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PRICING STRATEGY AND FINANCIAL POLICY

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ABSTRACT

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 levered firm charging higher prices on average. Notable exceptions exist when rival firms are relatively unlevered. The first observation is consistent with a relatively simple model where firms compete for market share on the basis of price. To explain the second observations (i.e. the exceptions) the model must be extended to allow for reputation effects related to product quality. The extended model illustrates how product market imperfections in combination with high leverage can make firms vulnerable to predatory pricing.

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1 Introduction

A firm's financing choices affect its overall corporate strategy in a number of important ways. Consider, for example, a firm that learns that its stock is substantially underpriced and is thinking about exploiting the situation by borrowing money to repurchase some of its shares. If the resulting capital structure change has no effect on the firm's operations, then purchasing underpriced shares improves the value of its remaining shares. However, in most cases major capital structure changes do affect how firms are operated and how they are perceived by their customers, suppliers, employees and competitors.[1].

The main focus of this paper is on how financial structure affects competition within the firm's industry. An underpriced firm might want to forego a leverage increasing share repurchase if it believes that competitors will respond to its new financial structure by aggressively cutting its prices to gain market share. However, if competitors are expected to react 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 levered firms in distressed industries lose market share to their less levered 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 effect how prices are determined in imperfectly competitive industries. Recent industry studies by Phillips (1995) and Chevalier (1995) provide more detailed evidence on how leverage affects pricing and output decisions. In 3 out of the 4 industries

[1]For example, increased leverage can force managers to increase efficiency (Grossman and Hart (1982)) and reduce their tendency to make inappropriate investments, (Jensen (1986)). However, since a levered firm is less likely to grow and is more likely to liquidate in the future, these positive changes may be offset by the fact that increased leverage can make it more difficult for the firm to attract and retain the best employees. For similar reasons, highly levered firms are less attractive to customers, suppliers and other external stakeholders, (Titman (1984) and Maksimovic and Titman (1991))

examined in Phillips (1995) prices were increased and output was reduced after one of the major players in the industry initiated a leveraged buyout. An important distinguishing feature of the Gypsum industry, where prices fell following the LBO, was the existence of a competitor which was not highly levered. 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 levered rivals. She also found that the tendency to raise prices following an LBO was related to the extent to which competitors were also highly levered.

There are a number of existing articles that examine how capital structure affects product market competition. The earliest articles on this topic present what are generally referred to as the deep pockets/predatory pricing argument (e.g., Telser (1963), Benoit (1984), Fudenberg and Tirole (1986), Brander and Lewis (1988) and Bolton and Scharfstein (1990)). These papers argue that a well-capitalized firm may choose to lower its price and take other predatory actions if by doing so it can drive its competitor out of business. A high debt ratio invites predation in these models if it is less costly to drive a highly levered firm out of business. While this assumption is plausible, it requires that the prey be unable to raise additional capital, which may make the models less applicable to the analysis of the recent LBOs which were backed by well capitalized sponsors like Kohlberg, Kravis and Roberts. In addition, the model suggests that leverage increases should be associated with increased output which is inconsistent with most of the recent empirical evidence.

The analysis in this paper is more closely tied to a second line of research which is based on the idea that leverage has an effect on the investment incentives of firms (see for example, Jensen and Meckling (1976) and Myers (1977)). For example, in Brander and Lewis (1986) and Maksimovic (1986, 1990) high leverage commits the firm to produce more since increasing output in these models increases risk which benefits the equityholders of a highly levered firm. Like the deep pockets arguments, these models also conclude that increased leverage results in increased output and lower prices.

In contrast to the Brander and Lewis and Maksimovic models, the firms in our model compete on the basis of price rather than quantities which has the advantage that it allows us to examine price dispersion within an industry. In addition, we examine a two period model as well as a one period model which allows us to examine the effect of long-term as well as short-term debt.[2] What we show is that the effect that leverage has on prices depends critically on the nature of the uncertainty (whether demand or costs are uncertain), the timing of the uncertainty (when prices are set relative to the realization of the uncertainty), characteristics of the debt (whether the debt is short-term or long-term, protected or not protected), the nature of the competition (Nash versus Stackelberg) and the characteristics of the product (whether or not the quality of the product is observable pre-purchase). As we show, these factors also have an effect on the firms' optimal capital structures.

Although our analysis of short-term debt is a fairly straightforward extention of the Brander and Lewis model, our analysis of how long-term debt affects pricing decisions builds on a number of other articles in the literature. The analysis is most closely tied to an idea put forth by Klemperer (1987, 1993) which suggests that pricing decisions can be viewed as a capital budgeting 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. The analysis is, in this respect, quite similar to a model developed independently by Chevalier and Scharfstein (1994), however, our link between financing choices and discount rates is somewhat different. In our model, long-term debt increases a firm's borrowing costs which shifts the firm's reaction curve upward and makes it flatter. In the Nash case (also examined in Chevalier and Scharfstein) the upward shift in the reaction curve leads to increased prices. However, in the Stackelberg case, the flattening of the reaction curve is also important and this can lead prices to decline.

The extension of this analysis to include products with unobservable quality is

[2] Glazer (1994) also examines long-term debt, but provides a story very different than ours. In his model, firms produce less in first period because it increases the profits of its rival, making them less levered and thus less aggressive in the final period.

closely tied to the Maksimovic and Titman (1991) model which established a link between financing choices, discount rates and the ability of firms to credibly offer high quality products. We show that the ability to credibly offer a quality product depends on the firm's market share as well as its discount rate. What this means, is that subsequent to a leverage increase, firms may have to cut their prices to attract a greater market share in order to credibly offer a quality product. We show that this implies that prices may be expected to fall following a leveraged buyout, and that the tendency of prices to fall may be related to the rival firm's leverage ratio in a way that is consistent with the observed evidence.

The rest of the paper is structured as follows: Section 2 presents a one period model that corresponds with the Brander and Lewis model and section 3 present our two period model. A specific example of this model with comparative statics is presented in section 4. Section 5 examines how the nature of competition affects the model's predictions and section 6 examines the effect of having unobservable product quality on the equilibrium. Section 7 provides a summary and some conclusions.

2 An Analysis of Short-term Debt: A One-Period Model

This section examines how short-term debt and the immediate threat of bankruptcy affects pricing decisions. [3] We do this within the context of a single period model which provides the starting point of our two period model which we use to analyze long-term debt.

The relevant distinction between short-term and long-term debt is as follows: increasing short-term debt increases the probability of bankruptcy in the current period, which creates an incentive for stockholders to shift wealth from states of the economy where the firm is bankrupt to states of the economy where they are

[3]Some of the results in this section have been derived independently by Showalter (1995). See also Bai and Li (1994).

not bankrupt. Long-term debt also has an effect on the short-run probability of bankruptcy, and in addition, it affects the rate at which the firm can borrow in the future. Firms with higher levels of long-term debt have higher future borrowing costs than firms with less long-term debt.

The model considers two firms, labeled 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, i.e., we will be considering a Nash equilibrium in prices. The firms are owned by risk neutral entrepreneurs, or equivalently, are managed for the benefits of risk neutral shareholders and thus act to maximize the expected value of their profits. To produce their product the firms must make a fixed investment of I_1 dollars which allows them to produce an unlimited amount at a fixed per unit cost.[4] The entrepreneur can fund this investment by either issuing additional equity or by issuing debt. At the end of the period the investment can be liquidated for an amount $\tilde{I}$.

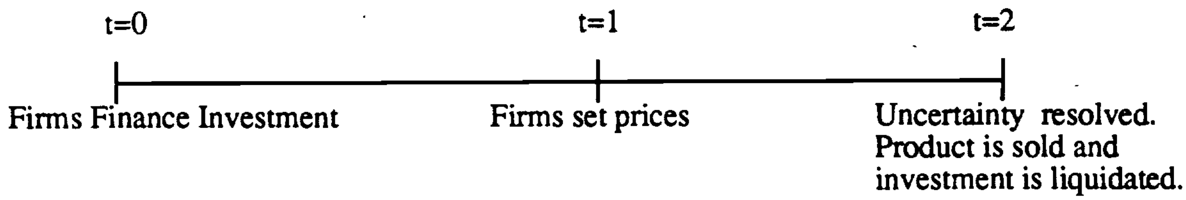
The above time line illustrates the sequence of events. At time t=0, the firms finance their fixed investment. At time t=1, they then simultaneously choose their prices: the financing choices of the previous stage are common knowledge at this point. At time t=2, the uncertainty is resolved, the variable costs are realized and the firm's output is sold. As we will discuss below, the fact that prices must be set prior to the uncertain state of the economy being revealed is crucial to this analysis.

2.1 Three Sources of Uncertainty

Leverage has different effects on pricing strategies depending on the nature of uncertainty. In this subsection we consider, in turn, three types of uncertainty: uncertainty about the liquidation value, $\tilde{I} = I + \tilde{z}$, where $\tilde{z}$ is random, uncertainty about the de-

[4]The assumption of fixed per unit costs is made only for expositional clarity, and only for the purposes of this section.

Figure 1a
Time Line for Single Period Model



mand curve faced by each firm, and uncertainty about the per unit cost. As we show, financial structure affects prices very differently depending on the nature of uncertainty.

We will focus mainly on the decisions of the firm at t=1, taking the financing choices of the previous stage as given.[5] At this point, the objective of the firm is to maximize equity value. The equity value of firm i can be expressed as,

$$V^i(p_i, p_j) = \int_{\hat{z}_i}^{\bar{z}} \{x^i(p_i, p_j, \tilde{z}_i) - D_i\} dF(\tilde{z}_i) \tag{1}$$

where $x^i(p_i, p_j, \tilde{z}_i)$ is profit gross of payments to debtholders for firm i, D_i is the face value of firm $i's$ debt, p_i is firm i's price, and $\tilde{z}_i$ is a random variable with a c.d.f. $F(\tilde{z}_i)$ defined over $[0, \bar{z}]$.

