THE STRATEGIC USE OF CONVERTIBLE DEBT IN "DEEP POCKET" PREDATORY GAMES

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Abstract

A model is developed to argue that an entrant can use noncallable convertible debt to avoid predation in a "deep pocket" predatory game. Adverse-selection problems force the entrant to enter the market heavily leveraged compared to the incumbent monopolist. The model demonstrates that there exist conversion ratios for which creditors only have incentive to convert if the entrant is high quality. The entrant can therefore issue convertible debt to signal quality to investors. Before production decisions are made, the creditors convert, preventing predation. The conclusions are relevant to both the convertible debt literature and the product market competition literature.

1. Introduction

The purpose of this study is to extend Poitevin (1989) to demonstrate that noncallable convertible debt can be used to avoid predation by an incumbent firm against an entrant in a "deep pocket" predatory game. The deep pocket argument, which was first described by McGee (1958), Telser (1966), and later by Benôit (1984), is used to explain evidence that young firms are more vulnerable to bankruptcy than older firms. For example, over 40% of U.S. firms that went bankrupt in 1997 were less than five years old, while over 66% were less than 10 years old (Dun and Bradstreet, 1998). The deep pocket argument states that since the incumbent has greater financial resources (a "deeper pocket") than the entrant, the incumbent is able to exhaust the entrant financially through engaging in predatory pricing, thereby forcing the entrant to leave the market. Predatory pricing refers to the practice of introducing a lower priced, higher quality, or more innovative product in direct competition with a rival after it enters the market.

However, it is not immediately clear why the incumbent has greater financial resources than the entrant. Telser (1966) and Benôit (1984) simply assume the entrant is financially vulnerable and unable to sustain a price war. A number of authors provide explanations as to why the entrant is more vulnerable. Fudenberg and Tirole (1986) argue that since the entrant does not have a history of cashflow generation, the entrant finds it difficult to find equity investors. Therefore, the entrant must borrow to finance its operations, and must satisfy interest payments requirements. Conversely, the incumbent has a record of cashflow generation and is able to acquire equity investment resulting in lower interest payment requirements. The incumbent is, therefore, able to engage in a price war, as it does not have as large an interest obligation to satisfy.

Williamson (1974) argues that an incumbent has lower financing costs due to its lower risk. The lower risk is due to its existing history of cashflows. Since the entrant is a riskier investment, it must pay a higher interest rate. Therefore, even if both firms have the same financial structure, the incumbent is able to lower prices more aggressively due to the lower interest requirement it faces.

Poitevin (1989) formalizes the deep pocket argument using a game in which the riskiness of the entrant's debt is revealed through a separating equilibrium. Debt acts as a signal of quality to investors, allowing the entrant to receive the same interest rate as the incumbent. However, the higher level of debt

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and the associated cashflow requirements leave the entrant vulnerable to predation on the part of the incumbent. Hence, the incumbent's reputation permits a flexible financial structure, while the entrant's lack of reputation forces it to use its financial structure as a signal, causing predation. Fulghieri and Nagarajan (1996) also consider the strategic implications of financial structure on "deep pocket" games. However, they develop their model in the context of Benôit (1984), with the same unsatisfying assumption that the incumbent is financially stronger.

The model developed in this study extends Poitevin (1989) to demonstrate that convertible debt can be used advantageously in the context of deep pocket predatory games. Through strategically choosing convertible debt with a specific conversion ratio, an entrant may be able to avoid predation while revealing its quality type through a separating equilibrium. The key difference between the model developed in this study and Poitevin (1989) is that this model allows the firm to issue convertible debt, while the model in Poitevin (1989) does not.

Finance literature provides a number of theoretical rationales to explain why firms issue convertible debt. Kim (1990) argues that the conversion ratio provides a signal to the market of management's expectations of future performance. Jensen and Meckling (1976), Mikkelson (1978), and Green (1984) argue that convertible debt can be used to protect bondholders against the opportunistic behavior of shareholders. Brennan and Schwartz (1988) argue that convertible debt's hybrid nature makes it easier for creditors and debtors to negotiate the value of the debt when there is disagreement about the riskiness of the company. Constantinides and Grundy (1989) discuss the use of convertible debt to overcome problems associated with asymmetric information.

This study is in the spirit of the delayed equity argument first proposed by Brigham (1966) and Hoffmeister (1977). Janjigian (1987) provides empirical support for this argument, and Stein's (1992) backdoor equity model is a recent variant of this explanation. Stein argues that when adverse selection causes equity issues to be untenable and there is a high cost associated with financial distress, managers have an incentive to issue convertible debt. In Stein's model, a medium quality firm will not issue equity, to avoid issuing underpriced equity. At the same time, the medium quality firm will not issue straight debt, to avoid financial distress costs. Instead, the medium quality firm will issue convertible debt to avoid equity issue until quality is determined. Once quality is determined, the medium firm will force conversion through threatening to call. Davidson, Glascock and Schwarz (1995) provide empirical support of Stein (1992) and Kim (1990). Lewis, Rogalski and Seward (1999) find that the reaction to new convertible debt issues depends on whether investors believe that risk shifting or backdoor equity motivates the choice of convertible debt.

