

Pricing Strategy and Financial Policy

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Recent empirical evidence indicates that capital structure changes affect pricing strategies. In most cases, prices increase following the implementation of a leveraged buyout of a major firm in an industry, with the more leveraged firm in the industry charging higher prices on average. Notable exceptions exist, however, when the leverage increasing firm's rival is relatively unlevered. The first observation is consistent with a model where firms compete for market share on the basis of price. The second observation can be explained within the context of a Stackelberg model where the relatively unlevered rival acts as the Stackelberg price leader.

When a firm becomes the target of an unwanted takeover attempt its managers often increase leverage in an attempt to deter the threat.¹ For example, in 1989, Krogers, a supermarket chain included in the Chevalier (1995) study discussed below, paid out a special \$40 per share dividend, financed with debt, to deter takeover bids by the Haft family and Kravis, Kohlberg, and Roberts.²

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¹ In a study of 573 terminated takeover offers, Safieddine and Titman (1997) found that about two-thirds of those firms that remained independent increased their leverage ratio.

² Financial economists have offered two views on how debt might deter unwanted takeovers. An increase in debt can signal higher expected productivity [Ross (1977)] or commit managers to improve productivity [Grossman and Hart (1982) and Jensen (1986)], which in turn increases targets' stock prices, and thus in-

A firm's incentive to increase leverage in these situations is mitigated by a variety of factors. For example, Zwiebel (1996) considers the personal costs that managers bear when they increase leverage (e.g., less empire building opportunities). Leverage increases are also mitigated by various product market considerations. For example, a firm may be concerned about how a substantial increase in leverage will be viewed by its customers. Titman (1984) and Maksimovic and Titman (1991) suggest that customers who depend on maintenance or other services from the firm, or who have reason to be concerned about the quality of the firm's products, may be less willing to do business with a highly leveraged firm.

Firms contemplating leverage increases also consider the likely reactions of their competitors, which is the subject of this article. A firm will be less willing to increase its leverage if it believes that its competitors will respond to its new financial structure by aggressively cutting their prices to steal its market share. However, if competitors are expected to react to the leverage increase by increasing their prices, there would be an added impetus to increasing leverage.

Recent empirical evidence demonstrates that financing choices do in fact affect pricing and output choices. For example, Opler and Titman (1994) found that highly leveraged firms in distressed industries lose market share to their less leveraged competitors. Although a number of explanations were offered for this finding, the fact that this effect was strongest in the more concentrated industries suggests that leverage may affect how prices are determined in imperfectly competitive industries. Recent industry studies by Phillips (1994) and Chevalier (1995) provide more detailed evidence on how leverage affects pricing and output decisions. In three of the four industries examined in Phillips (1994) prices were increased and output was reduced after one of the major players in the industry initiated a leveraged buyout (LBO). An important distinguishing feature of the Gypsum industry, where prices fell following the LBO, was the existence of a competitor which was not highly leveraged. In a study of supermarkets, Chevalier (1995) found that those firms that initiated leveraged buyouts subsequently charged higher prices on average and lost market share to their less leveraged rivals. She also found that the tendency to raise prices following an LBO was related to the extent to which competitors were also highly leveraged.

This article provides an explanation for the relation between prices and leverage found in the studies mentioned above. We are particularly interested in the observation that firms that increase their leverage tend to increase their prices, that their competitors generally also increase their prices but

creates the cost of the takeover. An alternative view, expressed by Harris and Raviv (1988), Stulz (1988), and Israel (1991), suggests that debt can deter potential acquirers by increasing the cost of the target without improving its value. See Stein (1988) and Zwiebel (1996) for discussions of how a firm's incentive to either signal higher profits or commit to higher profits increases when it is subject to an unwanted takeover.

not by as much, and that important exceptions exist when the competitors are not highly leveraged. Our analysis is thus part of the growing literature on how capital structure affects product market competition.³ The model is particularly close in its approach to the earlier work of Brander and Lewis (1986) and Maksimovic (1986, 1990) who suggest that increased debt commits the firm to being a more aggressive competitor. However, these models predict that leverage increases lead to price declines, which is inconsistent with most evidence. Showalter's (1995) extension of the Brander and Lewis model, which considers price competition, can explain the association between leverage increases and price increases but only in instances where bankruptcy is imminent.⁴

The model we develop is closely related to Klemperer's (1987, 1993) idea that pricing decisions can be viewed as discounted cash flow problems. When firms raise prices they initially realize higher profits, but lower market shares, which in turn implies lower profits in the future. The incentive to raise and lower prices is thus affected by the rate at which future profits are discounted, which in turn is related to the capital structure choice. In this respect, our work is quite similar to a model developed by Chevalier and Scharfstein (1996).⁵ In our model, because of a Myers (1977) debt overhang problem, long-term debt increases a firm's borrowing costs, which shifts the firm's reaction curve upward and makes it flatter (i.e., less responsive to changes in the other firm's price). In the Nash case, the upward shift in the reaction curve leads to increased prices. However, in the Stackelberg case, the change in slope of the reaction curve is also important and this can lead prices to decline following a leverage increase.

The rest of the article is structured as follows: Section 1 examines the role of debt in the context of a two-period model in which market share in the first period matters for second-period profits. A specific example of this model with comparative statics is presented in Section 2. Section 3 illustrates how market share effects of rivals' price responses can enable high quality firms to signal firm value by increasing leverage and thereby ward off unwanted takeover attempts. Section 4 examines how the nature of competition affects the model's predictions. Section 5 provides a summary and some conclusions.

³ The earliest articles on this topic present what are generally referred to as the deep pockets/predatory pricing argument, where increased debt invites predation which runs counter to most of the above evidence. Articles in this area include Telser (1963), Benoit (1984), Fudenberg and Tirole (1986), Brander and Lewis (1988), and Bolton and Scharfstein (1990).

⁴ See note 6 for further discussion of this model.

⁵ In Chevalier and Scharfstein (1996) the managers of highly leveraged firms use high discount rates, and thus charge higher prices, because the leveraged firm may be bankrupt and liquidated within one period, making future market share less important. Since their model is based on the idea that the managers can take all of the profits out of the firm prior to its liquidation, we think it may be less applicable to the larger firms examined in the above cited empirical literature. In addition, they do not consider cases where increased leverage can lead to decreased prices.

1. The Effect of Long-Term Debt on Product Prices

The model developed in this section examines the pricing choices of two firms, A and B, which produce a similar but differentiated product. The firms compete on the basis of price, taking their competitor's price as given when setting their own price, that is, we shall be considering a Nash equilibrium in prices. Customers are sensitive to price and tend to favor the firm from which they purchased the product in the previous period, for example, there are switching costs. As a result, since the price which a firm charges today affects the number of customers it attracts today, it also affects its profits in the future.

Our model builds on an idea put forth by Klemperer (1987) that suggests that since increasing one's price today can improve short-term profits at the expense of long-term profits, a firm's incentive to raise or lower its price is determined in part by its discount rate. With higher discount rates, firms have an incentive to charge higher prices. In order to explain the effect of debt on pricing choices, we combine this insight with Myers' (1977) observation that existing long-term debt can have the effect of increasing the rate at which firms discount future cash flows.

The firms in our model are owned by risk-neutral entrepreneurs, or equivalently, are managed for the benefit of risk-neutral shareholders and thus act to maximize the expected value of profits. These entrepreneurs select their financial structures just prior to period 1, the first period in this two-period model. Cash flows are realized at two points in time: at the end of period 1 and at the end of period 2. The firms are liquidated at the end of period 2, and generate a random liquidation value $\tilde{I}$ (see Figure 1). We shall assume that $\tilde{I}$ has a continuous distribution with c.d.f. $F(\tilde{I})$ and density $f(\tilde{I})$ over the interval $[0, \bar{I}]$. This random liquidation value is the only source of uncertainty in the model. This latter assumption allows us to ignore the effect that imminent bankruptcy has on the period 2 pricing choice, which we think is a second-order effect for firms that are not on the verge of bankruptcy.⁶

We shall focus primarily on the role of long-term debt in our analysis, that is, debt which is chosen at the beginning of period 1 and matures at the end of period 2. However, we also assume that the firm has a borrowing need at the end of period 1. We assume that this borrowing need reflects

⁶ We refer here to the effect that debt has on pricing choices considered in Showalter's (1995) extension of the Brander and Lewis (1986) model to the case of price competition. We assert that this effect is likely to be unimportant in most cases for two reasons. First, debt can have offsetting effects on pricing choices depending on whether uncertainty comes from demand for the product or from costs. For example, for the case of constant marginal costs and linear demand, if marginal costs are uncertain and demand is linear, imminent bankruptcy induces firms to lower prices, but if demand is uncertain, imminent bankruptcy induces firms to raise prices. When both forms of uncertainty are present, the effect is ambiguous. Second, the magnitude of the effect is determined by how much uncertainty exists between the time when the pricing choice is made and the products are sold. The effect should thus be small for firms with good estimates of their costs and the demand for their product prior to when they set prices.