We define $\hat{z}_i$ implicitly from the equation,

$$x^i(p_i, p_j, \hat{z}_i) = D_i, \tag{2}$$

and assume that the firm is bankrupt and its equity is worthless if $\tilde{z}_i$ is less than $\hat{z}_i$, i.e. we define $\tilde{z}_i$ in such a way that the firm's profit is increasing in $\tilde{z}_i$. With demand uncertainty the random element $\tilde{z}_i$ multiplies the firm's profit margin (p-c) so that gross profits can be expressed as,

$$x^i(p_i, p_j, \tilde{z}_i) = (p_i - c)[q(p_i, p_j) + \tilde{z}_i] + I. \tag{3}$$

With cost uncertainty the random element multiplies the amount sold so that,

$$x^i(p_i, p_j, \tilde{z}_i) = (p_i - c + \tilde{z}_i)q(p_i, p_j) + I. \tag{4}$$

Finally, with uncertainty coming from the liquidation value,

$$x^i(p_i, p_j, \tilde{z}_i) = (p_i - c)q(p_i, p_j) + \tilde{z}_i + I \tag{5}$$

[5]The analysis of optimal choice of debt and equity can be carried out as in Brander and Lewis (1986) and is not pursued further for the one period model. See Showalter (1995).

2.2 How Debt Affects Pricing

In order to maximize equity value, firms select prices that solve the following first-order condition,

$$V_i^i = 0 \Leftrightarrow \int_{\hat{z}_i}^{\bar{z}} x_i^i(p_i, p_j, \tilde{z}_i) dF(\tilde{z}_i) = 0. \tag{6}$$

The second-order condition for an interior optimum is

$$V_{ii}^i < 0 \tag{7}$$

which we assume holds.

To examine how debt affects a firm's pricing decision we differentiate (6) holding firm j's price fixed.

Differentiating (6), we get

$$\frac{dp_i}{dD_i} = \frac{x_i^i(p_i, p_j, \hat{z}_i) \cdot \frac{d\hat{z}_i}{dD_i} \cdot f(\hat{z}_i)}{V_{ii}^i} \tag{8}$$

This in effect tells us how an increase in debt causes firm i's reaction function to shift. Note that V_{ii}^i is negative by virtue of (7). Also, from (2), given that $\tilde{z}_i$ is defined so that x^i is increasing in $\tilde{z}_i$, we have $\frac{d\hat{z}_i}{dD_i} > 0$. Thus, the direction in which the reaction function shifts depends on the sign of the term $x_i^i(p_i, p_j, \hat{z}_i)$. As we will show, the sign of this derivative, which determines how debt affects pricing decisions, depends on the nature of the uncertainty.

From equation (6) note that if $x_i^i(p_i, p_j, \tilde{z}_i)$ is increasing in $\tilde{z}_i$ (i.e.($x_{iz}^i > 0$), then $x_i^i(p_i, p_j, \hat{z}_i)$ must be negative (otherwise the integral cannot "sum" to zero). Similarly, if $x_i^i(p_i, p_j, \tilde{z}_i)$ is decreasing in $\tilde{z}_i$ (i.e. $x_{iz}^i < 0$), then $x_i^i(p_i, p_j, \hat{z}_i)$ must be positive. Finally, if $x_i^i(p_i, p_j, \tilde{z}_i)$ is independent of $\tilde{z}_i$, then $x_i^i(p_i, p_j, \hat{z}_i) \equiv x_i^i(p_i, p_j) = 0$. Thus for the case in which the source of uncertainty is the liquidation value $\tilde{I}$, it is immediate from (5) that

$$x_i^i(p_i, p_j, \tilde{z}_i) = q(p_i, p_j) + (p_i - c)\frac{\partial q(p_i, p_j)}{\partial p_i}$$

is independent of $\tilde{z}_i$, so that $x_i^i(p_i, p_j, \hat{z}_i) = 0$. Hence, from (8), debt has no effect on the reaction functions, and thus capital structure has no strategic role in this case.

When uncertainty is from the demand side, from (3) we have:

$$x_i^i(p_i, p_j, \tilde{z}_i) = q(p_i, p_j) + \tilde{z}_i + (p_i - c)\frac{\partial q(p_i, p_j)}{\partial p_i}$$

which is increasing in $\tilde{z}_i$. Thus, $x_i^i(p_i, p_j, \hat{z}_i) < 0$. Consequently, from (8), $\frac{dp_i}{dD_i} > 0$. Thus, debt commits the firm to a higher price - given the rival's price (i.e., it shifts the reaction function outwards).

Finally, when the uncertainty is on the cost side from (4) we get

$$x_i^i(p_i, p_j, \tilde{z}_i) = q(p_i, p_j) + (p_i - c + \tilde{z}_i)\frac{\partial q(p_i, p_j)}{\partial p_i}$$

which is decreasing in $\tilde{z}_i$, since $\frac{\partial q(p_i,p_j)}{\partial p_i} < 0$. Thus, $x_i^i(p_i, p_j, \hat{z}_i) > 0$. Consequently, from (8), $\frac{dp_i}{dD_i} < 0$, which implies that debt commits the firm to a lower price for any given price of its rival, (i.e., it shifts the reaction function inwards). The above analysis implies the following proposition:

Proposition 1. *Suppose firm B's debt level is held constant. Under standard regularity conditions (described in the Appendix) the following is true:*

1. If uncertainty relates to demand, then the prices both firms charge are increasing in the level of firm A's debt. If firm B has no debt, but is otherwise identical to firm A, it will charge a lower price than will firm A.

2. If uncertainty relates to costs, then the prices both firms charge are decreasing in the level of firm A's debt. If firm B has no debt, but is otherwise identical to firm A, it will charge a higher price than will firm A.

3. If uncertainty relates to the firm's liquidation value, then debt has no effect on the equilibrium.

Proof: Please see the Appendix .

The above proposition indicates that increased levels of debt can result in either increased or decreased prices depending on the source of uncertainty. The results follow from two key assumptions that deserve some additional discussion.

The first assumption is that the firm is managed in the interests of its equity holders who prefer risk increasing actions that transfer payoffs from states of the economy where the firm is bankrupt to states where the firm is doing well. Specifically, since equityholders receive nothing in the event of bankruptcy, those states of the economy in which the firm is bankrupt can in effect be ignored in calculating optimal pricing choices. Increased debt, by increasing the probability of bankruptcy, thus effectively "eliminates" some states of the economy from the optimization problem. With cost uncertainty, debt leads managers to ignore those states where costs are highest, which induces them to price their product lower than they would in the all equity case. This case turns out to be identical to the case considered by Brander and Lewis (1986) where debt induces firms to increase output by leading them to ignore those states of the economy where marginal profits are low. With demand uncertainty debt leads managers to ignore those states of the economy where demand is low, and the effect therefore is to raise price. In the final case, where the uncertainty is additive, neither marginal cost nor marginal revenue is affected, so that debt has no effect.

The second important assumption is that firms commit to prices (or quantities in the case of quantity competition) prior to observing the state of the economy. The extent to which prices and output are influenced by debt in this model depends on the amount of uncertainty about the state of the economy at the time prices are set, i.e., the variance of z. If prices are fairly flexible, then the length of time between when prices are set and when uncertainty is resolved should be quite short implying that the variance of z should be quite low. This in turn implies that debt will have very little influence on pricing. In the limit, where prices can be set after the uncertainty is revealed, leverage will have no effect on prices.

3 A Two-Period Model: The Effect of Long-Term Debt on Prices

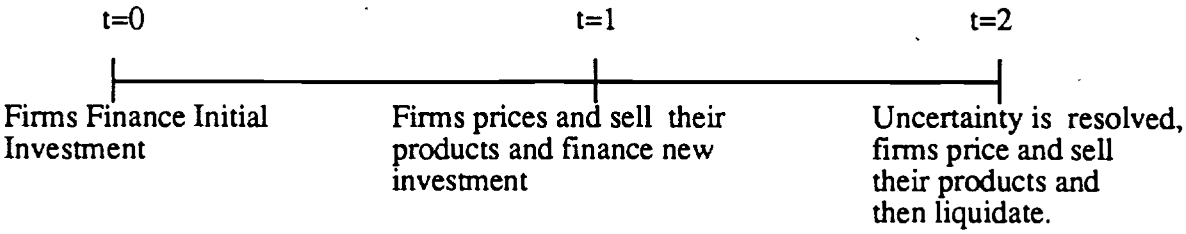
In this section, we extend the model to two periods and examine how long-term debt affects pricing decisions. The model builds on an idea developed by Klemperer (1987) that suggests that since increasing one's price today can improve short-term profits at the expense of long-term profits, a firm's incentive to raise or lower its price is determined in part by its discount rate. Our main results follow from combining this insight of Klemperer 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 model is structured basically the same as our single period model except for the following modifications: First, we assume that to produce in the second period an additional investment I_2 is required at the end of period one. Since this investment requirement is assumed to exceed the firm's period 1 profits, additional financing is needed at the intermediate date.[6] To simplify our notation we will assume, without loss of generality, that the risk-free interest rate is zero. In addition, to focus on the effect of discount rates on pricing choices we will consider the case where uncertainty affects only the liquidation value of the firm's capital so that the single period effects considered in the previous section are neutralized.[7]

[6]This assumption is not really required. Our results follow as long as the firm can obtain outside financing in the future. We could have alternatively assumed that the firm is refinancing debt that comes due at the end of period 1. Alternatively, the firm might have no need to go to the capital markets for new funding, but to the extent that it does raise revenues it can use the money to buy back existing bonds on the open market.

[7]We could equivalently assume that the firm sets its second period prices after observing the state of the economy.