The basic argument of this study is as follows. Following Fudenberg and Tirole (1986), Williamson (1974), and Poitevin (1989), the fundamental difference between the incumbent and the entrant is that the market knows the incumbent's quality, while the entrant's quality is unknown. Therefore, the entrant must use debt to overcome informational asymmetries in financial markets. In particular, the firm has information on its cost type not known to the market. Debt issued by the entrant causes predation on the part of the incumbent monopolist, as the incumbent is willing to sacrifice short term cashflows to receive the reward of the entrant's bankruptcy. Using convertible debt with a conversion ratio by which creditors have an incentive to convert only if the entrant is a low cost producer, the entrant is able to avoid predation while overcoming informational asymmetries. Note, however, that the entrant's ability to use of convertible debt to avoid predatory pricing requires the satisfaction of several conditions, as detailed in the model. Without the satisfaction of these conditions predation can occur. Hence, this model does not universally negate the occurrence of predatory pricing, in the context of the deep pocket predatory game described by Poitevin (1989), even if hybrid financial securities are available.

This study differs from Stein (1992) as revelation of quality alone motivates conversion, while in Stein's model a call feature is required to force conversion. However, convertible bonds are often noncallable for a significant period of time following the issue. Hence, this model broadens the relevance of the backdoor equity argument to situations in which the bond is noncallable. It suggests that in a concentrated market, voluntary conversion can take place without a call feature.

Besides extending the convertible debt literature, this model also suggests that the product market

competition literature cannot continue to assume that hybrid financial securities do not exist. Instead, future research, both empirical and theoretical, should recognize that firms can choose from non-traditional securities to avoid predation.

The structure of the rest of this paper is as follows. The model and notation are described in Section 2. The stages of the game and the solution are described in Section 3. This is followed by a discussion in Section 4. Section 5 concludes the paper.

2. Model and notation

The formalism of the model is similar to Poitevin (1989). All parties are risk neutral, and management's objective is to maximize shareholder value. Assume that only one entrant wishes to enter the market. Let e refer to the entrant and i refer to the monopoly incumbent. Throughout, any notation defined for e is similarly defined for i unless otherwise stated.

Both the incumbent and entrant produce the same product and face the same fixed production cost, K. There are two types of marginal costs, high (c_H) or low (c_L), for each unit produced. For the incumbent firm, the marginal cost is common knowledge as low. The entrant's marginal cost is unknown to the market. The prior probability distribution for the entrant's marginal costs is characterized by equally likely occurrence of c_H and c_L. The aggregate output of the industry is Q, and $P(Q)$ is the inverse market demand. Further, $Q = q_e + q_i$, where q_e represents the output of firm e. Assume the price function is linear.

Operating cashflow includes stochastic and non-stochastic elements. The stochastic component of operating cashflows, a_e, is random and independent of the other choices or market variables. The support of a_e is $A = [a_0, a_1]$ and its cumulative distribution is $F(a_e)$. For algebraic convenience, assume $F(a_e)$ is uniform. The nonstochastic element of operating cashflow is the quantity produced multiplied by the difference between the price and marginal cost of each product. Define the ex-post operating cashflow as

$$S(a_e,q_e,c_e,q_i) := P(Q)q_e - c_e q_e + a_e \ \forall a_e \in A \quad (1)$$

for which a_e has been observed. Profitability is a function of the stochastic component of operating cashflows. Hence, a high cost entrant is willing to enter the market when the incumbent is known as low cost, as the stochastic component ensures that there is some probability of a high cost entrant not being forced into bankruptcy. This formulation is based on Poitevin (1989).

Each firm is assumed to have existing equity shareholders. Each firm chooses its capital structure following the entrant's decision to enter the market. Cash is required to finance costs associated with production. All debtholders invest at the beginning of the period and receive their principal and interest at the end of the period. For simplicity, assume the risk free rate of interest is zero.

The variable x_e represents the percentage of shares into which e's debt can be converted. For example, If $x_e = 0.5$, then following conversion the original equityholders own 1/(1+0.5) = 2/3 of the firm and the new equityholders own 0.5/(1+0.5) = 1/3 of the firm. If the debt is nonconvertible, then $x_e = 0$. The variable x_e can range from zero to infinity. To relate x_e to the conversion ratio, note that the conversion ratio represents the number of shares received upon conversion. Hence, the associated conversion ratio is equivalent to x_e multiplied by the number of shares currently outstanding. The principal of the debt that firm e borrows at interest rate r_e is D_e. Debt broadly refers to all types of liabilities, including obligations to suppliers. E_e represents the cash raised through equity investment in the firm, with N^n_e and N^o_e representing the number of the shares held by new and existing equityholders, respectively. Define $t_e = (D_e,x_e,r_e,E_e,N^n_e,N^o_e)$ as the financial policy of firm e.