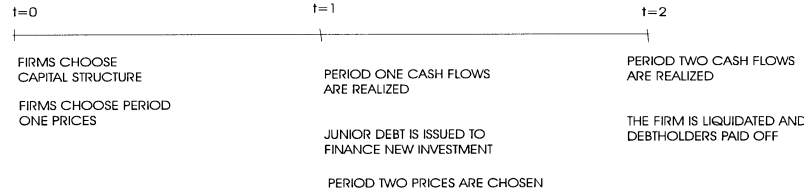


Figure 1
Time line for the two-period model

an investment I that the firm has to make before period 2 which exceeds period 1 cash flows. We could have alternatively assumed that the firm is refinancing debt that becomes due at the end of period 1. To simplify our notation we will assume, without loss of generality, that the risk-free interest rate is zero.

1.1 The all-equity firm

Our two-period model assumes that the demand for a firm's products in the second period depends on its success in attracting a "customer base" or a higher market share by selling more in the first period. The customer base is likely to be important for a variety of reasons. For example, we will examine an example in detail where customers have switching costs which allow the firms to exploit, in period 2, the customers they attract in period 1.⁷ We will assume that the firms' initial customer bases are exogenous (or that there is no preexisting customer base) so that first-period profits depend only on first-period prices: $x_1^i = x_1^i(p_1^A, p_1^B)$. Second-period profits depend on the customer base (i.e., the fraction of the customers buying the product) attracted in the first period, σ^A and σ^B , where $\sigma^A + \sigma^B = 1$, and second-period prices; the latter, however, are functions of the market shares, so that we can write $x_2^i = x_2^i(\sigma^i)$.⁸ Notice that the overall second-period profits are $x_2 + \tilde{I}$. The ex ante value of firm i can therefore be written as

$$V^i = x_1^i(p_1^A, p_1^B) + x_2^i(\sigma^i(p_1^A, p_1^B)) + E\tilde{I} - I, \quad (1)$$

where E denotes expected value.

⁷ Other reasons why the customer base is important, such as network externalities, can also be used to motivate our framework. Froot and Klemperer (1989), who develop a model which is quite similar to the one used here, discuss some other reasons for the dependence between first-period market share and second-period profits.

⁸ The second-period prices, as functions of the first-period market shares, are given by the pair of equations $\frac{\partial x_2^i(\sigma^i, p_2^i, p_2^j)}{\partial p_2^i} = 0$, $i, j = A, B$; $i \neq j$.

For all-equity firms, the first-period prices are given by the solution to the pair of equations:

$$V_i^i = \frac{\partial x_1^i}{\partial p_1^i} + \frac{\partial x_2^i}{\partial \sigma^i} \cdot \frac{\partial \sigma^i}{\partial p_1^i} = 0, \quad i = A, B. \quad (2)$$

The second-order condition is

$$V_{ii}^i < 0, \quad i = A, B \quad (3)$$

We shall make the following assumptions:

Assumption 1. $\frac{\partial x_2^i}{\partial \sigma^i} > 0$ and $\frac{\partial \sigma^i}{\partial p_1^i} < 0$.

The first condition requires that a higher first-period market share results in higher second-period profits. The second condition requires that ceteris paribus a higher first-period price results in a lower second-period customer base as fewer customers buy in the first period. This is intuitive and can be shown to hold for a wide range of scenarios [see Klemperer (1987) for examples].

Given these assumptions, Equation (2) illustrates an important point. The optimal first-period price is the solution to a present value problem. At the optimal price the marginal effect of lowering the price on first-period profits is negative. This negative effect is offset by the increased profits in the second period achieved because of the larger customer base attracted by the lower period 1 price. The trade-off between period 1 and period 2 profits will of course depend on the firm's discount rate, which in turn depends on the firm's financial structure.

1.2 The effect of outstanding debt

In this section we will examine how the firms' financial structures affect their pricing decisions. For now we will assume that the firms' debt obligations, d^A and d^B , are determined exogenously. These debt obligations are due at the end of period 2 and are assumed to be protected by covenants restricting the payout of period 1 and period 2 profits before the bonds are paid off in full. The covenants also require that the additional financing needed to fund the intermediate period investment must be junior to the existing senior debt. Our results are actually very robust with respect to the assumption that the firm cannot issue new debt that is senior to all existing debt. Although our analysis assumes that the new financing comes from junior debt, our

results would be essentially the same if the financing was raised with a stock issue or any other junior claim.⁹

The fact that equity-holders can gain by issuing debt which is senior to their existing debt is well understood. What we show is that shareholders can in essence generate senior financing by raising the prices of their products. By raising prices, the firm increases current profits at the expense of lowering their market share and future profits. (The reduction in future profits can be viewed as a claim that is senior to existing claims.) The incentive to indirectly raise senior funds in this manner will exist whenever existing covenants prohibit the firm from directly issuing senior debt.

One might ask why a firm would impose such covenants if they lead to pricing distortions. However, there are other distortions that would exist if the debt was not protected. For example, if a firm issued debt which allowed it to raise an unlimited amount of additional senior debt in the future, it would have an incentive to subsequently increase its leverage ratio beyond its optimal level. In addition, as we will discuss later, firms may benefit from the pricing distortions created as a result of having protected debt.

Let y denote the face value of junior debt required to finance the intermediate period investment. Then assuming that the newly issued debt is priced competitively, we have (dropping the superscript i),

$$I - x_1 = y[1 - F(d + y - x_2)] + \int_{d-x_2}^{d+y-x_2} (\tilde{I} + x_2 - d)dF. \quad (4)$$

Notice that this pricing equation reflects the fact that the debt issued to finance intermediate period investment is junior to the existing debt, that is, the new debt-holders receive payments if and only if the period 2 cash flows are sufficient to pay the senior claim d in full.

Now the firm's two-period profit is

$$\begin{aligned} \Pi &= \int_{d+y-x_2}^{\tilde{I}} (x_2 - d - y + \tilde{I})dF \\ &= (x_2 - d)[1 - F(d + y - x_2)] \\ &\quad - y[1 - F(d + y - x_2)] + \int_{d+y-x_2}^{\tilde{I}} \tilde{I}dF \\ &= x_1 + (x_2 - d)[1 - F(d - x_2)] \\ &\quad + E\tilde{I} - \int_0^{d-x_2} \tilde{I}dF - I \end{aligned} \quad (5)$$

$$= x_1 + \int_{d-x_2}^{\tilde{I}} (\tilde{I} + x_2 - d)dF - I, \quad (6)$$

⁹ Our results will also hold if the new debt is of the same priority as the existing debt. However, the results will not hold if the existing debt is completely unprotected so that the firm can fund its intermediate period investment requirement with debt that is senior to the existing debt.

where we have used Equation (4) in deriving Equation (5). To analyze the firms' equilibrium pricing strategies we begin as usual with the last period. At the beginning of period 2, notice that both the face value of senior and junior debt (D and y , respectively) are fixed. Hence, for a given σ^A , firm A chooses p_2^A to maximize $\int_{d+y-x_2^A}^{\tilde{I}} [x_2^A + \tilde{I} - d^A - y^A]$. The first-order condition is given by

$$\frac{\partial x_2^A(\sigma^A, p_2^A, p_2^B)}{\partial p_2^A} = 0. \quad (7)$$

Similarly, we have

$$\frac{\partial x_2^B(\sigma^B, p_2^B, p_2^A)}{\partial p_2^B} = 0. \quad (8)$$

It therefore follows that the second-period prices, as functions of first-period market share σ^A or σ^B , are exactly the same as when the firms are completely equity financed. The reason why second-period prices are independent of the firm's capital structure has to do with our assumption that marginal profits in the second period are known with certainty.

Consider now the choice of first-period price for firm A. Differentiating Equation (6) w.r.t. p_1^A , we get

$$\Pi_A^A = \frac{\partial x_1^A}{\partial p_1^A} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot [1 - F(d^A - x_2^A)] = 0. \quad (9)$$

Second-order conditions require

$$\Pi_{AA}^A < 0. \quad (10)$$

We have analogous conditions for firm B. Also, to ensure that reaction functions are positively sloped and that reaction function stability holds, we assume some standard regularity conditions:

Assumption 2. $\Pi_{ij}^i > 0$ and $\Pi_{ii}^i \Pi_{jj}^j - \Pi_{ij}^i \Pi_{ji}^j > 0$ for $i = A, B, \quad i \neq j$.

The following proposition follows directly:

Proposition 1. *If firm A has existing senior debt and requires additional (lower priority) debt to finance new investment, its first-period price is increasing in the level of its existing debt. Firm B's price is also increasing in A's existing debt level. If firm B is equity financed, but otherwise identical to firm A, its price will be lower than firm A's price.*

Proof. See the Appendix.

The intuition for this result follows directly from our interpretation that the first-period pricing decision is the solution to a present value problem. Outstanding debt increases the cost of new borrowing and thus increases the rate at which second-period profits are discounted [see Equations (2) and (9)]. Since discounting second-period profits at a higher rate decreases the current value of having a higher market share, there is less incentive to offer low prices. This shifts the reaction curve to the right. Given that the rival's reaction function is upward sloping, prices are higher. Under symmetry, since reaction function stability requires that firm B will react to a \$1 increase in firm A's price by raising its own price less than \$1 (and conversely), the firm that initiates a leverage increase increases its prices more than its rival.