Figure 1b
Time Line for 2-Period Model



3.1 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 allows the firms to exploit, in period two, the customers they attract in period one.[8] We will assume that the firms' initial customer bases are exogenous (or that there is no pre-existing 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 $x_2^i = x_2^i(\sigma^i)$.[9] The ex-ante value of firm i can therefore be written as:

$$V^i = x_1^i(p_1^A, p_1^B) + x_2^i(\sigma^i(p_1^A, p_1^B)) + E\tilde{I} - (I_1 + I_2) \tag{9}$$

Our notation for the second period profits implicitly assumes that the second period prices (which, of course, partially determine second period profits) depend on the first period market shares.

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

$$\frac{\partial x_1^i}{\partial p_1^i} + \frac{\partial x_2^i}{\partial \sigma^i} \cdot \frac{\partial \sigma^i}{\partial p_1^i} = 0, \qquad i = A, B. \tag{10}$$

We shall make the following assumptions:[10]: $\frac{\partial x_2^i}{\partial \sigma^i} > 0$ and $\frac{\partial \sigma^i}{\partial p_1^i} < 0$. The latter assumption simply states that - ceteris paribus -a higher first period price results

[8]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.

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

[10]Some additional standard "regularity" conditions such as the relative slopes of the reaction functions will be needed for some of our results and are discussed later and also in the Appendix.

in a lower second period customer base as fewer customers buy in the first period. The first assumption states that a higher first period market share results in higher second period profits. This is intuitive and can be shown to hold for a wide range of scenarios, see Klemperer (1987) for examples.

Given these assumptions, equation (10) 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, which is offset by the increased profits in the second period achieved because of the larger customer base attracted by the lower period one price. The tradeoff between period one and period two profits will of course depend on the firm's discount rate, which in turn depends on the firm's financial structure.

3.2 The effect of outstanding debt

In this subsection we will examine how the firms' financial structures affect their pricing decisions. As in the last section, we will assume that the firms' debt obligations, d^A and d^B, are determined exogenously. The obligations are due at the end of period two and are assumed to be protected by covenants restricting the payout of period one and period two 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.[11]

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

[11]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.

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 them to raise an unlimited amount of more senior debt in the future, they 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 we have (dropping the superscript i)

$$I_2 - x_1 = y[1 - F(d + y - x_2)] + \int_{d-x_2}^{d+y-x_2} (\tilde{I} + x_2 - d)dF. \tag{11}$$

Now, the firm's two-period profit is

$$\begin{aligned}
\Pi &= \int_{d+y-x_2}^{\bar{I}} (x_2 - d - y + \tilde{I})dF \\
&= (x_2 - d)[1 - F(d + y - x_2)] - y[1 - F(d + y - x_2)] + \int_{d+y-x_2}^{\bar{I}} \tilde{I} dF \\
&= x_1 + (x_2 - d)[1 - F(d - x_2)] + E\tilde{I} - \int_0^{d-x_2} \tilde{I} dF - I_2 \qquad (12') \\
&= x_1 + \int_{d-x_2}^{\bar{I}} (\tilde{I} + x_2 - d)dF - I_2 \qquad (12)
\end{aligned}$$

where we have used equation (11) in deriving (12').

To analyze the firms' equilibrium pricing strategies we begin as usual with the last period. For a given σ^A (and hence a given σ^B), firm A chooses p_2^A to maximize (12). The first order condition is given by

$$\frac{\partial x_2^A(\sigma^A, p_2^A, p_2^B)}{\partial p_2^A} = 0. \tag{13}$$

Similarly, we have

$$\frac{\partial x_2^B(\sigma^B, p_2^B, p_2^A)}{\partial p_2^B} = 0. \tag{14}$$

It is therefore immediate 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 (i.e., when prices are chosen to maximize the expression given in equation (9)). This result – given our assumption that the source of uncertainty is the liquidation value – should not be surprising given the discussion in section 2.

Consider now the choice of first-period price. Differentiating (12) w.r.t. p_1^A, we get:

$$\frac{\partial x_1^A}{\partial p_1^A} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot [1 - F(d^A - x_2^A)] = 0. \tag{15}$$

We can immediately note the following:

Proposition 2. *Assume that $\tilde{I}$ is continuously distributed with a distribution function $F(.)$, and standard regularity conditions hold, i.e., the reaction functions are stable and B's reaction function is upward sloping. 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: Please see the Appendix .

The intuition for this result is as follows: Given our interpretation that the choice of the first period price is analogous to a present value problem, the effect of outstanding debt is to increase the cost of new borrowing and thus to implicitly raise the discount rate for second period profits (see equations (10) and (15)). 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. If the rival is equity financed and otherwise symmetric, the new intersection will be below the 45- degree line, i.e. the rival's price will increase less.

For *all equity firms*, the assumption that reaction functions are positively sloped is quite standard, and requires that the term $\frac{\partial^2 x_1^A}{\partial p_1^A \partial p_1^B} + \frac{\partial}{\partial p_1^B}[\frac{\partial x_2^A}{\partial \sigma^A}\frac{\partial \sigma^A}{\partial p_1^A}]$ be positive. However, if firm B is debt financed, then there is an additional term $\frac{\partial x_2^A}{\partial \sigma^A}\frac{\partial \sigma^A}{\partial p_1^A}\frac{\partial x_2^A}{\partial p_1^B} f(d^A - x_2^A)$, which is negative. This indicates that leverage will tend to make a firm's reaction curve flatter, and in the extreme case, may even make it negative, at least for a range of prices, i.e., 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.[12]

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

An immediate consequence of the Proposition 2 is the following:

Proposition 3. *Prices are higher in a (partially) debt financed industry than in one in which all firms are completely equity financed.*

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, i.e.,

[12]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 unlevered.

Bertrand or Cournot. To see this, consider how the model would change if firms choose quantities rather than prices. Relabel the strategic varibles p_i as quantities q_i. Now in equation (10), $\frac{\partial \sigma^i}{\partial q_1^i} > 0$, 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, $\frac{\partial x_1^i}{\partial q_1^i} < 0$, i.e. the firms overproduce in the first period to grab market share. Comparing with equation (15), 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 2 can be stated in this case.[13]

4 A Switching Cost Model

At this point it is convenient 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. With this more explicit model we demonstrate that the regularity conditions assumed in the last section hold under reasonable conditions. The model also allows us to derive some additional comparative statics and is used to get some insights about the optimal capital structure choice. In addition, the model can be extended in ways that allow us to address two important issues. We first examine the extent to which our results are driven by the assumed Nash price-taking behavior of the two firms. We then extend the model to examine how unobservable product quality affects the interaction between debt and prices.

Our analysis is based on simple switching cost model described in Klemperer (1993). The model assumes that the products are somewhat different, with exogenous

[13]It should be pointed out, however, that while the effect of leverage changes on prices is similar for Cournot and Bertrand competition, they have different implications for the optimality of debt itself. Under price competition, both the firm undergoing the leverage increase and its rival will become more profitable; however, under 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)).

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 buys K_t units of the product, and they have a reservation price of r each period. Product differentiation in period one is modelled by assuming that 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 depends on where the consumers are located relative to the seller. A consumer at y has a transportation cost of Ty of buying from A, and $T(1-y)$ of buying from B. Thus, a consumer at y buys from A if and only if

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

i.e., iff

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

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 $s > (1/2)(r-c)$, 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 (1990).

Thus, the two-period profit of an all-equity firm is

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

We shall assume that the random variable $\tilde{I}$ is distributed uniformly over the interval $[0, \bar{I}]$. With this assumption, it can be checked that the reaction functions are positively sloped for all levels of debt provided $2TK_1\bar{I} > (r-c)^2 K_2^2 N$, and that reaction function stability holds.[14]

We now examine some additional issues concerning the effect of leverage on product market prices. We are particularly interested in Phillips (1995) and Chevalier's (1995) finding that product market prices rise more following an LBO if the rival firm is also highly levered. As we show in the next proposition, this observation is inconsistent with the model developed in this section.

Proposition 4 *For the switching cost model, and with the random variable $\tilde{I}$ distributed uniformly over $[0, \bar{I}]$, the increase in firm A's price following an increase in debt is less if firm B also has risky debt, as opposed to being equity financed.*

Proof: Please see the Appendix.

To understand the above proposition, note that in section 3 we showed that if the rival has risky debt his reaction curve will be flatter, i.e. in response to a given increase in the price charged by the leverage increasing firm, the rival should increase its price *less* if it is also highly levered. This "sluggish" response from the rival will, in turn, reduce the incentive of the leverage increasing firm to raise its price, so as a result neither price will increase as much.

4.1 The optimal choice of debt

Up to this point we have treated debt as an exogenous variable. Considering debt as exogenous is appropriate because there are a number of factors that we haven't modeled that affect a firm's capital structure choice. However, we are still interested in how the competitive forces described in the last section affect financing choices so for the sake of tractability, we will ignore these other factors and endogenize the capital structure choice. We will consider the capital structure choice within a setting where

[14]These are shown as part of the proof of Proposition 4 below. Also note that second order conditions corresponding to the equation (15) require $4TK_1\bar{I} > (r-c)^2K_2^2N$.

the two firms first set their debt levels simultaneously, and having selected their own capital structures and knowing each other's capital structure, they set their prices.

The market value of debt raised at the beginning of period one is,

$$\begin{aligned} d_0 &= d[1 - F(d - x_2)] + \int_0^{d-x_2} (\tilde{I} + x_2) dF \\ &= d[1 - F(d - x_2)] + \int_0^{d-x_2} \tilde{I} dF + x_2 F(d - x_2) \end{aligned} \tag{16}$$

Adding this to the equity value (equation (12')) and subtracting the initial investment I_1, the market value of the firm A is

$$\begin{aligned} V^A(d^A, d^B) = x_1^A(p_1^A(d^A, d^B), p_1^B(d^A, d^B)) &+ x_2^A(\sigma^A(p_1^A(d^A, d^B), p_1^B(d^A, d^B))) \\ &+ E\tilde{I} - (I_1 + I_2). \end{aligned} \tag{17}$$

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

$$\begin{aligned} \frac{dV^A}{d(d^A)} &= [\frac{\partial x_1^A}{\partial p_1^A} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A}] \cdot \frac{dp_1^A}{d(d^A)} \\ &+ [\frac{\partial x_1^A}{\partial p_1^B} + \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^B}] \cdot \frac{dp_1^B}{d(d^A)} \end{aligned} \tag{18}$$

The following can now be shown:

Proposition 5. *Suppose $\tilde{I}$ is continuously distributed. If reaction functions are upward sloping for all levels of debt and reaction function stability holds, both firms will choose debt in equilibrium.*[15]

[15] If 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. Further, even when the reaction functions are upward sloping, if the random variable is not continuously distributed, asymmetric equilibria with one firm being debt financed and the other not, are possible.