While a firm's credit quality depends on its marginal cost type, firm ability to repay its creditors will depend on the realized level of stochastic cashflows. Define $S(\bar{a}_e,q_e,c_e,q_i)$ as the level of operating cashflow for which

$$S(\bar{a}_e,q_e,c_e,q_i) + D_e + E_e - K = D_e(1 + r_e). \quad (2)$$

The variable $\bar{a}_e$ is the lowest level of stochastic cashflow for which firm e can prevent default. Note that the term "bankrupt" is not used to describe e's situation when $a_e < \bar{a}_e$, as even if e is unable to satisfy its interest payments using the cashflow it receives from production, it can be bailed out by its creditors. The total monopoly cashflows earned by firm e, if i is bankrupt and e is not, is $B > 0$.

$V_e(t_e,t_i,c_e,c_i,q_e,q_i)$ represents the expected value of the position held by the shareholders of e. The

expected value of the existing shareholders' position is

$$\Pi_e(t_e,t_i,c_e,c_i,q_e,q_i) = \frac{N_e^o}{N_e^x + N_e^o} V_e(t_e,t_i,c_e,c_i,q_e,q_i) \quad (3)$$

The expected value of the new shareholders' position is

$$\Phi_e(t_e,t_i,c_e,c_i,q_e,q_i) = \frac{N_e^x}{N_e^x + N_e^o} V_e(t_e,t_i,c_e,c_i,q_e,q_i) \quad (4)$$

It follows $V_e = \Pi_e + \Phi_e$. Finally, note that $\rho_e(t_e,t_i,c_e,c_i,q_e,q_i)$ is the expected value of the creditors' position.

3. The game and solution

The game is multistaged and nonrepeated. There are two major stages to the game, the financing stage and the output stage. As the game begins, the marginal cost of the entrant is unknown to the market. The management of the entrant privately believes that the firm is a low cost producer. The marginal cost of the incumbent firm is observed in the market as low.

In the financing stage, the capital structure of each firm is determined. The entrant decides which financial policy to propose to investors. A financial policy specifies both the leverage ratio and conversion ratio. The investors decide whether to accept the financial policy proposed by the entrant. Only a low cost entrant receives financing. Hence, if the proposed financial policy signals that the entrant is low cost financing is provided. Otherwise, investors choose not to accept the financial policy, and the incumbent continues to receive monopoly profits. The financing stage ends with the incumbent choosing its financial policy as well.

The output stage of the game begins with the revelation of the entrant's cost type. Following this revelation, the convertible debtholders decide whether to convert at the specified conversion ratio. Next, the two firms simultaneously choose the level of output to produce. Quantities are determined through solving for the Cournot-Nash equilibrium.

After production, the firm must repay all of the cash it borrows plus interest. The stochastic portion of cashflows is privately revealed to the firm and its creditor. Based on this information, the firm and its creditors privately know whether the firm will default. Creditors must therefore decide whether to provide additional credit if default is imminent. After this decision is made, the stochastic portion of cashflows is revealed publicly. If one firm is bankrupt and the other firm is not, the firm that has not gone bankrupt receives monopoly cashflows. Figure 1 illustrates the sequence of moves and revelations.

The game is solved using backward induction; hence we first solve the output stage and subsequently solve the financing stage. Kreps and Wilson (1982) demonstrate that solving for the Nash equilibrium in every stage using backward induction leads to a sequential equilibrium. For each decision, we discuss each player's best strategy for every possible situation the player is in due to previous realizations and revelations.

Three decisions are made during the output stage. Convertible debtholders decide whether to convert following the revelation of the entrant's cost type. The firms next choose production quantities. Following the revelation of stochastic cashflows, the creditors decide whether to bailout the firm.

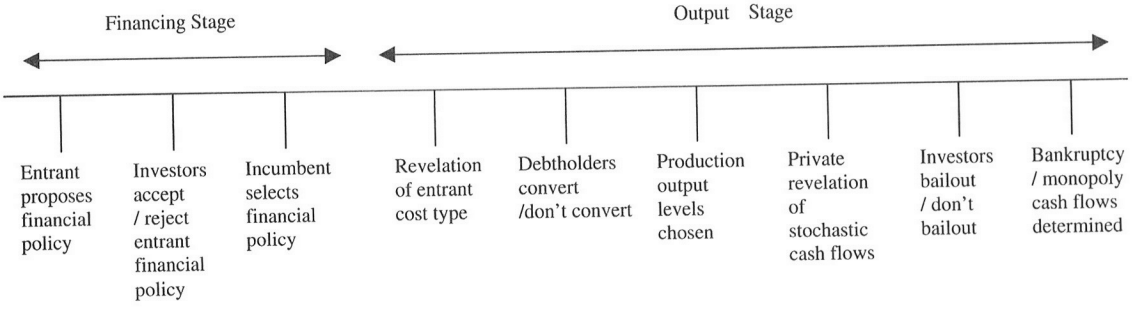

FIGURE 1. The sequence of moves and revelations associated with the "deep pocket" predatory game described in the model.