For *all-equity firms*, the assumption that reaction functions are positively sloped is quite standard, and requires (for firm A) that the term $\frac{\partial^2 x_1^A}{\partial p_1^A \partial p_1^B} + \frac{\partial}{\partial p_1^B} \left[\frac{\partial x_2^A}{\partial \sigma^A} \frac{\partial \sigma^A}{\partial p_1^A} \right]$ be positive. However, if firm A is debt financed, even with the terms $\frac{\partial x_2^A}{\partial \sigma^A}$ and $\frac{\partial \sigma^A}{\partial p_1^A}$ independent of p_1^B (as is the case in several switching cost models), there is an additional negative term $\frac{\partial x_2^A}{\partial \sigma^A} \frac{\partial \sigma^A}{\partial p_1^A} \frac{\partial x_1^A}{\partial p_1^B} f(d^A - x_2^A)$ which tends to make its reaction curve flatter, and in the extreme case, may even make it negative, at least for a range of prices, that is, firm A would lower its price in reaction to a price increase by firm B. While a negatively sloped reaction curve is theoretically possible, we will ignore this “perverse” case in the analysis that follows.¹⁰

However, the fact that debt may change the slope of the reaction curve (as well as shift it) is important and provides some insights, as we later demonstrate. The intuition for this change in the slope of the reaction curves is as follows: Suppose firm A has risky debt. If firm B raises its price, it makes firm A more profitable, causing its borrowing costs to decline. The fact that firm B has raised its price makes firm A also want to raise its price, however, the fact that its borrowing costs are lower makes firm A want to lower its price to gain market share. This changes the slope of firm A's reaction function.

Before concluding this section it should be noted that in contrast to the one-period models, [e.g., Brander and Lewis (1986)], the effect that debt has on pricing in our two-period model is robust with respect to the nature of the competition, that is, Bertrand or Cournot. In other words, a firm responding to a takeover threat can assess how an increase in its debt ratio affects its competitive position without specifying whether competition can

¹⁰ If B's reaction function is negatively sloped at the equilibrium prices, then a leverage increase by A will still result in a price increase for A, however, B's price will drop. While this is consistent with the observed empirical fact that prices may sometimes drop following an LBO, it is inconsistent with the fact that such declines generally occur when the rivals are relatively unleveraged.

be described by the Bertrand or Cournot models. To see this, consider how the model would change if firms choose quantities rather than prices. Relabel the strategic variables p_i as quantities q_i . Now in Equation (2), $\frac{\partial \sigma^i}{\partial q_1^i} > 0$, since higher first-period quantity *ceteris paribus* means higher first-period market share. $\frac{\partial x_2^i}{\partial \sigma^i} > 0$ as before. Hence $\frac{\partial x_1^i}{\partial q_1^i} < 0$, that is, the firms overproduce in the first period to grab market share. Comparing with Equation (9), it is clear that with debt, the term $\frac{\partial x_1^i}{\partial q_1^i}$ is less negative, suggesting that first-period output will be lower and prices higher with debt. An analogous result to Proposition 1 can be stated in this case.

In the next section, we examine how competitive considerations affect capital structure choices. On this issue, the implications of our model do depend on the nature of competition. With price competition, an increase in the debt ratio of one firm can make both firms more profitable. As we shall examine in detail in Section 1.3 and in Section 2, this causes firms to use debt financing in equilibrium, even in the absence of other costs and benefits of debt financing. However, with quantity competition, the firm undergoing a leverage increase will lose market share to the rival and become less profitable. This follows from the notion that while prices are strategic complements, quantities are strategic substitutes [see Bulow, Geanakoplos, and Klemperer (1985)]. Hence, with quantity competition, firms will be all-equity financed in the absence of other benefits associated with debt.

1.3 The optimal choice of debt

Up to this point we have treated debt as an exogenous variable. This is appropriate given our motivation, discussed in the introduction, of analyzing the effect of debt changes arising from exogenous takeover threats. However, to explore how the competitive forces described in the last section affect financing choices, we will initially assume that there are no takeover threats, as well as no other costs and benefits of debt financing, like taxes and financial distress costs, and endogenize the capital structure choice. In Section 3 we will examine how exogenous takeover threats can result in changes in optimal leverage ratios and how this in turn can affect pricing choices.

The capital structure choice is examined within a setting where the two firms simultaneously set their debt levels at an initial date, and then, knowing each other's capital structure, they set their prices. We assume that the firms pick capital structures that maximize the sum of the proceeds of the debt offerings and the market values of their equity.

The value of the debt issued in the initial period is

$$d_0 = d[1 - F(d - x_2)] + \int_0^{d-x_2} (\tilde{I} + x_2) dF$$

$$= d[1 - F(d - x_2)] + \int_0^{d-x_2} \tilde{I} dF + x_2 F(d - x_2). \quad (11)$$

The market value of firm A can then be obtained by adding the above expression to the equity value given in Equation (5):

$$\begin{aligned} V^A(d^A, d^B) = & x_1^A(p_1^A(d^A, d^B), p_1^B(d^A, d^B)) \\ & + x_2^A(\sigma^A(p_1^A(d^A, d^B), p_1^B(d^A, d^B))) \\ & + E\tilde{I} - I, \end{aligned} \quad (12)$$

and similarly for firm B. Differentiating this expression w.r.t. d^A , we get

$$\begin{aligned} \frac{dV^A}{d(d^A)} = & \left[\frac{\partial x_1^A}{\partial p_1^A} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \right] \cdot \frac{dp_1^A}{d(d^A)} \\ & + \left[\frac{\partial x_1^A}{\partial p_1^B} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^B} \right] \cdot \frac{dp_1^B}{d(d^A)}. \end{aligned} \quad (13)$$

The following can now be shown:

Proposition 2. *If each firm's profit is increasing in its rival's price when it is equity financed, then in equilibrium, both firms will include some debt in their capital structures.*¹¹

Proof. Suppose w.l.o.g. that firm A is completely equity financed. The first bracketed expression in Equation (13) is then zero, by virtue of Equation (9) [which is the same as Equation (2) in this case]. However, the second bracketed expression is the derivative of its profit with respect to firm B's price, and is assumed positive. From Proposition 1, $\frac{d(p_1^B)}{d(d^A)} > 0$, irrespective of whether B is debt financed or not. Hence $\frac{dV^A}{d(d^A)} > 0$, and consequently firm A must choose debt. An identical argument applies to firm B. ■

Discussion (i) The assumption that firm i 's profit is increasing in firm j 's price is justified in standard models of price competition if the goods are substitutes. However, in our context, the requirement is somewhat stronger. This is so because while the second term in $\left[\frac{\partial x_1^A}{\partial p_1^B} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^B} \right]$ is positive given our assumptions, the first term could be negative if, for example, the price firm A charges in period 1 is below its marginal cost (which is consistent with overall positive profits in a two-period model). In this case, an increase

¹¹ If contrary to Assumption 2, reaction functions are not upward sloping throughout with debt (but upward sloping when a firm is equity financed), then asymmetric equilibria with only one of the firms choosing debt are possible.

in firm B's price could increase market share and *lower* period-one profits for firm A. However, in spite of this, in most models of pricing for market share, the overall effect of an increase in the rival's price will still be positive when firm A is equity financed and responds optimally to its rival's price. For example, suppose we have $\frac{\partial \sigma^A}{\partial p_1^B} = -\frac{\partial \sigma^A}{\partial p_1^A} > 0$, and each customer buys one unit of the good. Let's write $x_1^A(p_1^A, p_1^B) = x_1^A(p_1^A, \sigma^A(p_1^A, p_1^B))$. Then $x_{1,1}^A > 0$, where $x_{1,i}^A$ denotes the partial derivative of $x_1^A(p_1^A, \sigma^A(p_1^A, p_1^B))$ with respect to its i th argument. The optimal choice of p_1^A implies [rewriting Equation (2)]:

$$x_{1,1}^A + x_{1,2}^A \cdot \frac{\partial \sigma^A}{\partial p_1^A} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} = 0. \quad (14)$$

Since $x_{1,1}^A > 0$, it follows that

$$x_{1,2}^A \cdot \frac{\partial \sigma^A}{\partial p_1^A} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} < 0. \quad (15)$$

Now, notice that

$$\frac{\partial x_1^A}{\partial p_1^B} = x_{1,2}^A \cdot \frac{\partial \sigma^A}{\partial p_1^B},$$

so that the term $[\frac{\partial x_1^A}{\partial p_1^B} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^B}]$ becomes

$$x_{1,2}^A \cdot \frac{\partial \sigma^A}{\partial p_1^B} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^B}. \quad (16)$$

Since $-\frac{\partial \sigma^A}{\partial p_1^A} = \frac{\partial \sigma^A}{\partial p_1^B} > 0$, it follows from Equation (15) that the expression in Equation (16) is positive.

(ii) The two terms in Equation (13) represent the marginal cost and benefit of debt, respectively. We argued above that the second expression can be expected to be positive at least for small levels of debt. For $d > 0$, the first bracketed expression in Equation (13) is negative and equal to $\frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot F(d^A - x_2^A) \cdot \frac{dp_1^A}{d(d^A)}$ [this follows immediately from Equation (9)]. An interior optimum obtains when this marginal cost equals the marginal benefit. In Section 2, for a specific example, the interior optimal level of debt is derived.