Proof:

If a firm (w.l.o.g. firm A) is completely equity financed, then the first bracketed expression in (18) is zero, by virtue of equation (15) (which is the same as (10) in this case). However, the second bracketed expression is positive, since each of the terms is positive. From Propositions 2, $\frac{d(p_1^B)}{d(d^A)} > 0$, 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. ■

Remark. For $d > 0$, the first bracketed expression in equation (18) is negative (this follows immediately from equation (15)). Since the second expression has already been shown to be positive, it follows that an interior level of debt is possible. This is confirmed below with a specific example. The interpretation of the two terms in equation (18) are as follows: Consider the second term first, which reflects the strategic effect of senior debt. Pre-existing senior debt raises the cost of new borrowing and thus reduces the incentive to gain market share by lowering first period price, i.e. it leads to higher first period price. This credible commitment of a higher first period price causes the rival to raise its price. This is the strategic effect of debt. Now consider the first term which reflects the cost of debt. The tendency to set too high a price in the first period is ex-ante costly. 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. The optimal amount of debt trades off these costs and benefits.

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

Proposition 6. *In a symmetric equilibrium, the value of each firm is higher when debt financing is used than it is when both firms are completely equity financed. However, the values are lower than they would be if the firms could collude and charge the monopoly price.*

Proof: Please see the Appendix.

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

Proposition 7. *Consider the switching cost model, and assume that the distribution of the random variable $\hat{I}$ is uniform over $[0, \bar{I}]$, and the reaction functions are upward sloping. The symmetric equilibrium debt level is given by*

$$d = (\frac{K_1}{K_2}) \cdot (\frac{T}{r-c}) \cdot \bar{I} \tag{19}$$

Proof: Please see the Appendix .

The following comparative statics follow directly from equation (19):[16]

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 have occurred primarily in industries that do not seem to have strong growth prospects. The intuition for this result is as follows: If the period two demand is smaller, there is a smaller gain from lowering price in the first period. Thus, the loss from the distortion introduced by debt (which results in a higher first period price), is smaller. Since the cost of debt is lower more debt is chosen.

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

Again, the intuition here is that with more inelastic demand the incentive is to set higher first period prices, so that the distortionary cost of debt discussed above is lower. This means that more competitive industries should have less debt which is consistent with a finding by Spence (1985).

[16]It is worth pointing out that we are assuming $K_2N(r-c) < d < K_2N(r-c) + \bar{I}$ in deriving this expression, i.e. the probability of default is between zero and one.

3. *The debt level is higher the higher the expected salvage value of the firm's capital, given by* $\bar{I}/2$.

This result supports the empirically observed fact that firms with more tangible assets have higher debt.

5 The Stackelberg Case

As we showed previously, increased leverage has the effect of shifting a firm's reaction curve upward and decreasing its slope. The results discussed up to this point follow directly from the fact that the reaction curves shift upward. With the exception of what we called the perverse case, the change in the slope of the reaction curve had no substantive effects on our main result that prices increase following an increase in leverage. In this section, we examine the extent to which these results are sensitive to the nature of the competition.

To understand why the slope of the reaction curve can be important, consider the following scenario: Firm B 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. Observing this, Firm B lowers its price and successfully steals some of Firm A's customers.

The model presented in the last section does not capture the above intuition since the Nash equilibria requires that the firms set their prices simultaneously, while the above story implicitly assumes that the firms react to each others 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 paper to model this kind of dynamic price process we can capture at least part of this intuition in a simple Stackelberg model.

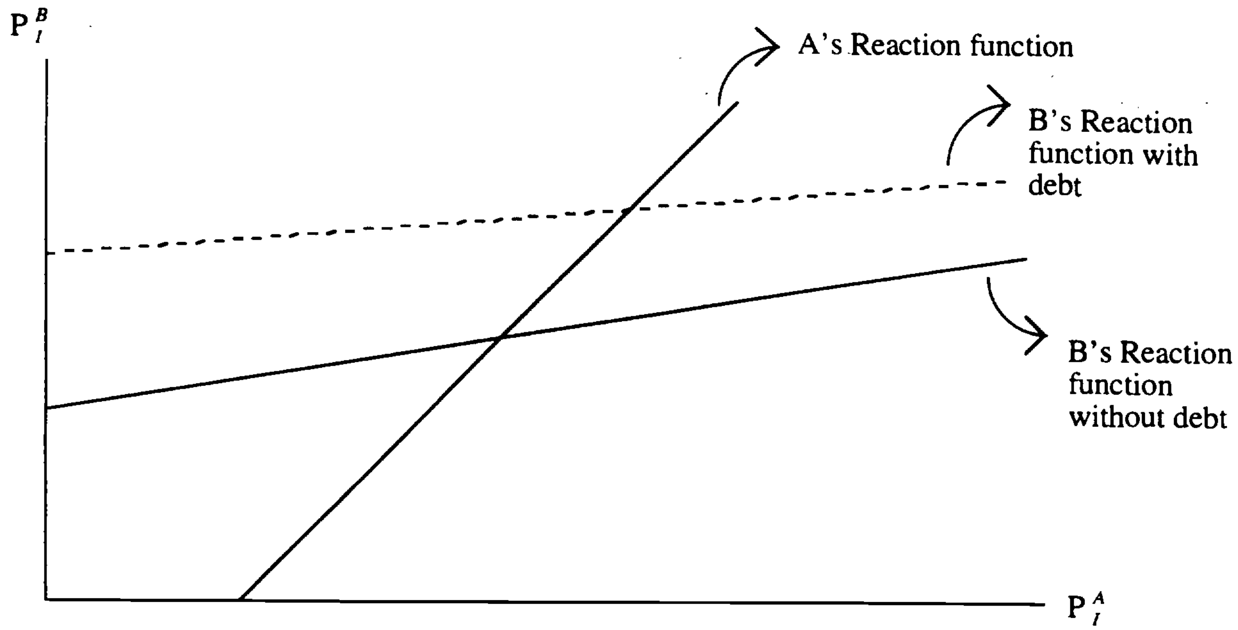
We again assume that one of the two firms is increasing its leverage. The firm not increasing its leverage, assumed to be the Stackelberg leader, observes the leverage increasing firm's reaction curve and selects its price accordingly. The leverage increasing firm, the Stackelberg follower, selects its price after observing its rival's price. As we have seen, the leverage increase makes the firm's reaction curve flatter which tends to lower the Stackelberg price. However, debt also shifts firm B's reaction function up. In general, the slope of the leader's isoprofit curve may also become flatter as one moves vertically up in the graph to the new reaction curve of the rival. Thus, the slope of the latter has to become sufficiently small for the Stackelberg price to fall e.g. from X to Y in figure 2. The following can be readily shown:

Proposition 8. *For the switching cost example with a uniform distribution, (i) the Stackelberg leader's price will fall following debt financing by the follower if* $\bar{I}$ *is not significantly greater than* $\frac{(r-c)^2 K_2^2 N}{2TK_1}$ *, and the follower's price may either rise or fall (ii) if the leader is levered, both prices will be higher than if the leader were equity financed, and (iii) if the firms have identical demand and cost configurations, then the leader's price will be higher than the follower's before the LBO, but this could be reversed after.*

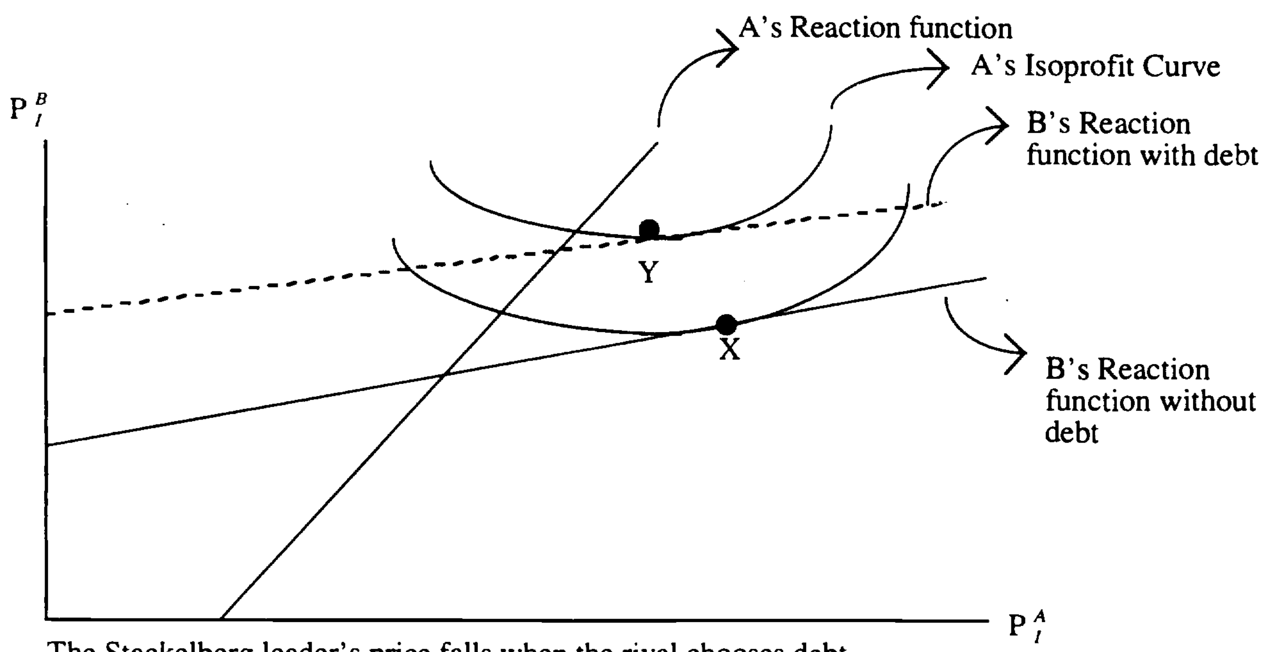
Proof: Please see Appendix.