The decision to bailout is made in response to revelation of the firm's stochastic cashflows. Both a_e and a_i are revealed privately, and each firm's potential for default is privately known. If the firm is facing default, i.e., if $a_e < \bar{a}_e$, the creditors must either bailout the firm or allow the firm to go bankrupt. Risk neutral investors are willing to invest some amount to bailout the firm. The amount of bailout that investors are willing to provide is equal to the probability of i's bankruptcy multiplied by the expected value of the monopoly cashflows that flow to e should bailout of e occur. The expected value of these monopoly cashflows is conditional on e not going bankrupt, as the bailout eliminates any chance of e going bankrupt. Following Poitevin (1989), Define $\hat{a}_e$ as the level of a_e for which

$$S(\hat{a}_e,q_e,c_e,q_i,) + D_e + E_e - K + F(\hat{a}_i)B = D_e(1 + r_e) \quad (5)$$

where $F(\hat{a}_i)$ represents the probability of i's bankruptcy, and $F(\hat{a}_i)B$ represents the amount of bailout that investors are willing to provide to e. The right hand side of equation (5) represents the debt obligation of firm e, while the left hand side represents the total cash, including bailout, from which e pays its debt obligation. The creditors are effectively investing in the expected value of future bankruptcy cashflows.

If $a_e < \hat{a}_e$, the creditors will not bailout the firm, as the expected payoff from the bailout investment is zero. Therefore, divide A into two possible subintervals: $[a_0,\hat{a}_e)$ and $(a_0,\hat{a}_i]$. If a_e is in the subinterval $(\hat{a}_e,a_1]$ then $a_e > \hat{a}_e$, and the creditors expect to receive $D_e(1+r_e)$. If $\hat{a}_e$ is in the subinterval $[a_0,\hat{a}_e)$ then $a_e < \hat{a}_e$, and the creditors expect to receive the remaining assets of the firm.

The objective function satisfied by each firm, and stated here for e, is

$$\max_{q_e} V_e(t_e,t_i,c_e,c_i,q_e,q_i) \quad (6)$$

for which

$$V_e(t_e,t_i,c_e,c_i,q_e,q_i) = V_e(t_e,c_e) = \int_{\hat{a}_e}^{a_1}\Big(S(a_e,q_e,c_e,q_i) + D_e + E_e - K + F(\hat{a}_i)B - D_e(1 + r_e)\Big)dF(a_e). \quad (7)$$

Note that if e's creditors convert their debt in an earlier stage, then $D_e = 0$ in this context.

Quantities are chosen in Cournot-Nash equilibrium. Noting equation (5), the first order condition for firm e is

$$\frac{\partial}{\partial q_e}V_e(t_e,c_e) = P'(Q)q_e + P(Q) - c_e + f(\hat{a}_i)\frac{d\hat{a}_i}{dq_e}B = 0. \quad (8)$$

As Poitevin notes, $\frac{d\hat{a}_i}{dq_e}B = -P'(Q)q_i \geq 0$ and $\frac{d\hat{a}_e}{dq_e} = 0$. The second order condition is $2P'(Q) < 0$.

The first and second order conditions for i are identical to those for e. The first order conditions, acting as reaction functions for the two firms, are solved for the Cournot-Nash equilibrium levels of q_e and q_i, notated q_e^* and q_i^*.

If i has 100% equity in its capital structure there is no possibility of bankruptcy, and therefore $\frac{d\hat{a}_i}{dq_e} = 0$ and $F(\hat{a}_i) = 0$. Observing equation (8), it is apparent that the expression $f(\hat{a}_i)\frac{d\hat{a}_i}{dq_e}B$ is only nonzero when i has a capital structure consisting of a combination of debt and equity. This implies that firm e produces more when i uses a combination of debt and equity than when i is fully equity financed. This excess production is the predatory effect: in equilibrium, a firm practicing predation increases the probability of receiving monopoly profits through producing a greater quantity than it would otherwise.

Three additional inferences can be drawn from equation (8). First, the reaction function is a positive function of B. This suggests that the firm's willingness to engage in predation is a positive function of the potential bankruptcy profits. Second, the influence of the additional debt on quantities is unrelated to the specific level of debt, D. This is due to the assumption of uniform distribution. Hence, any level of debt causes the predatory effect. Third, the level of production through which predation is achieved, includes the predation effect regardless as to whether the cost type of the entrant is revealed as high or low. Hence, the model permits the possibility of predation against both high and low cost rivals.

The creditors' conversion decision follows the revelation of the entrant's marginal costs. The payoff to e's creditors is

$$\rho_e(t_e,t_i,c_e,c_i,q_e,q_i) = \rho_e(t_e,c_e) = (1 - F(\hat{a}_e))D_e(1 + r_e) = \int_{a_0}^{\hat{a}_e}\left(S(a_e,q_e,c_e,q_i) + D_e + E_e - K\right)dF(a_e). \quad (9)$$

Define t_e^{DE} and t_e^{E} as financial policies consisting of debt and equity and equity alone, respectively. Consider a situation in which the marginal cost type of the entrant is revealed as low. In this case, the creditors will be indifferent about converting their debt at a certain level of x_e, $\bar{x}_e$, such that

$$\rho_e(t_e^{DE},c_L) = \frac{\bar{x}_e}{1 + \bar{x}_e}V_e(t_e^{E},c_L). \quad (10)$$

Hence, $x_e < \bar{x}_e$ the creditors will not convert and vice versa. Solving for $\bar{x}_e$, it follows

$$\bar{x}_e = \frac{\rho_e(t_e^{DE},c_L)}{V_e(t_e^{E},c_L) - \rho_e(t_e^{DE},c_L)} \quad (11)$$

When the marginal cost type is high a similar x_e, $\bar{x}_e$, can be defined. Clearly, the firm can determine whether conversion will take place through specification of x_e and D_e, implicit in t_e^{DE}. Generally, the higher the specification of x_e and the lower the specification of D_e, the more likely conversion will take place. Hence, the choice of conversion ratio and leverage ratio, given the firm's private knowledge of its cost type, dictates whether conversion will take place in the future.

