chevalier, 1995a, 1995b; Phillips, 1995). In our paper, higher leverage, which is caused by the financing constraints, delays preemptive entry timing and increases firm values.

Our paper is most closely related to the following papers. Lambrecht (2001) studies the entry and exit decisions of levered firms in a duopoly. The paper exogenously assumes an incumbent with debt and examines the follower's entry and financing decision. Our paper complements this previous research by extending his model to a new market model in which two firms compete for first-mover advantage. Zhdanov (2008), like our paper, examines a preemptive competition model with leverage. His model assumes that the leader survives as an all-equity firm after its default, while, as in Lambrecht (2001), we simply assume that the leader exits the market. Because of this simplification, our model is more tractable and easier to analyze.[2] We reveal the effects of first-mover advantage and financing constraints, which are not examined in Zhdanov (2008). Nishihara and Shibata (2010) also study preemption with leverage, but the previous paper assumes that the follower cannot enter the market until the leader exits it. Because of the polar assumption, the applicability of the model is restricted to situations involving extremely strong first-mover advantage. In this paper, we relax this assumption and show how the degree of first-mover advantage influences the results.

The remainder of this paper is organized as follows. As a benchmark, Section 2 introduces the investment policies of unlevered firms in a duopoly. In Section 3, we illustrate the investment and financing policies for levered firms in a duopoly. In Section 4, we exercise numerical analysis and provide empirical implications. Section 5 briefly summarizes the paper.

## 2. Unlevered firms in a duopoly

### 2.1. Setup

We use the same setup as in the standard literature (e.g., Chapter 9 in Dixit & Pindyck, 1994, Chapter 7 in Huisman, 2001). We consider two symmetric firms that have an opportunity to enter a new market. The entry into the market requires irreversible capital expenditure $I$. Throughout this paper, we assume that both firms are risk-neutral and have full information concerning each other. When only one of the firms is active in the market, the active firm receives an instantaneous cash flow $X(t)$ that is influenced by the market demand. Following the standard real options literature, we assume that $X(t)$ follows a geometric Brownian motion:

$$dX(t) = \mu X(t)dt + \sigma X(t)dB(t) \ (t>0), \quad X(0) = x,$$

where $B(t)$ denotes the standard Brownian motion defined in a probability space $(\Omega, \mathcal{F}, \mathbb{P})$ and $\mu, \sigma(>0)$ and $x(>0)$ are constants. We assume that the initial value, $X(0) = x$, is sufficiently low to exclude a firm's entry into a market at the initial time. For convergence, we assume that $r > \mu$,[3] where a positive constant $r$ is the interest rate. When both firms are active in the market, the first mover, denoted by the leader, receives an instantaneous cash flow $Q_L X(t)$, while the second mover, denoted by the follower, receives $Q_F X(t)$. Assume that $Q_L$ and $Q_F$ are constants satisfying $0 < Q_F \le Q_L < 1$, which means that the value for the leader's profit in a duopoly rests in between the values of the monopolistic profit and the follower's profit. We presume the negative externalities and first-mover advantage so as to focus on the analysis of preemptive competition.

### 2.2. Preemptive equilibrium

This section explains preemptive equilibrium following Dixit and Pindyck (1994), Huisman (2001), and Grenadier (1996), among others. In a duopoly game, we need to consider the problem backwards. We denote the "unlevered" case with the subscript $U$. Suppose that the leader has invested at time $s$. The follower optimally enters the market by solving the optimal stopping problem:

$$F_U(X(s)) = \sup_{T_{FU} \ge s} \mathbb{E}^{X(s)}\left[\int_{T_{FU}}^{\infty} e^{-r(t-s)}(1-\tau)Q_F X(t)dt - e^{-r(T_{FU}-s)} I\right], \quad (1)$$

where $T_{FU}$ runs over stopping times and $\mathbb{E}^{X(s)}[\cdot]$ denotes the expectation conditional on $X(s)$. We denote the corporate tax rate by a positive constant $\tau$. The value $F_U(X(s))$ corresponds to the follower's option value at time $s$. Because of the strong Markov property of $X(t)$, problem (Eq. (1)) can be reduced to

$$\sup_{T_{FU} \ge s} \mathbb{E}^{X(s)}\left[e^{-r(T_{FU}-s)}\left(\frac{(1-\tau)Q_F}{r-\mu}X(T_{FU}) - I\right)\right]$$

and has an explicit solution given by

$$F_U(X(s)) = \begin{cases} \left(\dfrac{(1-\tau)Q_F x_{FU}^*}{r-\mu} - I\right)\left(\dfrac{X(s)}{x_{FU}^*}\right)^{\beta} & (X(s) < x_{FU}^*) \\ \dfrac{(1-\tau)Q_F}{r-\mu}X(s) - I & (X(s) \ge x_{FU}^*), \end{cases}$$

where $\beta = 1/2 - \mu/\sigma^2 + \sqrt{(\mu/\sigma^2 - 1/2)^2 + 2r/\sigma^2}(>1)$ is a positive characteristic root, and $x_{FU}^* = \beta(r-\mu)I/\{(\beta-1)(1-\tau)Q_F\}$ is the entry trigger. The follower enters the market at time

$$T_{FU}^* = \inf\{t \ge s | X(t) \ge x_{FU}^*\}. \quad (2)$$

By moving first at time $s$, the leader gains

$$L_U(X(s)) = \mathbb{E}^{X(s)}\left[\int_s^{T_{FU}^*} e^{-r(t-s)}(1-\tau)X(t)dt + \int_{T_{FU}^*}^{\infty} e^{-r(t-s)}(1-\tau)Q_L X(t)dt\right],$$

where $T_{FU}^*$ is defined by Eq. (2). Note that the leader's profit flows will decrease to $Q_L X(t)$ when $t \ge T_{FU}^*$. By straightforward calculation, we have

$$L_U(X(s)) = \frac{1-\tau}{r-\mu}X(s) - \frac{(1-\tau)(1-Q_L)x_{FU}^*}{r-\mu}\left(\frac{X(s)}{x_{FU}^*}\right)^{\beta}.$$

[2] Numerical analysis in Zhdanov (2008) is largely unclear due to technical difficulties.

[3] For the economic rationale behind this, refer to Dixit and Pindyck (1994).