What the second term in Equation (13) shows is that the benefit of debt comes from the strategic effect of debt on the rival's pricing strategy. Pre-existing senior debt raises the cost of new borrowing and thus reduces the incentive to gain market share by lowering price. Since prices are strategic complements, this credible commitment to a higher first-period price causes

the rival to raise its price, which is beneficial. As we show in Section 2, a firm's incentive to increase debt increases when the rival's price responds more to the firm's leverage increase.

Now consider the first term, which reflects the cost of debt created by the distortion in the firm's pricing strategy. For a given price set by the rival, debt financing, by raising the discount rate, causes the firm to set a price higher than the value maximizing optimum. As noted above, this cost is proportional to the bankruptcy probability, since the latter determines the discount rate. However, close to the optimum when the firm is equity financed, this cost is almost zero; hence, a small amount of debt is always beneficial.

In *symmetric equilibria*, firms choose the same level of debt and charge the same price. The following result is shown in the Appendix:

Proposition 3. *In a symmetric equilibrium, the value of each firm is higher than it would be if they were not able to use debt financing. However, the values are lower than they would be if the firms could collude to pick the debt levels that lead them to charge the joint profit maximizing price.*

Proof. See the Appendix.

The above proposition indicates that firms in an industry would benefit if they could collude and each choose higher debt ratios than they would independently choose. Similarly, firms can benefit from takeover threats and other external forces that may motivate firms throughout the industry to increase their debt ratios and thereby raise their prices.

2. A Switching Cost Model

At this point it is useful to introduce a specific model to address a broader set of issues. In particular we will present a model that provides closed-form solutions for both the market shares and the prices of the rival firms. For this more explicit model we demonstrate that the regularity conditions assumed in the last section hold for a range of parameter values. In addition, the model also allows us to explicitly derive symmetric equilibrium debt levels, and provides the basis for our analysis in Sections 3 and 4.

Our analysis is based on a simple switching cost model described in Klemperer (1993). The model assumes that the products are somewhat different, with exogenous tastes (for the differences) determining consumer demands in period 1. In period 2, these initial taste differences no longer play a role in determining demands, however, consumers bear a cost associated with switching products. In period t ($t = \{1, 2\}$), each of N consumers, subject to a reservation price of r , buys K_t units of the product. Consumers are uniformly distributed along a line segment $[0,1]$, with firms A and B located at 0 and 1, respectively. To buy the product, consumers bear

“transportation costs,” which depend on where the consumers are located relative to the seller. A consumer at y bears a transportation cost of Ty when buying from A, and $T(1 - y)$ when buying from B. Thus a consumer at y buys from A if and only if

$$p_1^A + Ty \leq p_1^B + T(1 - y),$$

which reduces to

$$y \leq 1/2 + \frac{p_1^B - p_1^A}{2T}.$$

Hence

$$\sigma^A = 1/2 + \frac{p_1^B - p_1^A}{2T}.$$

In the second period, consumers develop switching costs. If the switching cost s satisfies $s > \sigma(r - c)$, where c is the unit cost of production, then the unique second-period equilibrium is one where each firm charges the price r [see Klemperer (1993)].

The number of customers N plays no direct role in our analysis, so without any loss of generality, we set $N = 1$ for the rest of the analysis. Thus the two-period profit of an all-equity firm is

$$V^i = (p_1^A - c)\sigma^A K_1 + (r - c)\sigma^A K_2.$$

For the case of the all equity firm, Klemperer (1993) demonstrates that this switching cost model has the standard properties of stable and upward sloping reaction functions. The following result demonstrates that when the firm is debt financed, these properties continue to hold under reasonable conditions.

Proposition 4. *Suppose that the random variable $\tilde{I}$ is distributed uniformly over the interval $[0, \bar{I}]$. For the switching cost model, (i) the reaction functions are positively sloped for all levels of debt provided $2TK_1\bar{I} > (r - c)^2 K_2^2$, (ii) are flatter (meaning less responsive to changes in the other firm’s price) when the firm is leveraged rather than equity financed, and (iii) reaction function stability holds.¹²*

The switching cost model introduced in this section is useful for understanding the determinants of the symmetric industry equilibrium debt levels.

Proposition 5. *Consider the switching cost model and assume that the distribution of the random variable $\tilde{I}$ is uniform over $[0, \bar{I}]$ and the reaction*

¹² It is also worth noting that second-order conditions corresponding to Equation (10) require $4TK_1\bar{I} > (r - c)^2 K_2^2$.

functions are upward sloping. The symmetric equilibrium debt level is given by¹³

$$d = \left(\frac{K_1}{K_2} \right) \cdot \left(\frac{T}{r - c} \right) \cdot \bar{I}. \quad (17)$$

Proof. See the Appendix.

The following comparative statics follow directly from Equation (17):

1. *Ceteris paribus, the symmetric equilibrium level of debt is higher the lower is the period two demand (K_2).*

This result is consistent with the observation that leveraged buyouts occur primarily in industries that do not have strong growth prospects. This follows from the fact that increased debt causes the firm to lose market share, which is costlier when second-period demand is higher.

2. *Ceteris paribus, the greater the product differentiation in period one, or the more inelastic the demand (higher T), the higher is the debt.*

When demand is more inelastic the benefit associated with committing to a higher price is less. This means that industries in which competition is more intense should have less debt, which is consistent with a finding by Spence (1985).

A third influence on the industry debt level is $\bar{I}$, which is proportional to the expected liquidation values, $\frac{\bar{I}}{2}$. Notice that because we are looking at a symmetric industry equilibrium, $\bar{I}$ should be interpreted as an industry characteristic rather than a firm-specific one. Equation (17) then implies that

3. *Industries in which assets have higher liquidation values have higher debt.*

This result is consistent with the empirical result reported in Rajan and Zingales (1995) that the average debt ratios are higher in U.S. industries (identified by their two-digit SIC codes) with more tangible assets.

An increase in the expected liquidation value has two effects. Notice that since it is an industry characteristic, it lowers the discount rate of both firms. Thus, for firm A, it increases the rival firm's second-period market share since it lowers its discount rate. This makes B less inclined to raise its price following leverage increases by the other firm, and lowers the marginal benefit from debt to A. On the other hand, it lowers A's own probability of default, and hence lowers its cost of debt. For the case of the uniform distribution, the latter effect dominates, but with other distributions, this could be reversed.

¹³ It is worth pointing out that we are assuming $\frac{1}{2}K_2(r - c) < d < \frac{1}{2}K_2(r - c) + \bar{I}$ in deriving this expression, that is, the probability of default is between zero and one.

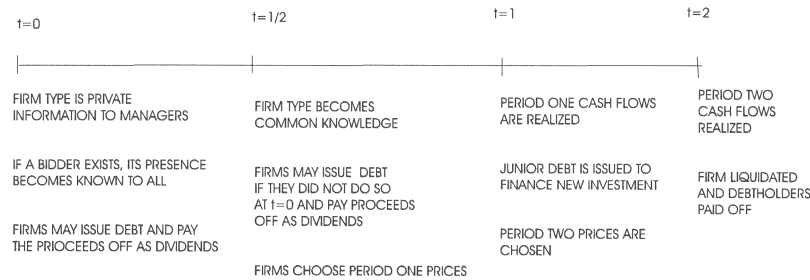


Figure 2
Time line for the signaling model

3. Leverage Increases as a Takeover Defense

Although we have shown how product market and financing strategies interact, the model developed up to this point cannot explain the large leverage changes observed in the empirical studies described earlier. In this section we extend our model to allow for changes in leverage triggered by outside control events and show that the basic intuition developed in Section 1 continues to hold.

As mentioned earlier, many of the firms examined in the Phillips (1994) and Chevalier (1995) studies initiated leverage increases in response to external takeover threats. Although the academic literature includes a number of explanations for these leverage increases, the model that follows is based on the idea that when firms are subject to external takeover threats, their managers have incentives to take actions which convey favorable information to market participants [see Stein (1988)]. In the case we consider, target firms convey favorable information by increasing their leverage to a level that exceeds the debt levels described in the previous section. Firms in this model trade off the information benefits of debt (i.e., the elimination of an unwanted takeover) against the costs that arise from the distortion of their product strategy (see Figure 2).

As before, firm A (the potential target) faces a rival firm (firm R) with which it competes. At $t = 0$, shareholders as well as a potential bidder — if present — are unaware of the true quality of firm A, which could be high (H) or low (L). The managers of the firm, however, who run the firm in the interest of their shareholders, do know the quality. The difference between the high and the low quality firm is due entirely to differences in operational efficiency. We assume that the fixed cost of production in period i , $i = 1, 2$, for the low quality firm is $z_i > 0$, while that of the high quality firm is zero. The ex ante probability that the firm type is high is $\pi \in (0, 1)$. There is no uncertainty about the rival firm's type, and to focus attention on how

firm A's financing choice is affected by the presence of the bidder, we shall assume that the rival is completely equity financed.