The Stackelberg model is consistent with the observation that prices can fall as well as rise following an LBO. The Stackelberg model is particularly applicable in the case where the firm doing a LBO has only one strong relatively unlevered rival and thus fits particularly well Chevalier's (1995) finding that prices may fall following LBOs when the dominant rivals are not highly levered. In addition, Part (ii) of Proposition 8 indicates that prices for both firms are higher if the rival is levered, so that prices will in fact be lower if the rival firm has relatively little debt. However, the pre-LBO prices will also be higher if the rival is relatively levered so that we cannot

Figure 2
The Effect of Debt on Prices in Nash and Stackelberg Equilibrium



In the Nash Equilibrium price increases when B includes Debt in its capital structure.



The Stackelberg leader's price falls when the rival chooses debt.

say for sure whether or not prices drop more when the rival is levered.

6 Product quality choice and predatory pricing

As we mentioned previously, our analysis of the capital structure choice should be viewed with caution since it ignores other important determinants of the debt-equity choice. The usefulness of these results probably depend on the extent to which these other determinants affect the capital structure choice in ways that are independent of the competitive factors considered here. In this section we present a model that illustrates how a second determinant of capital structure does in fact interact with these competitive considerations. As we will show, the analysis provides some useful insights about why LBOs can sometimes lead to lower rather than higher prices and why price cuts may be more likely when the rival firms are relatively unlevered.

The model in this section is an extension of the switching cost model discussed in section 4. We assume that the quality of one of the firm's products, say firm A, cannot be observed before it is purchased, but is discovered with a one period lag. For simplicity, we assume that firm B faces no product choice decision, i.e. its product quality is known to be high. Product quality, which can be either "High" or "Low," is determined by whether or not the firm has made a one time investment of Z in period 1, which allows the firm to produce high quality in *both* periods.[17] The fact that firm A's product quality is not observable is relevant to this analysis since, as we will show, the price that the firm charges as well as its financial condition provides information to consumers about its incentives to provide a high quality product. As a result, the unobservability of product quality affects pricing strategies and affects how these strategies interact with financing choices.

Since quality is assumed to be observable with a one period lag, consumers observe the true quality of the product in period two but not in period one. In period one consumers form rational beliefs about product quality based on prices and the firm's

[17] We still assume that all first period costs – including Z – are paid at the end of the period.

financial structure. Given these beliefs, and depending on prices and the consumer's location in the interval [0,1], a consumer will decide whether he wants to buy the product from firm A or B. To simplify our arguments we assume that consumers want to buy one unit of the product in both periods and that their reservation price for one unit of a H quality product is r, while that for an L quality product is θr, where $\theta < 1$.

A time line illustrating the sequence of events is given below:

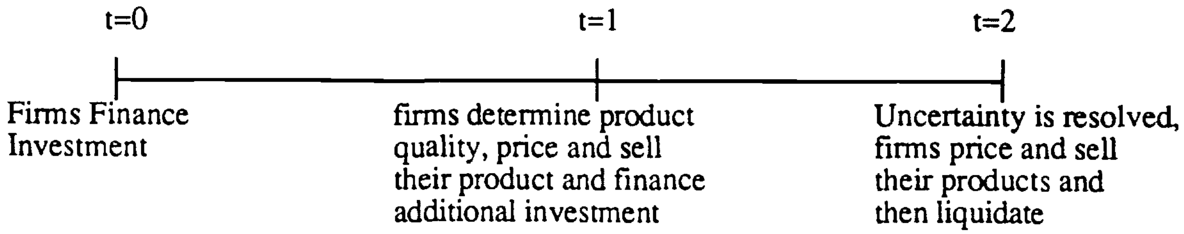
The firms first select their debt ratios, which are exogenous in this analysis. Firms A and B then set their period 1 prices and at the same time firm A also determines its product quality. Based on the observed prices and financial structures consumers form beliefs about quality and make their period 1 purchasing decisions. At the end of period 1 the firm borrows additional funds to finance the second period investment requirement. In the second period quality becomes known, prices are set, profits are realized, the debt is paid off and the firm is liquidated.

6.1 The case where firms are equity financed

In this subsection we examine the ability of firm A to credibly offer a high quality product. Since quality is unobservable in period 1, in setting its period 1 price, firm A must take into account how its pricing decisions affects its customers' beliefs about the quality of the product. Since at the time the product quality decision is made, firm B's price is unobserved, we shall assume that everybody shares a common conjecture about the price firm B will charge (this conjecture, of course, will have to be correct in equilibrium).

The specified beliefs about firm A's quality will be assumed to have the following "self- fulfilling " property : for any price set by firm A (given a conjectured price by

Figure 3
Time Line for Product Quality Model



firm B), if beliefs are that quality $q = \{H, L\}$ will be produced, then it is optimal for firm A to produce that quality at this price. Thus, suppose p_1^A is a price at which the customers believe firm A will produce high quality. Then we must have:

$$x_1(p_1^A, (p_1^B)^*) + x_2^H(\sigma^A(p_1^A, (p_1^B)^*)) \geq x_1(p_1^A, (p_1^B)^*) + x_2^L(\sigma^A(p_1^A, (p_1^B)^*)) + Z \quad (20)$$

where x_1 is period one profit, given the market's belief that quality is H; x_2^q, $q = \{H, L\}$, is the period two profit if quality chosen is q, and $(p_1^B)^*$ is firm B's conjectured price. This condition reduces to

$$r(1-\theta)N[1/2 + \frac{(p_1^B)^* - p_1^A}{2T}] \geq Z. \quad (*)$$

Given $(p_1^B)^*$, if p_1^A is less than or equal to the value for which the above condition (*) is satisfied with equality, let the market's belief be that the quality produced is high; otherwise,[18]beliefs are that the quality is low. Let $\rho^B(p_1^A)$ denote firm B's reaction function. We have an equilibrium in which firm A produces high quality and sets $p_1^A = (p_1^A)^e$, firm B sets $p_1^B = (p_1^B)^e$, and the conjectured price for firm B when the quality choice decision is made is $(p_1^B)^*$ provided: (i) $(p_1^A)^e$ gives firm A the highest profit, subject to (*) when it produces high quality (ii) there is no p_1^A such that producing low quality at this price gives a higher profit to A, and (iii) $(p_1^B)^* = (p_1^B)^e = \rho^B((p_1^A)^e)$.

For convenience of presentation, let us denote the Nash equilibrium prices when quality choice is not an issue (i.e. the market knows firm A to be high quality) by P^*, which can be shown to equal $T + 2c - r$. The following result holds:

Proposition 9. *If $r(1-\theta)N > 2Z$, there is an equilibrium in which firm A produces high quality, the prices charged by both firms are given by $p_1^A = p_1^B = P^*$, and the market's beliefs are that quality is high if p_1^A satisfies condition(*) with $(p_1^B)^* =$*

[18]We show in the Appendix that the other part of such beliefs are also self fulfilling in the sense that should the price be higher, it is optimal for firm A to produce low quality.

P^*, and low otherwise. Moreover, there is no other equilibrium outcome which is consistent with "reasonable beliefs".

Proof: Please see the Appendix.

Proposition 9 states that under some conditions firms can credibly offer high quality at the prices that would prevail if quality were observable. In these cases, the equilibrium is not affected by the unobservability of quality. However, if the conditions stated in Proposition 9 are not satisfied, a high quality product cannot be credibly offered given the market shares prevailing in the equilibrium where quality is observable. In these cases, as we discuss in more detail in the next subsection, the firm might be able to credibly offer high quality by cutting prices and attracting a larger market share. The intuition for this is straightforward. With a larger market share, the firm's incentive to produce a high quality product is greater since the gain in its period two profits from having a "favorable" reputation is proportional to its market share.[19]

6.2 Product quality, market share and leverage

In the previous section we demonstrated that the ability of a firm to credibly sell high quality products is enhanced if the firm's market share is higher. The unobservability of product quality would thus, ceteris paribus, lead firms to price their products lower to gain market share. In the next two subsections we examine how this interaction between the quality choice and the pricing decision is affected by debt financing.

Our intuition is as follows: As shown by Maksimovic and Titman (1991), by increasing the discount rate, debt increases a firm's tendency to produce low quality (since cutting quality increases profits today at the expense of future profits). This

[19]An interesting implication of this is that, if the nature of competition were in quantity rather than prices, the firm with unobservable quality may be able to obtain higher profits than its rival because the unobservability of quality can have the effect of commiting it to a higher output strategy.

implies that with higher debt ratios, firms require higher market shares to credibly commit to producing high quality, which in turn requires them to charge lower prices.

We consider first the case where firm B is unlevered and firm A is levered. To keep things simple we assume that the random variable $\tilde{I}$ can take on only two values, $\bar{I} > 0$ and 0, and we assume that the level of debt d is such that there exist fractions $\overline{\sigma}$ and $\underline{\sigma}$, $\overline{\sigma} > \underline{\sigma}$, such that $d > (r - c)N\overline{\sigma}$ and $d < (\theta r - c)N\underline{\sigma} + \bar{I}$. If we restrict attention to σ in this range, then the probability of default is $1 - \pi = \Pr[\tilde{I} = 0]$.