Note that when $x_e > \bar{x}_e$ (when $c_e = c_L$) or $x_e > \bar{x}_e$ (when $c_e = c_H$), conversion will occur, regardless of whether there is a later opportunity to convert. This is because the conversion, in itself, increases the expected future value of the firm through eliminating the debt in the capital structure. As demonstrated earlier, debt in a firm's capital structure leads to predation on the part of the rival firm. The decision to convert has two immediate effects. First, it converts the debt position into an equity position. Second, it eliminates the threat of predation. These two effects are interrelated. A decision to convert increases the value of the equity position through eliminating the predation threat. In turn, the increased equity value provides the convertible debtholder motivation to convert.

The observation that conversion eliminates the predation effect dictates that the convertible debt does not have to be callable for conversion to take place. The benefits of conversion flow to both the existing equityholders and the convertible debtholders. Failure to convert results in lower cashflow to the firm, which, in turn, results in diminished ability to repay liabilities, and the inability to earn the otherwise higher cashflow flowing to an equityholder not facing predation.

We next solve the financing stage. Three decisions are made during this stage. The entrant decides which financial policy to propose to investors. The investors decide whether to accept the financial policy proposed by the entrant. The incumbent then chooses its capital structure. The entrant and incumbent follow different objectives when choosing their financial policies. Each considers the impact of the financial policy on its cashflow. However, the entrant also recognizes that investors use the financial policy as a signal of its marginal cost type, and true value. Since investors are only willing to invest if the entrant is low cost, the entrant must signal.

The incumbent's choice of capital structure in this model is identical to the incumbent's choice in Poitevin (1989). In proposition (1), Poitevin demonstrates that the incumbent's dominant strategy is to finance entirely using equity. While Poitevin provides a formal proof, the intuitive explanation is as follows. As demonstrated, the use of debt has potential benefit and cost. The benefit, in the context of this model, is that the use of leverage sends a signal of quality to the market. The cost is that the rival firm engages in predation. Since the incumbent firm has no need to signal quality, there is no benefit to the use of debt, and a full equity policy is optimal. The entrant, on the other hand, has an uncertain cost type, and therefore must signal quality to investors through its choice of financial policy.

The entrant's financial policy specifies the levels of D_e and x_e. We consider each in turn.

3.1. Specification of D_e

The debt level is chosen such that only a low cost firm will use debt. Define

$$\Pi_e^*(t_e,c_e) = \Pi_e^*(t_e,t_i,c_e,c_i,q_e^*(c_i,t_e,t_i,q_i^*),q_i^*(c_e,t_i,t_e,q_e^*)) \quad (12)$$

as the value of the existing shareholders' position when product price levels are chosen to maximize shareholder value. Similarly define $\rho_e^*(t_e,c_e)$ and $\Phi_e^*(t_e,c_e)$. A low cost firm wishing to signal will choose a financial policy that will bankrupt a high

cost firm with certainty. Following Poitevin (1989), the problem to be solved is

$$\prod^*(t_e,c_L) = \max_{t_e} \prod^*(t_e,c_L)$$

$$\text{s.t. (i) } \prod^*(t_e,c_H) \le 0 \text{ (ii) } \rho_e^*(t_e,c_L) \ge 0$$

$$\text{(iii) } \Phi_e^*(t_e,c_L) \ge 0 \text{ (iv) } D_e \ge 0 \text{ (v) } E_e \ge 0 \qquad (13)$$

$$\text{(vi) } r_e \ge 0 \text{ (vii) } N_e \ge 0 \text{ (viii) } E_e + D_e - K \ge 0.$$

The value $\prod^*(t_e,c_L)$ is the value of a low cost firm that has chosen a suboptimal level of debt, due to signaling considerations. The first constraint ensures that a high cost firm is bankrupt with probability equal to one should it attempt to take on the debt level specified in the solution. A firm with an uncertain cost type does not receive financing. Hence, management uses the debt to permit financing.

To ensure that only a low cost firm uses debt, i.e., to satisfy the constraint $\prod^*(t_e,c_H) \le 0$, a debt level is selected such that firm e will go bankrupt with probability equal to one if the firm is a high cost firm and conversion does not take place. Formally, the condition is stated as

$$S(a_1,q_e^*,c_H,q_i^*) + D_e + E_e - K < D_e(1 + r_e). \quad (14)$$

The above condition states that at even the highest possible level of stochastic cashflow, a_1, a high cost firm will not have enough cash to satisfy its debt obligation. The key conclusion is that when a firm's cost type is unknown to the market, a low cost firm can signal its cost type through the level of debt it chooses. To signal quality in order to receive financing, a firm that privately believes it is low cost firm chooses a debt level such that bankruptcy is guaranteed if it is a high cost firm. This level of debt is specified in equation (14), and the low cost firm's ability to signal is conditional on setting debt at this level. A high cost firm will never choose this debt level, as bankruptcy is guaranteed. Hence, the high cost firm cannot signal that it is a low cost firm, and therefore cannot receive financing.