Period 1 production occurs at time $t = \frac{1}{2}$, at which time its type becomes common knowledge. If the firm did not issue debt at $t = 0$, then at this time it has another opportunity to raise debt and pay it out as dividends. As before, period 1 cash flows are realized at $t = 1$, and an investment need of I , which exceeds period 1 cash flows, has to be financed in part by issuing new junior debt. Finally, period 2 cash flows and the random liquidation value are realized at $t = 2$, and debt-holders are paid off.

We assume that a potential bidder may arrive just prior to $t = 0$. If the bidder does arrive, it can purchase the target at a price just slightly above the firm's perceived market value as an independent entity. If the bidder successfully acquires the firm, it will have the same operational efficiency as the type L target firm, but will have a synergy gain of $\epsilon > 0$ net of bidding and other transaction costs of the takeover. The synergy gain is assumed to be sufficiently small that it is not worthwhile for the bidder to acquire a firm at a price that equals or exceeds the value of the high quality firm; however, since the synergy benefit is positive, it is attractive to purchase a firm for a price equal to the value of the low quality firm.

In this setting, if an external bidder does arrive at $t = 0$, the high-type target has an incentive to signal its type to prevent being taken over at an unattractive price. As we show, issuing a large amount of debt is a credible signal in this case.¹⁴ If, however, an external bidder does not exist at $t = 0$, then in equilibrium, both firms, regardless of type, issue debt at $t = \frac{1}{2}$, when firm type becomes common knowledge. This (full-information) debt level for the high type is lower than the separating debt level that it chooses when the bidder exists at $t = 0$. Thus the need to provide information to the shareholders necessitated by the presence of a potential bidder provides a rationale for the high-type target taking on a large amount of debt.

The results outlined above can be illustrated within the context of a simple example. In particular, we consider the switching cost model introduced in Section 2, with the following parameter values: $K_1 = K_2 = \bar{I} = 1$, $T = \frac{1}{2}$, and $r - c = 1$, where c is the marginal production cost in each period for both firm types. Further, let $z_1 = z_2 = 0.035$. For this example we show the following:

Proposition 6. (i) *If the bidder does not appear at $t = 0$, there exists an equilibrium where both types issue senior debt only at $t = \frac{1}{2}$. The high-type firm chooses a level of debt $d^H = 0.75$ and the low-type firm chooses $d^L = 0.715$.*

¹⁴ Managers, acting in the interest of shareholders, are assumed to maximize the market value of debt plus the intrinsic value of equity. The latter could differ from the market value of equity for a mimicking low-type firm. Our analysis would not change significantly if we allowed managers to maximize the market value of debt plus some weighted average of the market and intrinsic values of equity.

(ii) If the bidder appears with a positive synergy gain ϵ , there exists a continuum of separating equilibrium in which both types issue debt at $t = 0$. Each equilibrium is characterized by a distinct target debt level of d_e such that (a) $d_e \geq 1$, (b) the high quality firm chooses $d^H = d_e$, or (c) the low quality firm A chooses $d^L = 0.715$. In equilibrium, the low quality firm is sold to the bidder for its market value and the high quality firm remains independent.¹⁵

Proof. See the Appendix.¹⁶

To understand how debt works as a signal in this example, consider the incentives of the low quality firm to mimic. The low quality firm can potentially gain from mimicking the high-valued firm since this enables it to borrow at a lower rate. Hence the high quality firm cannot signal its type by borrowing only a trivial amount more than the low quality firm would otherwise borrow, since the low quality firm's gain from mimicry in this case would be strictly positive, but its cost would be close to zero. There is, however, a cost associated with choosing a debt level that is significantly higher than the debt level it would otherwise choose, since doing so distorts its pricing choice in period 1. The high-type firm is willing to bear the costs associated with this distortion to avoid being taken over at too low a price. It should be stressed, however, that the low quality firm neither gains or loses by signaling to the raider, since its shareholders are indifferent about remaining independent on the one hand, and alternatively, selling at its true value. One could generalize this model to allow the target managers to experience some disutility from selling to the raider, but this would not change the overall results since the high quality firm will still have a greater incentive to signal its type.¹⁷

4. The Stackelberg Model and Predatory Pricing

An important aspect of the previously discussed empirical results that our model does not capture is the fact that prices sometimes drop following large increases in leverage. As we showed previously, increased leverage

¹⁵ The beliefs that support this separating equilibrium are (i) if a bidder does not exist at $t = 0$, then a firm issuing debt at $t = 0$ is a low-type firm, and (ii) if a bidder does exist at $t = 0$, and if a firm chooses $d < d_e$, then its type is low; otherwise, the firm type is high.

¹⁶ We have focused only on separating equilibrium here. In general, pooling equilibria may also exist in this model. However, it is easy to show that for a range of π , there exist values of ϵ such that the above separating equilibria exist, but pooling equilibria do not.

¹⁷ Moreover, as long as management has a *slight* disutility of selling to a raider, it would be impossible for a high type to separate from the low type by simply announcing that its type is high, as the low type would always mimic. Another reason why such nondissipative signalling will not work in this context is that the management might assign some weight to the market value of equity at $t = 0$, as in some dividend signalling models. In this case also, the low type will have an incentive to mimic the high-type's announcement.

has the effect of shifting a firm's reaction curve and changing its slope (Propositions 1 and 4). Up to this point we have focused on the shift in the reaction curves which imply that prices should increase. In this section we show that, depending on the nature of competition in the particular market, prices can drop with an increase in leverage if the slope of the reaction curve changes sufficiently.

To understand why the slope of the reaction curve can be important, consider the following scenario: firm R (the rival) observes that firm A has substantially increased its leverage and notes that, as a result, firm A will be less willing to protect its market share in the presence of increased competition since it discounts future profits at a higher rate. Observing this, firm R lowers its price and successfully steals some of firm A's customers.

The model presented in the earlier sections does not capture the above intuition since the Nash equilibrium requires that the firms set their prices simultaneously while the above story implicitly assumes that the firms react to each other's prices and take into account the other firm's entire reaction curve rather than just its price. In this case, the fact that the slope of the reaction curve changes with increased debt is important since the magnitude of a firm's reaction to a price change affects the decision of its rival. Although it is beyond the scope of this article to model this kind of dynamic price process, we can capture at least part of this intuition in a simple Stackelberg model.

The effect of a change in firm A's leverage is shown in Figure 3. The rival, assumed to be the Stackelberg leader, observes firm A's reaction curve and selects its price accordingly. Firm A, the Stackelberg follower, selects its price after observing its rival's price. As we have seen, the leverage increase makes firm A's reaction curve flatter, which tends to lower the Stackelberg price. However, debt also shifts firm A's reaction function up. Since the leader's isoprofit curve also becomes flatter as one moves vertically up from the initial equilibrium point, whether the leader lowers its price depends on the extent of the shift as well as the flattening of the follower's reaction curve. Specifically, we have the following proposition:

Proposition 7. *Consider the switching cost example with a uniform distribution for $\tilde{I}$, and assume that one firm is a Stackelberg price leader and the other the follower.*

(i) If the firms are otherwise identical and entirely equity financed, then the Stackelberg leader's price will be higher than the follower's.

(ii) Suppose the Stackelberg follower undergoes a leverage increase. There exist parameter values for the switching cost model such that for a range of the follower's debt level, the Stackelberg leader's price will be lower than the price it sets when both firms are equity financed.

(iii) For such a level of debt, the follower's price may be either higher

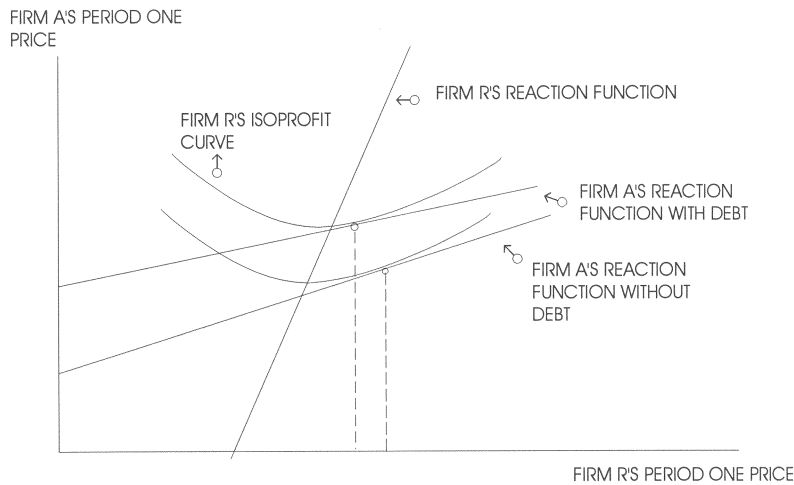


Figure 3
The Stackelberg Case

This figure illustrates the case where firm R, the Stackelberg leader, changes its price in response to an increase in debt by firm A, the Stackelberg follower. In the case illustrated, firm R's price, determined at the intersection of firm R's isoprofit curve and firm A's reaction curve, declines when firm A increases its debt. This should be contrasted with the Cournot case where an increase in firm A's debt leads to an increase in both firms' prices, which is illustrated by the intersections of the reaction curves.

or lower than under equity financing, and could be either higher or lower than the leader's price.