For $I_2 > x_1$, the equity value of the firm when it produces high quality can be written directly from equation (12) as

$$x_1 + \pi x_2^H + E\tilde{I} - \pi d - I_2$$

whereas when it produces low quality, the borrowing need is $I_2 - Z - x_1$, (which we assume is positive) so that the equity value is

$$x_1 + \pi x_2^L + E\tilde{I} - \pi d - I_2 + Z.$$

It is easy to check that the condition corresponding to (*) is now

$$\pi r(1 - \theta)N[1/2 + \frac{(p_1^B)^* - p_1^A}{2T}] > Z. \qquad (**)$$

Suppose π is low enough so that

$$\pi r(1 - \theta)N < 2Z. \qquad (21)$$

Then producing high quality and charging $p_1^A = P^*$ or higher is no longer an equilibrium strategy. Given these prices, firm A will want to produce low quality. Since firm A's market share is decreasing in p_1^A, there is a value of p_1^A less than P^* for which

$$\pi r(1 - \theta)[1/2 + \frac{\rho^B(p_1^A) - p_1^A}{2T}] = Z. \qquad (22)$$

Let $(p_1^A)'$ denote the value of p_1^A for which equation (22) holds. If beliefs are that quality is low for $p_1^A > (p_1^A)'$ and high otherwise, then provided π is not too low, there is an equilibrium in which firm A produces high quality and sets $p_1^A = (p_1^A)'$ and firm

B sets $p_1^B = \rho^B((p_1^A)')$. It can also be established exactly as above that this is the only equilibrium that is governed by "reasonable beliefs". Thus, we have:

Proposition 10. *Suppose firm B is completely equity financed but firm A is debt financed. For π satisfying the condition*

$$\pi r(1-\theta)N < 2Z$$

but not too low, there is a unique equilibrium consistent with reasonable beliefs in which firm A produces high quality, and both firms charge prices that are lower than the equilibrium prices when both firms are completely equity financed.

The preceding proposition provides an alternative explanation for the observation that product prices sometimes fall following leveraged buyouts. Consider the case where $r(1-\theta)N > 2Z$. As we saw in Proposition 9, under this condition in the all equity case, prices will be the same as they were when quality was observable. However, if debt is sufficiently risky (i.e. π is low enough), the incentive to lower quality is greater, implying that a greater market share is needed to credibly offer high quality. As a result, prices will fall following a leverage increase. Within this setting one can also explain why prices may be more likely to fall if the rival is relatively unlevered. The intuition for this is fairly straigtforward: If firm B is relatively highly levered it will price its product relatively higher allowing firm A to credibly offer a high quality product without cutting its price. We show this formally in the following proposition:

Proposition 11. *There exists a range of values for π such that in equilibrium, both firms charge higher prices following debt financing by firm A if firm B is leveraged, whereas both firms charge lower prices if firm B is unlevered.*

Proof: Please see the Appendix.

Proposition 11 follows from the fact that when the rival firm (firm B) is itself levered, at any given price for its product, firm A will have a higher market share. As a result, firm A may be able to credibly offer a high quality product without lowering its price. When the rival firm is not levered, it will compete harder for market share, thereby lowering firm A's market share for any given price. In this case firm A may have to lower its price to attain sufficient market share to credibly offer a quality product. This positive relation between the rival firms leverage and the incidence of price cuts following leveraged buyouts is consistent with the empirical findings discussed previously.

6.3 Predatory pricing

In the last subsection we described a case where prices would fall following a leverage increase. The incentive to cut prices in that case came from the firm that increased its leverage rather than from its less levered rival. Hence, one cannot interpret the price decline in this case as resulting from predatory pricing.

In this section we will consider a case where a leverage increase does lead to predatory price cuts by the firm's less levered rival. The basic idea is a follows: If Firm A is sufficiently levered it will need a combination of a sufficient price (to generate sufficient profits so it will not have to borrow too much) and a sufficient market share to credibly commit it to producing a quality product. Firm A's ability to do this depends on its own leverage ratio and Firm B's price. If Firm B lowers its price sufficiently, Firm A will not be able to credibly commit to selling a high quality product. Firm B benefits from this because the demand for its own product depends on the perceived quality of its competitor's product.

In cases where predatory pricing is profitable for Firm B we must assume that it can commit to the lower price.[20] The reason why we must allow for commitment is as follows: If firm B prices its product sufficiently low, firm A will produce a low quality

[20] Commitment to a price which is lower than the Nash equilibrium price is more plausible than commitment to a price that is higher. In both cases, there are incentives to change the price ex-post, but it may be costlier to revise the price upwards.

product which in turn results in higher profits for firm B. However, if we assume that firm A produces low quality we can show that firm B has an incentive to charge a higher price. Hence, there will not be predatory pricing when we consider only Nash strategies without commitment.[21]

When product quality is unobservable, there may be an incentive for firm B to set a low price since doing so makes it difficult for firm A to maintain the market share necessary to satisfy condition (*). However, the profits associated with predatory pricing depends on the cost that firm B itself has to bear by commiting to a low price. For example, it is intuitive that if A's cost saving from producing low quality is small relative to its loss of market share, then predatory pricing may impose too high a cost on firm B, since it will have to set a very low price to discourage A from maintaining market share. This is confirmed by the following proposition:

Proposition 12. *There exists a value of Z, say Z^*, where $Z^* \in (\frac{r(1-\theta)N}{4}, \frac{r(1-\theta)N}{2})$, such that for $Z < Z^*$, it is not optimal for B to set p_1^B so low that firm A will produce low quality, when both firms are completely equity financed.*

Proof: Please see the Appendix .

We show below that when firm A is debt financed predatory pricing may be profitable even for values of Z less than Z^*. The intuition is as follows: It can be shown that in the equilibrium described in Proposition 10, firm A's profit is increasing in π; hence for π sufficiently low, firm A will produce low quality and set a price that conveys this fact. Suppose the actual value of π is slightly above this critical value so that within the Nash equilibrium the firm will have a slight preference for producing high quality. Now consider what would happen if firm B could commit to a price slightly lower than the Nash equilibrium price. Firm A would then produce low quality which would result in a much higher market share for firm B. Thus, we have

[21]When product quality is observable it is never optimal – given *full* commitment ability –for a firm to set its price below the Nash equilibrium prices: the optimal commitment price is always above the Nash price.

the following:

Proposition 13. *Even for $Z < Z^*$, there is a range of values of π for which firm B will credibly commit to a price which is lower than the Nash price. At this price, firm A produces low quality, both firms charge prices which are lower than the equilibrium prices when the firm A is completely equity financed, and firm B has lower price and larger market share than A.*

Proof: Please see the Appendix .

Proposition 12 in combination with Proposition 13 illustrates how leverage can invite a predatory price response by one's competitors. Proposition 12 showed that for some parameter values that when Firm A is unlevered, Firm B will not choose to commit to a price low enough to induce Firm A to lower its product quality. However, Proposition 13 shows that if Firm A is levered, then Firm B can induce Firm A to lower its product quality at a higher price, so in this case, predatory pricing may be profitable.

It was noted earlier that empirical evidence suggests that the tendency to predate may be less following an LBO if the predator firm itself is leveraged. The above model is consistent with this observation. To see this note that in period 1 there are both benefits and costs of setting a predatory price that would cause the levered firm to abandon high quality, so period 1 profits may be either higher or lower with predation. However, second period profits are always higher with predation: the predator, by forcing its rival to produce low quality always gains market share and earns higher profits period 2. If period 1 profits are higher with predation, then of course predation will be the preferred policy regardless of leverage. However, if predation generates costs in period 1, then the incentive to predate depends on the rate at which the profits generated in period 2 are discounted which in turn depends on the predator's capital structure. This intuition is demonstrated in the following proposition.

Proposition 14. *Assume that firm B is also levered (but has no quality choice* *problem) and that the default probability is* $1 - \pi_B$. *There is a range of values for firm A's default probability such that predation is unprofitable but would be profitable if firm B were not levered.*

Proof: Proof: Please see the Appendix .

7 Conclusion

The primary goal of this paper is to provide a framework for understanding the recent empirical studies of pricing choices following leveraged buyouts. Our main emphasis was on the findings of Chevalier (1995) and Phillips (1995) that product prices tended to increase after LBOs, with important exceptions occurring when the industry rivals of the LBO firms are relatively unlevered.

The analysis indicates that the effect of leverage on pricing policies depends on characteristics of the debt contracts, the nature of uncertainty, the way in which firms compete and the type of product that is sold. Short-term debt increases the immediate threat of bankruptcy which can under certain conditions affect pricing decisions. However, the way in which prices are affected by the immediate threat of bankruptcy depends very much on the nature of the uncertainty, and the nature of competition. In particular, leverage has no effect on prices in the case where prices are set after the uncertainty is revealed. In these cases, long term debt can still affect pricing through its affect on the rate used to discount future cash flows. Firms with existing senior debt bear higher costs when they acquire new debt and thus discount future cash flows at higher rates. This makes firms less willing to price aggressively today in order to enjoy a higher market share and higher profits in the future. What this means is that prices generally increase following leverage increases.

We also showed that firms tend to compete more aggressively for market share when the quality of their products are not directly observable prior to their purchase. This is because a firm can more credibly provide a high quality product if it attracts a higher market share since it gains more from a favorable reputation if its future customer base is larger. The ability to credibly provide a high quality product is also related to financial structure; highly levered firms (being more short-sighted), have more incentive to cut quality and are thus less credible when they claim that their products have high quality. The combination of these factors imply that highly levered firms may have to attract higher market shares to maintain their reputations as quality producers. What this means is that when product quality is unobservable, a firm might decide to cut its price following an increase in leverage.

Having unobservable product quality provides a motivation for predatory pricing that has not been previously explored in the literature. We show that this incentive is increased when the potential "prey" is highly levered. The "predator" can benefit by cutting its price if by doing so it keeps its competitor from credibly offering a high quality product. Consistent with empirical observations, we find that the incentive to predate is an increasing function of the prey's debt ratio and a decreasing function of the predator's debt ratio.