3.2. Specification of x_e

The entrant will only use convertible debt when its use negates predation while sustaining the intended quality signal. The convertible debt will only negate predation if conversion takes place. As demonstrated earlier, this will occur when x_e is specified such that $x_e > \bar{x}_e$ or $x_e > \underline{x}_e$, depending on the value of c_e. Hence, firm e can ensure conversion through specification of x_e, given the specification of D_e as defined in equation (14).

The convertible debt will sustain the intended quality signal if conversion only takes place when the firm is a low cost firm. This condition is satisfied through specifying such that

$$\bar{x}_e > x_e > \underline{x}_e. \qquad (15)$$

Recall that conversion takes place when $x_e > \bar{x}_e$ or $x_e > \underline{x}_e$, depending on the value of c_e. Hence, when $\bar{x}_e > x_e > \underline{x}_e$, conversion will only take place if the firm is low cost, as $x_e > \bar{x}_e$. Conversion will not take place if the firm is high cost, as $x_e < \bar{x}_e$. Noncallability ensures that a high cost firm does not force conversion when $x_e < \underline{x}_e$.

The opportunity to select $\bar{x}_e > x_e > \underline{x}_e$ depends on the existence of $\bar{x}_e > \underline{x}_e$. By definition of $\underline{x}_e$ and $\bar{x}_e$ (equation (11)), $\bar{x}_e > \underline{x}_e$ occurs when

$$\frac{\rho_e(t_e^{DE},c_H)}{V_e(t_e^E,c_H) - \rho_e(t_e^{DE},c_H)} > \frac{\rho_e(t_e^{DE},c_L)}{V_e(t_e^E,c_L) - \rho_e(t_e^{DE},c_L)} \qquad (16)$$

It follows that $\bar{x}_e > \underline{x}_e$ exists when

$$0 > \frac{\rho_e(t_e^{DE},c_L)V_e(t_e^E,c_H) - \rho_e(t_e^{DE},c_H)V_e(t_e^E,c_L)}{(V_e(t_e^E,c_L) - \rho_e(t_e^{DE},c_L))(V_e(t_e^E,c_H) - \rho_e(t_e^{DE},c_H))}. \qquad (17)$$

The denominator of the above expression is positive. Hence, the relation exists when the numerator is less than zero. Rearranging the numerator, it follows $\bar{x}_e > \underline{x}_e$ will occur when

$$\frac{V_e(t_e^E,c_L)}{V_e(t_e^E,c_H)} > \frac{\rho_e(t_e^{DE},c_L)}{\rho_e(t_e^{DE},c_H)} \qquad (18)$$

In words, $\bar{x}_e > \underline{x}_e$ exists when the percentage increase in value as c_e shifts from c_H to c_L is greater for V_e than for ρ_e.

A cost associated with the use of convertible debt is that a low cost firm wishes to retain as much of the risky stake for existing shareholders as possible. The firm is, therefore, reluctant to relinquish part of the stake through issuing convertible debt, and prefers to use straight debt. However, note that when the use of convertible debt negates predation and sustains the intended quality signal, there exists x_e such that the benefit to existing shareholders from negating predation outweighs the cost associated with issuing convertible debt. To demonstrate, observe that for the shareholders of firm e, the ben-

efits associated with negating predation outweigh the costs when owning part of a debt-free firm is superior to owning all of a leveraged firm. Formally, shareholders prefer to use convertible debt when

$$\frac{1}{1+x_e}V_e(t_e^E,c_L) > V_e(t_e^{DE},c_L) \qquad (19)$$

Rearranging, it follows

$$\frac{V_e(t_e^E,c_L)}{V_e(t_e^{DE},c_L)} - 1 > x_e. \qquad (20)$$

In words, shareholders prefer to use convertible debt when the percentage increase in value due to the elimination of predation, $\frac{V_e(t_e^E,c_L)}{V_e(t_e^{DE},c_L)}$, is greater than the percentage of equity sacrificed to offer the conversion feature, x_e. Consider $x_e = \bar{x}_e$. Noting equation (11), it follows from equation (20) that, when $x_e = \bar{x}_e$, shareholders prefer to use convertible debt when

$$\frac{V_e(t_e^E,c_L)}{V_e(t_e^{DE},c_L)} - 1 > \frac{\rho_e(t_e^{DE},c_L)}{V_e(t_e^E,c_L) - \rho_e(t_e^{DE},c_L)}. \qquad (21)$$

Rearranging, restate the above as

$$V_e(t_e^E,c_L) > V_e(t_e^{DE},c_L) + \rho_e(t_e^{DE},c_L). \qquad (22)$$

The right hand side of the above equation is the value of a firm that uses both debt and equity, while the left hand side is the value of a firm that uses equity exclusively. This condition is always satisfied, as the use of debt in the capital structure is costly, in terms of predatory pricing, while the signal can be sent using convertible debt. This implies that equation (20) is satisfied when $x_e = \bar{x}_e$. It follows that there exists some $x_e > \bar{x}_e$ for which shareholders are indifferent regarding the use of convertible debt.