(iv) If the leader is leveraged, both prices will be higher than if the leader were completely equity financed.

Proof. See the Appendix.

We previously argued, within the context of a Nash model, that an increase in leverage induced by the appearance of a corporate raider could increase industry profits by increasing product market prices. However, in a Stackelberg model, this need not be the case. The appearance of a corporate raider, which leads to increased leverage, can, in this case, lead to decreased prices and profits.¹⁸

5. Conclusion

The primary goal of this article is to provide a framework for understanding the recent empirical studies of pricing choices following leveraged buyouts.

¹⁸ An extension of our Section 3 analysis to include the Stackelberg case is available from the authors on request.

Our main emphasis was on the findings of Chevalier (1995) and Phillips (1994), who found that product prices tended to increase after LBOs, with important exceptions occurring when the industry rivals of the LBO firms were relatively unlevered.

The price increases following LBOs are straightforward to explain within the context of a two-period Nash model where firms benefit at date 2 from obtaining a higher market share in date 1. It follows that firms will price their products less aggressively at the earlier date, gaining market share at the expense of date 1 profits, if their borrowing costs are higher, which will be the case following a substantial leverage increase. In this case, since prices are strategic complements, the LBO firm's Nash rival will also raise its price.

Under Nash price competition, firms have an incentive to commit to a less aggressive pricing policy since the commitment will induce the firm's rivals to also price less aggressively. This is not necessarily the case, however, if the firm is a Stackelberg follower. A Stackelberg leader may see a rival's commitment to a less aggressive pricing strategy, arising from its leverage increase, as offering it an opportunity to steal market share at a reduced cost. This tendency to steal market share will be higher for the less leveraged leader, which places a higher value on the long-term benefits of the increased market share.

We started this article by asking whether competitive considerations affect whether firms use debt as part of their takeover defenses. The analysis suggests that competitive considerations sometimes encourage firms to add debt while in other cases, these considerations tilt firms away from increased debt. The above considerations suggest that one should be cautious about making general statements about how leverage affects pricing decisions based on empirical studies of firms that implement LBOs. Although debt can have positive as well as negative effects on product prices, we are more likely to observe LBOs in those cases where higher product market prices arise as a result of increased leverage. To test the more general relation between debt and product prices it may be more appropriate to examine price changes induced by exogenous leverage changes, perhaps imposed as a result of an external shock, like an industry downturn.¹⁹

Appendix

Proof of Proposition 1. First, notice that Equation (2) which corresponds to the case of a firm being equity financed, can be viewed as a special case

¹⁹ A recent Chevalier and Scharfstein (1996) article takes this approach, relating the prices charged at different supermarkets with exogenous business cycle variables that are likely to affect the supermarkets' financial conditions.

of Equation (9) with $F(d - x_2) = 0$. Totally differentiating Equation (9) and the analogous one for firm B, we get

$$\begin{aligned}\Pi_{AA}^A dp_1^A + \Pi_{AB}^A dp_1^B &= \left[f(d^A - x_2^A) \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \right] d(d^A) \\ \Pi_{BA}^B dp_1^A + \Pi_{BB}^B dp_1^B &= \left[f(d^B - x_2^B) \frac{\partial x_2^B}{\partial \sigma^B} \cdot \frac{\partial \sigma^B}{\partial p_1^B} \right] d(d^B).\end{aligned}\quad (18)$$

Note that if a firm is equity financed, the corresponding right-hand side in the above equation is zero. Denote $\Delta = \Pi_{AA}^A \Pi_{BB}^B - \Pi_{AB}^A \Pi_{BA}^B$, and to see the effect of a leverage change by firm A, set $d(d^B) = 0$. We have

$$\frac{dp_1^A}{d(d^A)} = \frac{\Pi_{BB}^B \cdot \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot f(d^A - x_2^A)}{\Delta} \quad (19)$$

and

$$\frac{dp_1^B}{d(d^A)} = \frac{-\Pi_{BA}^B \cdot \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot f(d^A - x_2^A)}{\Delta}. \quad (20)$$

By Assumption 2, $\Delta > 0$. Since $\Pi_{BB}^B < 0$ by virtue of the second-order conditions corresponding to Equation (9), we get $\frac{dp_1^A}{d(d^A)} > 0$. Similarly, from Assumption 2, Π_{BA}^B is positive. Hence $\frac{dp_1^B}{d(d^A)}$ is positive.

Finally, note that if the firms are symmetric, then reaction function stability implies that B's reaction function when it is equity financed can intersect the 45-degree line only once (at this point, it will also intersect the reaction function of A when the latter is equity financed). Thus the new intersection point when A's reaction function shifts out as A takes on risky debt must be below the 45-degree line. ■

Proof of Proposition 3. From Proposition 1, it follows that in a symmetric equilibrium with debt, each firm sets a higher first-period price than those corresponding to a completely equity financed industry. In symmetric equilibrium, the market share and consequently the second-period prices are unchanged. Thus the result follows if the common symmetric equilibrium price is less than the common price that maximizes first-period joint profit $2 \cdot x_1(p, p)$ (and provided this latter function is concave in p — which we assume). The joint first-period profit-maximizing price is given by the condition $D_1 x_1(p, p) + D_2 x_1(p, p) = 0$, where D_i represents the derivative with respect to the i th argument, $i = 1, 2$. However, from Equation (9), it follows that at the symmetric equilibrium $D_1 x_1(p, p) > 0$. Hence, at the symmetric equilibrium prices, $D_1 x_1(p, p) + D_2 x_1(p, p) > 0$, since $D_2 x_1(p, p) > 0$ for all p . Thus, from the assumed concavity of $x_1(p, p)$

in p , it follows that the symmetric equilibrium price is less than the joint first-period profit-maximizing price. Since the second-period profits are functions only of the first-period market shares, and the latter are the same when both firms set the same price, the result follows. ■

Proof of Proposition 4. We first derive expressions for Π_{AA}^A , Π_{BB}^B , Π_{AB}^A , and Π_{BA}^B , and the slopes of the reaction functions. The first-order condition corresponding to Equation (8) for firm A is

$$-\frac{(p_1^A - c)K_1}{2T} + K_1 \left[1/2 + \frac{p_1^B - p_1^A}{2T} \right] - \frac{(r - c)K_2}{2T} \left[1 - \frac{d^A - (r - c)K_2 \left[1/2 + \frac{p_1^B - p_1^A}{2T} \right]}{\bar{I}} \right] = 0. \quad (21)$$

Let us denote this by $\Pi_A^A = 0$. The slope of A's reaction function is given by $\frac{\Pi_{AB}^A}{-\Pi_{AA}^A}$.

Differentiating, we get

$$\Pi_{AA}^A = -\frac{K_1}{2T} - \frac{K_1}{2T} + \frac{(r - c)^2 K_2^2}{4T^2 \bar{I}} = -\frac{K_1}{2T} \left[2 - \frac{(r - c)^2 K_2^2}{2TK_1 \bar{I}} \right]$$

and

$$\Pi_{AB}^A = \frac{K_1}{2T} - \frac{(r - c)^2 K_2^2}{4T^2 \bar{I}} = \frac{K_1}{2T} \left[1 - \frac{(r - c)^2 K_2^2}{2TK_1 \bar{I}} \right].$$

Thus the slope of A's reaction function is

$$\frac{dp_1^A}{dp_1^B} \Big|_A \equiv \rho'^A = \frac{1 - \frac{(r-c)^2 K_2^2}{2TK_1 \bar{I}}}{2 - \frac{(r-c)^2 K_2^2}{2TK_1 \bar{I}}} \quad (22)$$

and that of B is similarly obtained as

$$\frac{dp_1^B}{dp_1^A} \Big|_B \equiv \rho'^B = \frac{1 - \frac{(r-c)^2 K_2^2}{2TK_1 \bar{I}}}{2 - \frac{(r-c)^2 K_2^2}{2TK_1 \bar{I}}}. \quad (23)$$

Notice that second-order conditions require the denominators to be positive. Thus the reaction functions are positively sloped iff the numerators are positive. It is also straightforward to check that firm B (A) changes its price less in response to a change in firm A's (B's) price compared to the case in which it is equity financed, for which the reaction function has a

slope of $\frac{1}{2}$. Also, notice that reaction function stability requires

$$\left. \frac{dp_1^B}{dp_1^A} \right|_A > \left. \frac{dp_1^B}{dp_1^A} \right|_B,$$

which is equivalent to

$$\frac{2 - \frac{(r-c)^2 K_2^2}{2TK_1\bar{I}}}{1 - \frac{(r-c)^2 K_2^2}{2TK_1\bar{I}}} > \frac{1 - \frac{(r-c)^2 K_2^2}{2TK_1\bar{I}}}{2 - \frac{(r-c)^2 K_2^2}{2TK_1\bar{I}}},$$

which requires $\frac{(r-c)^2 K_2^2}{2TK_1\bar{I}} < 3/2$, and is satisfied when the reaction functions are positively sloped. ■

Proof of Proposition 5. Here we derive the expression for the symmetric industry equilibrium level of debt [Equation (17)]. Since we are looking for symmetric equilibrium levels, we shall drop the superscripts for firm types, and we shall require the market share for each firm to be equal to 1/2 (i.e., $\sigma^A = \sigma^B = 1/2$).