We started this paper by asking whether competitive considerations tilt firms towards more or less debt. We directly analyze this question only for the case where leverage leads to price increases and conclude that in these cases firms will in fact take on risky debt even if there are no other benefits associated with debt financing. Although we do not discuss the case where prices can fall, it can be shown that the tendency to select high debt ratios is in fact suppressed in cases where leverage can invite a predatory price response.

The above considerations suggests that one should be cautious about making general statements about how leverage affects pricing decisions based on empirical studies of firms that do LBOs. Our analysis suggests that debt can have positive as well as negative effects on product prices. However, we are more likely to observe LBOs in those cases where increased leverage results in lower product market prices. 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.

The recent Chevalier and Scharfstein (1994) paper takes exactly this approach, relating the prices charged at different supermarkets with business conditions that are likely to effect the stores borrowing costs. Our analysis suggests that one may be able to more directly test the models by comparing product price changes to exogenous changes in the yields on the firms' most junior securities. Our results also suggests that a cross-industry analysis of the relation between discount rates and pricing decisions would be of interest since industries where product quality is unobservable may react very differently to external shocks to their discount rates than would industries like supermarkets where the observability of quality is less of an issue.

APPENDIX

Proof of Proposition 1.

The regularity conditions we assume are that of reaction function stability, and that the slope of an *equity financed firm's* reaction function is less than 1. The statements can be slightly strengthened if we assume that the latter condition holds even for debt financed firms. The rest is immediate from equation (8) and the discussion in the text. Details are omitted as they are similar to the proof of Proposition 2 below. ∎

Proof of Proposition 2.

Let Π^A_A denote the derivative of firm A's equity value with respect to own period one price, Π^B_B denote that for firm B, and let Π^F_G denote the second and cross-partial derivatives, for F= A,B and G = A,B. Then we can write equation (15) as

$$\Pi^A_A = 0.$$

Let the corresponding equation for firm B be denoted by

$$\Pi^B_B = 0.$$

Notice that (10) which corresponds to the case of a firm being equity financed, can be viewed as a special case of (15) with $F(d - x_2) = 0$.

Totally differentiating these equations, we get

$$\begin{aligned} \Pi^A_{AA} dp^A_1 + \Pi^A_{AB} dp^B_1 &= [f(d^A - x^A_2)\frac{\partial x^A_2}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p^A_1}]d(d^A) \\ \Pi^B_{BA} dp^A_1 + \Pi^B_{BB} dp^B_1 &= [f(d^B - x^B_2)\frac{\partial x^B_2}{\partial \sigma^B} \cdot \frac{\partial \sigma^B}{\partial p^B_1}]d(d^B). \end{aligned} \quad (23)$$

When a firm is equity financed, the corresponding R.H.S. in the above equation is zero.

Hence, denoting $\Delta = \Pi^A_{AA}\Pi^B_{BB} - \Pi^A_{AB}\Pi^B_{BA}$, we get

$$\frac{dp_1^A}{d(d^A)} = \frac{\Pi^B_{BB} \cdot \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot f(d^A - x_2^A)}{\Delta} \tag{24}$$

and

$$\frac{dp_1^B}{d(d^A)} = \frac{-\Pi^B_{BA} \cdot \frac{\partial x_2^A}{\partial \sigma^A} \cdot \frac{\partial \sigma^A}{\partial p_1^A} \cdot f(d^A - x_2^A)}{\Delta} \tag{25}$$

It can be checked that reaction function stability implies $\Delta > 0$. Since $\Pi^B_{BB} < 0$ by virtue of the second order conditions corresponding to (15), we get $\frac{dp_1^A}{d(d^A)} > 0$. On the other hand, if B's reaction function is positively sloped, Π^A_{BA} 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 4.

We first derive expressions for Π^A_{AA}, Π^B_{BB}, Π^A_{AB} and Π^B_{BA}, and the slopes of the reaction functions.

The first-order condition corresponding to equation (15) for firm A is:

$$-\frac{(p_1^A - c)K_1N}{2T} + K_1N[1/2 + \frac{p_1^B - p_1^A}{2T}] - \frac{(r-c)K_2N}{2T}[1 - \frac{d^A - (r-c)K_2N[1/2 + \frac{p_1^B - p_1^A}{2T}]}{\bar{I}}] = 0.$$

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

Differentiating, we get

$$\Pi^A_{AA} = -\frac{K_1 N}{2T} - \frac{K_1 N}{2T} + \frac{(r-c)^2 K_2^2 N^2}{4T^2 \bar{I}} = -\frac{K_1 N}{2T}[2 - \frac{(r-c)^2 K_2^2 N}{2TK_1 \bar{I}}]$$

and,

$$\Pi^A_{AB} = \frac{K_1 N}{2T} - \frac{(r-c)^2 K_2^2 N^2}{4T^2 \bar{I}} = \frac{K_1 N}{2T}[1 - \frac{(r-c)^2 K_2^2 N}{2TK_1 \bar{I}}]$$

Thus, the slope of A's reaction function is

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

and that of B is similarly obtained as

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

Notice that second order conditions require the denominators to be positive. Thus, the reaction functions are positively sloped iff the numerators are positive. Also, notice that reaction function stability requires

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

which is equivalent to

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

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

Proof of Proposition:

From the expression for $\frac{dp_1^A}{d(d^A)}$ obtained in the proof of Proposition 2 it is clear that given the switching cost model and our assumption of uniform distribution, the result will hold if $\frac{\Delta}{-\Pi_{BB}^B} = -\Pi_{AA}^A + \frac{\Pi_{AB}^A \Pi_{BA}^B}{\Pi_{BB}^B}$ is higher if firm B is debt financed.

Let us set $\frac{(r-c)^2 K_2^2 N}{2TK_1 I} = x$. Then we have, when B is debt financed:

$$\begin{aligned}\frac{\Delta}{-\Pi_{BB}^B} &= \frac{K_1 N}{2T}[2-x] - \frac{\frac{N^2K_1^2}{4T^2}(1-x)^2}{\frac{NK_1}{2T}(2-x)} \\ &= \frac{NK_1}{2T}[(2-x) - \frac{(1-x)^2}{2-x}]\end{aligned}$$

Similarly, when B is equity financed, noting that $\frac{\Pi_{BA}^B}{\Pi_{BB}^B} = -1/2$, we get

$$\begin{aligned}\frac{\Delta}{-\Pi_{BB}^B} &= \frac{K_1 N}{2T}[2-x] - \frac{NK_1}{2T}(1-x)\frac{1}{2} \\ &= \frac{NK_1}{2T}[(2-x) - \frac{1-x}{2}]\end{aligned}$$

The result now follows since

$$(2-x) - \frac{(1-x)^2}{2-x} > (2-x) - \frac{1-x}{2}$$

.

■

Proof of Proposition 6. From Proposition 3, it follows that in a symmetric equilibrium with debt the normal case, 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, $i = 1, 2$. Since $D_2 x_1(p,p) > 0$ for all p, it follows that $D_1 x_1(p,p) < 0$. However, from (15), it follows that at the symmetric equilibrium, $D_1 x_1(p,p) > 0$. Hence, at the symmetric equilibrium prices, $D_1 x_1(p,p) + D_2 x_1(p,p) > 0$. 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 in any symmetric equilibrium, the result follows. ■

Proof of Proposition 7.

Here, we derive the expression for the symmetric industry equilibrium level of debt (equation (19)).

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 (15)) can then be written as

$$-\frac{(p_1 - c)K_1 N}{2T} + \frac{K_1 N}{2} - \frac{(r-c)K_2 N}{2T}[1 - \frac{d - (r-c)K_2 N/2}{\bar{I}}] = 0. \tag{26}$$

The first order condition for firm value maximization is obtained by setting equation (18) to zero. Using equation (15), this reduces to

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

This reduces to

$$\begin{aligned} 0 &= -\frac{(r-c)K_2 N}{2T}[\frac{d}{\bar{I}} - \frac{(r-c)K_2 N}{2\bar{I}}] \\ &+ [\frac{(p_1 - c)K_1 N}{2T} + \frac{(r-c)K_2 N}{2T}]\rho'(p_1). \end{aligned} \tag{27}$$

where $\rho'(p)$ denotes the slope of the other firm's reaction function.

Substituting from (26), and simplifying, this reduces to

$$[\frac{d}{\bar{I}} - \frac{(r-c)K_2N}{2\bar{I}}][\frac{1}{\rho'} - 1] = \frac{K_1}{K_2} \cdot \frac{T}{r-c}. \tag{28}$$

Now, the inverse of the slope of the reaction function was shown in the proof of Proposition 4 as

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

Substituting this in (28), we get after simplification

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

■

Proof of Proposition 8.

(i) The proof readily follows from the fact that for $\bar{I}$ satisfying the condition of the proposition, the slope of firm B's reaction function - as given in the proof of Proposition 4 - is almost flat.

(ii) This follows from the fact that A's isoprofit curves will be flatter if it has higer leverage. The slope of A's isoprofit curves can be shown to be (assuming $K_1 = K_2 = 1$)

$$\frac{dp_1^B}{dp_1^A} = \frac{\frac{(r-c)}{2T}[1 - \frac{d^A - \sigma^A(r-c)N}{\bar{I}}] + \frac{p_1^A - c}{2T} - \sigma^A}{\frac{(r-c)}{2T}[1 - \frac{d^A - \sigma^A(r-c)N}{\bar{I}}] + \frac{p_1^A - c}{2T}}$$

It is easily checked that this is decreasing in d^A.

(iii) When firm B is equity financed, the optimum point is always to the right of the 45-degree line. However, it is easily checked that in figure 2, if firm B's post-leverage reaction function is sufficiently flat, then the optimum point could be to the left of the 45-degree line. ■

Proof of Proposition 9. It is easy to check that at a conjectured price $(p_1^B)^* = P^*$, if firm A produces high quality and chooses $p_1^A = P^*$, the market's beliefs are justified. At this conjectured p_1^B, it is also immediate that the optimal decision for firm A is indeed to produce high quality and set $p_1^A = P^*$. Given this, it is optimal for B to set $p_1^B = P^*$ (since the market's beliefs depend only on p_1^A).