To summarize, the firm will choose to use convertible debt if the conditions specified in equations (14), (15), and (18) are satisfied. Equation (14) stipulates that a high cost firm will never issue debt, as issuing debt ensures that a high cost firm is bankrupt with probability one, given the specified debt level. Because of this, the issuance of debt sends a signal to the market about the entrant's quality. Equation (15) stipulates that conversion will not take place if the entrant is high cost. This ensures that a high cost firm using convertible debt will never have its debt converted. It also stipulates that conversion will take place if the entrant is low cost. Satisfaction of this condition ensures that a low cost firm does not face predation if it issues convertible debt, as the debt will definitely be converted. Equation (18) stipulates the scenario under which it is possible to satisfy equation (15). Without the satisfaction of these conditions, predation can occur.

4. Discussion

The model presented in this paper argues that an entrant can use noncallable convertible debt to avoid predation in entry deterrence games. A model is presented in the spirit of Poitevin's (1989) deep pocket formalization in which adverse selection problems force the entrant to enter the market heavily leveraged when compared to the incumbent. The model demonstrates that there exist conversion ratios for which creditors have an incentive to convert only if the entrant is a low cost producer. The low cost entrant can therefore issue convertible debt to signal quality to investors. Before production decisions are made, the creditors will convert, preventing predation.

The model is highly formalized. For example, the stochastic component of operating cash flows is independent of the other choices or market variables. Alternatively, stochastic component of cash flows can be defined as containing two elements: an element positively correlated with the parallel stochastic profit element of the rival, and an independent element. The first would reflect underlying influences that lead to higher stochastic profits for both firms, while the second would reflect idiosyncratic stochastic profits. However, the independent stochastic component is used, as the inclusion of the positively correlated element would increase the complexity and magnitude of the equations, without added insight. Earlier studies, such as Poitevin (1989) and Dasgupta and Titman (1998), do not use positively correlated profit elements.

While the model is highly formalized, the conclusions are relevant to both the convertible debt literature and the product market competition literature.[1] We consider each contribution in turn.

4.1. Contribution to the convertible debt literature

An interesting contribution is the idea that convertible debt does not have to be callable to force conversion after revelation of firm type. Contrast this conclusion with the Stein (1992) model, in

which convertible debt must be callable to force conversion. The root of the difference between the callability status of the convertible debt in this model and Stein's model is that in the Stein model only equityholders benefit from conversion, through a reduction of financial distress costs upon conversion. Therefore, a call feature is required to motivate conversion by debtholders. In this model, both equityholders and debtholders benefit from conversion, due to the elimination of the predation threat upon conversion. Hence, there is no need for the debt to be callable.

Support for the idea that convertible debt does not have to be callable comes from Nyborg (1995). Nyborg provides empirical evidence questioning Stein's argument that using convertible debt with forced conversion can preserve the initial advantage associated with the convertible debt. Nyborg demonstrates that, in terms of the adverse impact on prices, issuing equity is preferable to issuing callable convertible debt and later forcing conversion.

Note that while in our model the firm does not need a call feature to force conversion, it is conceivable that a firm will wish to include a call feature for some exogenous reason. In such a case, following Stein, the exercise price associated with the call must be greater than the value received, upon conversion, by debtholders of a high cost firm. Otherwise, the high cost firm can force conversion through threatening a call, even when the conversion value of the debtholders' position is below the nonconversion value.

Note as well that in both Stein (1992) and in the model presented in this study, the signal of quality is provided through the issuance of debt, not through the convertibility feature. Instead, the convertibility feature is used to offset the downside associated with straight debt issuance. In Stein (1992), the downside is financial distress. In the model presented in this study, the downside is predation by the incumbent firm.

4.2. Contribution to the product market competition literature

The model demonstrates that consideration must be given to the role of hybrid financial securities, such as convertible debt, when evaluating the influence of capital structure decisions on product market competition. The model demonstrates that convertible debt can reduce an incumbent's ability to practice predation. While the model is an entry game, the conclusions have implications for any game in which debt is used for signaling purposes in a concentrated market.

Most notably, a number of recent empirical and theoretical studies have challenged the argument that leveraged transactions executed in response to unwanted takeover attempts lead to predatory pricing on the part of a competitor. Empirical studies by Chevalier (1995) Phillips (1995) and Khanna and Tice (2000) find that prices generally increase following leveraged transactions executed in response to an unwanted takeover attempt. The evidence also suggests that prices do not increase when the rival firm is relatively unleveraged and has very large market share. In response to this empirical evidence, recent theoretical models demonstrate how increases in debt can result in increased prices. These include Dasgupta and Titman (1998), Chevalier and Scharfstein (1996), and Showalter (1995).

However, none of the empirical or theoretical studies consider the influence hybrid securities have on product market competition following highly leveraged transactions. As demonstrated, hybrid securities, such as convertible debt, can drastically limit or alter the degree to which a rival can practice predation following a leveraged transaction. Clearly, future research should incorporate hybrid securities when testing the relation between capital structure and product market competition.