The first-order condition for equity value maximization [Equation (9)] can then be written as

$$-\frac{(p_1 - c)K_1}{2T} + \frac{K_1}{2} - \frac{(r - c)K_2}{2T} \left[1 - \frac{d - (r - c)K_2/2}{\bar{I}} \right] = 0. \quad (24)$$

The first-order condition for firm value maximization is obtained by setting Equation (13) to zero. Using Equation (9), this reduces to

$$\frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot F(d^A - x_2^A) + \left[\frac{\partial x_1^A}{\partial p_1^B} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^B} \right] \cdot \frac{d\rho^B(p_1^A)}{d(p_1^A)} = 0.$$

This reduces to

$$\begin{aligned} 0 = & -\frac{(r - c)K_2}{2T} \left[\frac{d}{\bar{I}} - \frac{(r - c)K_2}{2\bar{I}} \right] \\ & + \left[\frac{(p_1 - c)K_1}{2T} + \frac{(r - c)K_2}{2T} \right] \rho'(p_1), \end{aligned} \quad (25)$$

where $\rho'(p)$ denotes the slope of the other firm's reaction function. Substituting from Equation (24) and simplifying, this reduces to

$$\left[\frac{d}{\bar{I}} - \frac{(r - c)K_2}{2\bar{I}} \right] \left[\frac{1}{\rho'} - 1 \right] = \frac{K_1}{K_2} \cdot \frac{T}{r - c}. \quad (26)$$

Now, the inverse of the slope of the reaction function was shown in the

proof of Proposition 4 as

$$\frac{1}{\rho'} = \frac{2 - \frac{(r-c)K_2^2}{2TK_1\bar{I}}}{1 - \frac{(r-c)K_2^2}{2TK_1\bar{I}}}.$$

Substituting this in Equation (26), we get after simplification

$$d = \frac{K_1}{K_2} \cdot \frac{T}{r-c} \cdot \bar{I}. \quad \blacksquare$$

Proof of Proposition 6. We first introduce some new notation. Let $\hat{p}_1^A = p_1^A - c$ and $\hat{p}_1^R = p_1^R - c$. Further, we denote by x_i^H profits in period i , $i = 1, 2$, for the high-type firm A. For the low-type firm A, we distinguish between profits and profits excluding fixed costs. X_i^L denotes profits in period i inclusive of the fixed costs of production, and $X_i^L = x_i^L - z_i$. Moreover, we assume that managers of the firms maximize the sum of the market value of debt and the *intrinsic* value of equity (i.e., the present value of cash flows to equity-holders), and in our statements below, we refer to this sum as the “value” of the firm.

Lemma A1. Suppose the high-type firm A choose a level of debt d^A :

(i) Period 1 product prices for firm A and its rival are, respectively,

$$\hat{p}_1^A = d^A - 1 \quad (27)$$

$$\hat{p}_1^R = \frac{d^A}{2} - \frac{3}{4}. \quad (28)$$

(ii) If the high-type firm A is believed to be high type when it issues debt, its value for a level of debt d^A is

$$\Pi^H = \frac{d^A}{4}(3 - 2d^A) + \frac{1}{2} - I. \quad (29)$$

(iii) The optimum level of debt for a high-type firm under full information is $d_{FI}^H = 0.75$ and its value is $\Pi_{FI}^H = 0.2815 + \frac{1}{2} - I$.

Proof. Before the price is set by firm A, its type becomes known. The first-order condition for the optimal choice of price p_1^A , for any price p_1^R set by firm R, is given by the following condition obtained analogously to Equation (21):

$$-(p_1^A - c) + \left[\frac{1}{2} + (p_1^R - p_1^A) \right] - \left[1 - d^A + \frac{1}{2} + p_1^R - p_1^A \right] = 0,$$

which can be equivalently expressed as

$$-\hat{p}_1^A + \left[\frac{1}{2} + (\hat{p}_1^R - \hat{p}_1^A) \right] - \left[1 - d^A + \frac{1}{2} + \hat{p}_1^R - \hat{p}_1^A \right] = 0.$$

Simplifying, we get

$$\hat{p}_1^A = d^A - 1, \quad (30)$$

that is, firm A's reaction function if it has risky debt is flat.

Similarly, firm R, if it is equity financed, chooses p_1^R to maximize

$$(p_1^R - c + 1) \left[\frac{1}{2} + p_1^A - p_1^R \right],$$

which gives the first-order condition

$$-(p_1^R - c) - 1 + \frac{1}{2} + p_1^A - p_1^R = 0,$$

or equivalently

$$-\hat{p}_1^R - \frac{1}{2} + \hat{p}_1^A - \hat{p}_1^R = 0,$$

which can be written as

$$\hat{p}_1^R = \frac{\hat{p}_1^A}{2} - \frac{1}{4}.$$

Substituting for $\hat{p}_1^A$ from Equation (30), we get

$$\hat{p}_1^R = \frac{d^A}{2} - \frac{3}{4} \quad (31)$$

If the high-type firm is believed to be a high-type firm when it issues debt, the value of this firm is the sum of its two-period cash flows less the investment outlays, and is given by

$$\Pi^H(d^A) = (\hat{p}_1^A + 1) \left[\frac{1}{2} + \hat{p}_1^R - \hat{p}_1^A \right] + E(\tilde{I}) - I \quad (32)$$

$$= \frac{d^A}{4} [3 - 2d^A] + E(\tilde{I}) - I. \quad (33)$$

The result now follows from the fact that $E(\tilde{I}) = \frac{1}{2}$, given the assumption that $\tilde{I}$ is distributed uniformly over the unit interval. ■

Lemma A2. Suppose the low-type firm A choose a level of debt d^A :

(i) Period 1 product prices for firm A and its rival are, respectively,

$$\hat{p}_1^A = d^A + z_2 - 1 \quad (34)$$

$$\hat{p}_1^R = \frac{d^A + z_2}{2} - \frac{3}{4} \quad (35)$$

(ii)(a) If the low-type firm A is believed to be low type when it issues debt, its value for a level of debt d^A is

$$\Pi^{LL}(d^A) = \frac{d^A + z_2}{4}[3 - 2(d^A + z_2)] - (z_1 + z_2) + \frac{1}{2} - I. \quad (36)$$

The optimum level of debt for a low-type firm under full information is $d_{FI}^A = 0.715$ and its value is $\Pi_{FI}^A = 0.2815 + \frac{1}{2} - (z_1 + z_2) - I$.

(b) If the low type is believed to be a high type when it issues debt, then its value for a level of debt d^A is

$$\begin{aligned} \Pi^{LH}(d^A) = & \frac{1}{2} \left(\frac{3}{2}(d^A + z_2) - \frac{3}{4} \right)^2 - \frac{1}{2} \left(\frac{3}{2}d^A - \frac{3}{4} \right)^2 \\ & + \frac{d^A + z_2}{4}[3 - 2(d^A + z_2)] - (z_1 + z_2) + \frac{1}{2} - I. \end{aligned} \quad (37)$$

Proof. Part 1. The first-order condition for the low-type firm A's choice of p_1^A is given by

$$-(p_1^A - c) + \left[\frac{1}{2} + (p_1^R - p_1^A) \right] - \left[1 - d^A - z_2 + \frac{1}{2} + p_1^R - p_1^A \right].$$

Thus, the expressions for the prices are the same as for the high-type firm A with d^A replaced by $d^A + z_2$, and Part 1 of the Proposition follows.

Part 2(a). The value under full information is the sum of the cash flows net of investment outlays. The sum of the cash flows is the same as for the high type in Equation (32), with d^A replaced by $d^A + z_2$, less $(z_1 + z_2)$. The optimum value of $d^A + z_2$ that maximizes this expression is the same as the optimum value of d^A for the high type, which is 0.75. Thus the optimum d^A for the low type is $0.75 - 0.035 = 0.715$. The full information value at the optimum level of debt is thus that for the high type less $z_1 + z_2 = 0.07$.

Part 2(b). First, notice that the market value of debt corresponding to a face value of d^A if the issuing firm is believed to be a high type is

$$d_0^H(d^A) = d^A[1 - F(d^A - x_2^H(d^A))] + \int_0^{d^A - x_2^H(d^A)} [\tilde{I} + x_2^H(d^A)]dF.$$

From the fact that $F(\tilde{I})$ is uniform over $[0, 1]$, it follows after simplification that

$$d_0^H(d^A) = d^A - \frac{(d^A - x_2^H(d^A))^2}{2}. \quad (38)$$

Next, consider the equity value of a low-type firm. We have assumed that the type of the firm will be revealed before it chooses its period 1 price. Accordingly, the equity value of a low-type firm is given by

$$\Pi_E^L = \int_{y+d^A-X_2^L(d^A)}^1 [X_2^L + \tilde{I} - d^A - y] dF,$$

where, as in Section 1, y is the face value of junior debt issued at $t = 1$ and satisfies

$$\begin{aligned} I - X_1^L(d^A) &= y[1 - F(d^A - X_2^L(d^A) + y)] \\ &\quad + \int_{d^A-X_2^L(d^A)}^{d^A+y-X_2^L(d^A)} [X_2^L(d^A) + \tilde{I} - d^A] dF. \end{aligned}$$

Substituting for y in the expression for Π_E^L and integrating, we get

$$\begin{aligned} \Pi^{LH} &= d_0^H(d^A) + \Pi_E^L \\ &= -\frac{1}{2}[(d^A - x_2^H(d^A))^2] \\ &\quad + \frac{1}{2}[(d^A - X_2^L(d^A))^2] + x_1^L(d^A) + x_2^L(d^A) - (z_1 + z_2) + \frac{1}{2} - I. \end{aligned}$$

The expression for Π^{LH} given in the proposition now follows from the fact that $x_2^H(d^A) = [\frac{1}{2} + p_1^R - p_1^A] = \frac{3}{4} - \frac{d^A}{2}$, $x_2^L(d^A) = \frac{3}{4} - \frac{d^A+z_2}{2}$ and $x_1^L(d^A) + x_2^L(d^A) = \frac{d^A+z_2}{4}[3 - 2(d^A + z_2)]$. ■

Proof of the proposition.

Part 1. If a bidder does not exist at $t = 0$ and a firm issues debt, then it is believed to be a low-type firm. Thus a low-type firm is indifferent between issuing debt at $t = 0$ and $t = 1/2$, when its type is publicly revealed. The optimal amount of debt for a low-type firm when it is believed to be a low type has been shown in Lemma A2 to be $d^L = 0.715$. A high-type firm, however, obviously suffers a mispricing loss in issuing debt at $t = 0$, and therefore prefers to issue debt at $t = 1/2$ when its type is publicly revealed. By Lemma A1, the optimal amount of debt for the high-type firm is $d^H = 0.75$.

Part 2. Let d_e be a level of debt such that if a potential bidder appears and firm A chooses $d^A \geq d_e$, it is believed to be a high type, otherwise it is believed to be a low type. These beliefs constitute an equilibrium if the

following conditions are satisfied:

$$d_e > d_{FI}^L \quad \text{and} \quad \Pi^{LL}(d_{FI}^L) \geq \Pi^{LH}(d) \quad \text{for} \quad d \geq d_e \quad (39)$$

$$\Pi^{LL}(d_{FI}^L) \leq \Pi^H(d_e) \quad (40)$$

and

$$\Pi^H(d_e) > \Pi^H(d) \quad \text{for} \quad d > d_e \quad (41)$$

Equation (39) ensures that the low-type firm A prefers not to mimic the high-type firm A. This is so because in choosing $d \geq d_e$, the low-type firm will be believed to be a high-type firm and will not be taken over, so that $\Pi^{LH}(d)$ denotes the actual payoff to the shareholders. For a similar reason, Equation (40) ensures that the high-type firm A prefers to choose $d = d_e$ rather than choose a lower level of debt and be believed to be low type — in which case the bidder will be able to acquire it for the value of a low-type firm A and shareholders will only get $\Pi^{LL}(d_{FI}^L)$. Finally, Equation (41) ensures that it is not optimal for the high-type firm A to deviate to any higher level of debt either.

We first find the level of debt at which Equation (39) holds with equality (this level of debt corresponds to the so-called lowest separating equilibrium), and show that at this level of debt, the other conditions are also satisfied. From Lemma A2, Equation (39) can be written as

$$\begin{aligned} 0.2815 = & \frac{1}{2} \left(\frac{3}{2}(d_e + z_2) - \frac{3}{4} \right)^2 - \frac{1}{2} \left(\frac{3}{2}d_e - \frac{3}{4} \right)^2 \\ & + \frac{d_e + z_2}{4} [3 - 2(d_e + z_2)]. \end{aligned} \quad (42)$$

Substituting for $z_2 = 0.035$ and solving for d_e , we get $d_e = 1.0$. Again, from Lemma A2, at this level of debt, we get $\Pi^{LL}(1) = 0.2815 + \frac{1}{2} - (z_1 + z_2) - I = 0.2115 + \frac{1}{2} - I$, whereas $\Pi^H(1) = 0.25 + \frac{1}{2} - I$. Thus Equation (40) also holds. Finally, notice that (i) $\Pi^H(d)$ is concave in d and the optimum occurs at $d = 0.75$, so that Equation (41) is satisfied, and (ii) $\Pi^{LH}(d)$ is concave in d , and its slope is negative at $d = d_e = 1$, so that Equation (39) holds for $d > d_e$ as well. ■

Proof of Proposition 7. (i) Immediate from the fact that the slope of R's isoprofit curve at the Nash equilibrium point (on the 45-degree line) is flat, whereas A's reaction curve has a positive slope.

(ii) We show this by example. Consider the switching cost model with the following parameter values: $K_1 = 0.75$, $K_2 = T = r - c = 1$, and $c = \frac{1}{3}$, and let the distribution of the random variable $\tilde{I}$ be uniform over the unit interval. Assume also that firm A's rival (the Stackelberg leader) is completely equity financed.

(a) First, suppose that firm A has risky debt. The first-order condition for firm A for p_1^R is obtained analogously to Equation (21) by substituting the relevant parameter values. We get

$$-\frac{p_1^A - \frac{1}{3}}{2} + \left[\frac{1}{2} + \frac{p_1^R - p_1^A}{2} \right] - \frac{2}{3} + \frac{2}{3} \left[d^A - \left(\frac{1}{2} + \frac{p_1^R - p_1^A}{2} \right) \right].$$

Simplifying, this reduces to

$$p_1^R - 4p_1^A + 4d^A - 2 = 0. \quad (43)$$

The rival firm R is a Stackelberg leader, and for a given d^A , it sets its price p_1^R to maximize

$$(p_1^R - c)K_1 \left[\frac{1}{2} + \frac{p_1^A(p_1^R, d^A) - p_1^R}{2T} \right] + (r - c)K_2 \left[\frac{1}{2} + \frac{p_1^A(p_1^R, d^A) - p_1^R}{2T} \right],$$

where $p_1^A(p_1^R, d^A)$ is given in Equation (43). Substituting the relevant parameter values and maximizing this with respect to p_1^R , we get

$$p_1^R = \frac{2}{3}d^A - \frac{1}{6}. \quad (44)$$

Substituting this into Equation (43), we get

$$p_1^A = \frac{7}{6}d^A - \frac{13}{24}. \quad (45)$$

(b) Now consider the case in which firm A is completely equity financed. The optimal response for firm A to a given p_1^R is given by

$$-\frac{p_1^A - \frac{1}{3}}{2} + \left[\frac{1}{2} + \frac{p_1^R - p_1^A}{2} \right] - \frac{2}{3} = 0. \quad (46)$$

The optimal Stackelberg price for firm R maximizes the following:

$$\left[\frac{3}{4} \left(p_1^R - \frac{1}{3} \right) + 1 \right] \left[\frac{1}{2} + \frac{p_1^A(p_1^R) - p_1^R}{2} \right],$$

where the function $p_1^A(p_1^R) = \frac{p_1^R}{2}$ is obtained from Equation (46). It is easily checked that the maximization yields $p_1^R = 0.5$ and $p_1^A = 0.25$.

Now, from Equation (44), it can be checked that the Stackelberg leader's price is lower when firm A has risky debt d^A compared to when firm A is completely equity financed if and only if $d^A < 1$.²⁰

²⁰ Because of the bounded support of the uniform distribution, the follower's reaction function is actually kinked when it has debt: it is flatter for low prices set by the leader for which the debt is risky and steeper

(iii) When firm A is equity financed, the optimum point is always to the right of the 45-degree line. However, it is easily checked that in Figure 3, if firm A's postleverage reaction function is sufficiently flat, then the optimum point could be to the left of the 45-degree line. In fact, for the example discussed above, the postleverage price of firm R exceeds that of firm A if and only if $d^A < 0.75$.

(iv) This follows from the fact that R's isoprofit curves will be flatter if it has higher leverage. The slope of A's isoprofit curves can be shown to be

$$\frac{dp_1^A}{dp_1^R} = \frac{\frac{(r-c)}{2T} K_2 [1 - \frac{d^R - \sigma^R (r-c) K_2}{I}] + \frac{(r-c)^2 K_2^2}{2TI} \sigma^R + \frac{p_1^R - c}{2T} K_1 - \sigma^R K_1}{\frac{(r-c)}{2T} K_2 [1 - \frac{d^R - \sigma^R (r-c) K_2}{I}] + \frac{(r-c)^2 K_2^2}{2TI} \sigma^R + \frac{p_1^R - c}{2T} K_1}.$$

It is easily checked that this is decreasing in d^R . ■

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at higher prices for which the debt is risk-free. There exists a critical level of d^A at which the Stackelberg leader is indifferent between choosing a price on the follower's reaction function at which the debt remains risk-free and a lower price at which the debt is risky. For a higher level of debt, the leader prefers to choose the lower price and the debt is risky. Thus there is a discontinuous drop in the price as the debt becomes risky. Thereafter the prices are increasing in the follower's debt as the reaction function shifts up.

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