5. Conclusion

A model is developed to argue that an entrant can use convertible debt to avoid predation in entry deterrence games. The model, in the spirit of Poitevin's (1989) deep pocket formalization, demonstrates that there exist conversion ratios for which creditors have an incentive to convert only if the entrant is a low cost producer. The low cost entrant can therefore issue convertible debt to signal quality to investors, as creditors will convert before production, preventing predation. The conclusions differ from Stein (1992) as revelation of quality alone motivates conversion, while in Stein's model a call feature is required. It suggests that in a concentrated market, voluntary conversion can take place without a call feature. Besides extending the convertible debt literature, the model also suggests

that the product market competition literature cannot continue to assume that hybrid financial securities do not exist. Instead, future research, both empirical and theoretical, must recognize that firms can choose from nontraditional securities to avoid predation.

Note

1. Please see Gottesman (2004) for a case study that applies this paper's conclusions to Euro Disney's 1991 convertible debt issue.

References

Benôit, J.P., 1984. Financially constrained entry in a game with incomplete information. *RAND Journal of Economics* 15, 490–499.

Brennan, M.J., Schwartz, E., 1988. The case for convertibles. *Journal of Applied Corporate Finance* 1, 55–64.

Brigham, E.F., 1966. An analysis of convertible debentures: Theory and some empirical evidence. *Journal of Finance* 21, 35–54.

Chevalier, J.A., 1995. Do LBO supermarkets charge more? An empirical analysis of the effects of LBOs on supermarket pricing. *Journal of Finance* 50, 1095–1112.

Chevalier, J.A., Scharfstein, D., 1996. Capital market imperfections and countercyclical markups: Theory and evidence. *American Economic Review* 86, 703–725.

Constantinides, G., Grundy, B., 1989. Optimal investment with stock repurchase and financing as signals. *Review of Financial Studies* 2, 445–465.

Dasgupta, S., Titman, S., 1998. Pricing strategy and financial policy. Review of Financial Studies 11, 704–737.

Davidson, W.N., Glascock, J.L., Schwarz, T.V., 1995. Signaling with convertible debt. *Journal of Financial and Quantitative Analysis* 30, 425–440.

Dun & Bradstreet, 1998. *Business Failure Record.* Dun & Bradstreet Corporation.

Fudenberg, D., Tirole, J., 1986. *Predation without reputation.* Working paper No. 377, Department of Economics, Massachusetts Institute of Technology.

Fulghieri, P., Nagarajan, S., 1996. On the strategic role of high leverage in entry deterrence. *Journal of Banking and Finance* 20, 1–23.

Gottesman, A.A., 2004. *Euro Disney's 1991 convertible debt issue and the backdoor equity argument.* Working paper, Pace University.

Green, R.C., 1984. Investment incentives, debt and warrants. *Journal of Financial Economics* 13, 115–136.

Hoffmeister, J.R., 1977. Use of convertible debt in the early 1970s: A reevaluation of corporate motives. *Quarterly Review of Economics and Business* 17, 21–31.

Janjigian, V., 1987. The leverage changing consequences of convertible debt financing. *Financial Management* 16, 15–21.

Jensen, M.C., Meckling, W.H., 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3, 305–360.

Khanna, N., Tice, S., 2000. Strategic responses of incumbents to new entry: The effect of ownership structure, capital structure, and focus. *Review of Financial Studies* 13, 749–779.

Kim, Y.O., 1990. Informative conversion rations: a signaling approach. *Journal of Financial and Quantitative Analysis* 25, 229–243.

Kreps, D., Wilson, R., 1982. Sequential equilibria. *Econometrica* 50, 863–894.

Lewis, C.M., Rogalski, R.J., Seward, J.K., 1999. Is convertible debt a substitute for straight debt or for common equity? *Financial Management* 28, 5–27.

McGee, J.S., 1958. Predatory price-cutting: the Standard Oil (N.J.) case. *Journal of Law and Economics* 1, 137–159.

Mikkelson, W., 1978. *Agency Costs and convertible securities.* Unpublished Ph.D. Dissertation.

Nyborg, K.G., 1995. Convertible debt as delayed equity: Forced versus voluntary conversion and the information role of call policy. *Journal of Financial Intermediation* 4, 358–395.

Phillips, G.M., 1995. Increased debt and industry product markets: An empirical analysis. *Journal of Financial Economics* 37, 189–238.

Poitevin, M., 1989. Financial signaling and the deep-pocket argument. *RAND Journal of Economics* 20, 26–40.

Rasmusen, E., 1994. *Games and information.* Blackwell Publishers Inc., Cambridge, Massachusetts.

Showalter, D., 1995. Oligopoly and financial structure; comment. *American Economic Review* 85, 647–653.

Stein, J.C., 1992. Convertible bonds as backdoor equity financing. *Journal of Financial Economics* 32, 3–22.

Telser, L.G., 1966. Cutthroat competition and the long purse. *Journal of Law and Economics* 9, 259–277.

Williamson, O.E., 1974. *Book review of Patents and Antitrust Law* by W. Bowman, Yale Law Journal 83, 647–661.