We have already seen that the belief that quality is high if firm A's price is at or below the level where (given $(p_1^B)^*$) condition (*) is satisfied with equality are justified. It is easy to check that the belief that quality is low otherwise is also justified. To see this, we need to compute firm A's profit from producing, respectively, High and Low quality at a price where the market believes the Low quality is being produced. A consumer located at y buys firm A's product if and only if

$$r\theta - p_1^A - Ty \geq r - (p_1^B)^* - T(1-y).$$

This implies that

$$\sigma_L^A = 1/2 + \frac{(p_1^B)^* - p_1^A}{2T} + \frac{r(\theta-1)}{2T}.$$

Hence, firm A produces low quality if and only if

$$(p_1^A - c)\sigma_L^A N + (\theta r - c)\sigma_L^A N + Z \geq (p_1^A - c)\sigma_L^A N + (r - c)\sigma_L^A N$$

i.e.

$$Z \geq [1/2 + \frac{(p_1^B)^* - p_1^A}{2T} + \frac{r(\theta-1)}{2T}]r(1-\theta)N \qquad (A*)$$

which is satisfied since at this price, condition (*) is violated by assumption.

For some parameter values, other equilibria exist which yield different outcomes. For example, consider a price $(p_1^A)'$ slightly below P^*, and let the market conjecture that $(p_1^B)^* = \rho^B((p_1^A)')$, and that quality is low if the price exceeds $(p_1^A)'$, and high otherwise. Then, $p_1^A = (p_1^A)'$ and $p_1^B = \rho^B((p_1^A)')$ is an equilibrium. However, such beliefs are not reasonable. If firm A charged slightly higher out-of- equilibrium price, the market should believe it produced high quality. This is so because the only reason it would deviate from the equilibrium price would be if the market believed it was producing high quality – and in that case producing high quality would be optimal (since condition (*) would still hold) and its payoff would be greater than the equilibrium payoff. ■

Proof of Proposition 11.

Consider the case where firm B is also levered (however, for simplicity, we continue to assume that it does not have any quality choice problem). Let $1 - \pi^B$ denote its default probability. It can be checked that when firm B is also debt financed, ceteris paribus, its price is higher and thus firm A's market share is higher. Let $\rho^B(p_1^A, \pi^B)$ denote firm B's reaction function when it is levered. Suppose π violates the condition $\pi r(1-\theta)N \geq 2Z$ but satisfies

$$\pi r(1-\theta)N[1/2 + \frac{\rho^B(P^*, \pi^B) - P^*}{2T}] > Z. \qquad (***)$$

Clearly, such values of π exist since $\rho^B(P^*, \pi^B) - P^* > 0$.

For π in this range, consider the Nash equilibrium level of p_1^A when both firms are levered. Since both firms are levered, it follows from Corollary 1 that the Nash equilibrium price exceeds P^*, the Nash equilibrium price when both firms are unlevered. Suppose condition (***) holds when P^* is replaced in this condition by the Nash equilibrium price p_1^A when both firms are levered. Let beliefs be that quality is high if firm A's price is below that level and low otherwise. Then we have an equilibrium with p_1^A at this level, $p_1^B = \rho^B(p_1^A, \pi^B)$, and high quality being produced, and as before this is the unique equilibrium consistent with reasonable beliefs. If (***) does not hold for the Nash equilibrium p_1^A, one can find a level of $p_1^A > P^*$ for which condition (***) is satisfied with equality (when P^* is replaced by p_1^A in condition (***)), and the appropriate beliefs are then defined with respect to this price. ■

Proof of Proposition 12.

The following Lemma is useful:

Lemma A1. *If the price that firm B commits to satisfies*

$$p_1^B \geq \frac{4TZ}{r(1-\theta)N} + 2c - r - T \tag{29}$$

then firm A will produce high quality.

Proof: Given p_1^B, if the market believes it will produce high quality, the best price for firm A is that which maximizes

$$(p_1^A - c + r - c)[1/2 + \frac{p_1^B - p_1^A}{2T}]$$

The optimal price is given by the following first-order condition:

$$1/2 + \frac{p_1^B - p_1^A}{2T} = \frac{p_1^A - c}{2T} + \frac{r - c}{2T} \tag{30}$$

It is straightforward to show that at this optimal price, condition (*) is satisfied provided

$$p_1^B \geq \frac{4TZ}{r(1-\theta)N} + 2c - r - T$$

Suppose next that for p_1^B satisfying this condition, p_1^A is set at a level where the market believes quality is low. Given that the market believes its quality is Low, the price that will maximize firm A's profit from producing Low quality satisfies

$$1/2 + \frac{p_1^B - p_1^A}{2T} + \frac{r(\theta - 1)}{2T} = \frac{p_1^A - c}{2T} + \frac{\theta r - c}{2T} \tag{31}$$

i.e.

$$1/2 + \frac{p_1^B - p_1^A}{2T} = \frac{p_1^A - c}{2T} + \frac{r - c}{2T} \tag{32}$$

which is the same as in equation (30). Hence, its profit from producing Low *at a price where the market believes its quality is Low* must be necessarily less than producing Low at the price given in equation (31), where the market believes its quality is High.

Thus, when p_1^B satisfies condition (29), firm A's profit from producing High at a price given by (30) is higher (given that the market believes it produces High quality) than from producing Low at that price, which is higher than producing Low at any other price where the market might believe its quality is Low. ■

Proof of Proposition: Let $\hat{P}_1^B \equiv$ the R.H.S. of (29).

First, we show the existence of Z^* such that for $Z \leq Z^*$, if firm A were to produce Low when B sets a price slightly less than $\hat{P}_1^B$, B's profit would be lower than if it set a price $p_1^B = T + 2c - r$ (i.e. the Nash equilibrium price).

If firm A were to produce low at $\hat{P}_1^B$, B's market share would be

$$\sigma^B = \frac{1}{2} + \frac{p_1^A - \hat{P}_1^B}{2T} + \frac{r(1-\theta)}{2T}$$

Substituting for p_1^A from equation (32), we get

$$\sigma^B = 1 - \frac{Z}{r(1-\theta)N} + \frac{r(1-\theta)}{2T}$$

Hence, firm B's profit is

$$N\sigma^B[\hat{P}_1^B + r - 2c] = N[1 - \frac{Z}{r(1-\theta)N} + \frac{r(1-\theta)}{2T}][\frac{4ZT}{r(1-\theta)N} - T].$$

Differentiating this w.r.t. Z, it can be checked that the expression decreses as Z decreases for $Z < \frac{r(1-\theta)N}{2}$. Moreover, the exprssion is zero for $Z = \frac{r(1-\theta)N}{4}$. On the other hand, if firm B had set $p_1^B = T + 2c - r$, i.e. the Nash equilibrium price, it would earn a two period profit of NT/2 (it can be checked that at this price, equation (29) would hold, and firm A would produce high quality). Thus, there exists Z^* in the interval $[\frac{r(1-\theta)N}{4}, \frac{r(1-\theta)N}{2}]$ for which the Nash equilibrium price yields higher profit for B.

It remains to show that for no price below $\hat{P}_1^B$ can B's profit be higher. Differentiating B's profit

$$(p_1^B + r - 2c)[\frac{1}{2} + \frac{p_1^A - p_1^B}{2T} + \frac{r(1-\theta)}{2T}]N$$

w.r.t. p_1^B, it can be checked that the derivative is positive at $\hat{P}_1^B$. From the concavity of the profit function, it then follows that if A produces low quality, then B's profit is lower at any price $p_1^B < \hat{P}_1^B$. If A produces high quality, B's profit is still lower. Hence, the result follows. ■

Proof of Proposition 13.

From equation (22), since $\rho^B(p_1^A) - p_1^A$ is decreasing in p_1^A, it is clear that the price firm A has to charge if it produces high quality approaches the average cost of production c as π becomes sufficiently small. For such a value of π, its gain from producing high quality is less than $\pi r(1-\theta)N\sigma^A - Z$, and is thus negative by virtue of equation (22). Thus, there exists π sufficiently small such that at the equilibrium price of firm B, firm A is indifferent between producing high quality and low quality. Let π^* denote this critical value of π. We now show that there is a range of values of π for which firm B will optimally commit to a price at which firm A will produce low quality. For this, it is enough to show that firm A will chose low quality if $\pi = \pi^*$ and firm B commits to a price slightly less than the equilibrium price - the rest follows from continuity.

Firm A's profit from producing low quality is

$$(p_L^A - c + \pi(\theta r - c))[\frac{1}{2} + \frac{p_1^B - p_L^A}{2T} + \frac{r(\theta - 1)}{2T}]N,$$

where we have denoted the first period price by p_L^A. Hence, its gain (loss) from producing low quality when p_1^B changes is given by the envelope theorem to be $N \cdot \frac{p_L^A - c + \pi(\theta r - c)}{2T}$. The first order condition for profit maximization when it produces low quality is

$$\sigma_L^A = \frac{p_L^A - c + \pi(\theta r - c)}{2T},$$

so that this gain (loss) is $N\sigma_L^A$. On the other hand, note that if it produces high quality, since (22) must hold, a change in p_1^B must cause an equal change in p_H^A, so that σ_H^A remains unchanged. Thus, the gain (loss) from producing high quality when p_1^B changes is $N\sigma_H^A$. Since σ_H^A is necessarily greater than σ_L^A, it follows that a reduction in p_1^B causes firm A to switch to low quality.

To see that both firms charge lower prices than those when firm A is completely equity financed, note that $p_1^B < \rho^B(p_1^A(\pi^*)) < \rho^B(P^*) = P^*$. Also, it can be checked that firm A's reaction function is the same irrespective of whether it produces high or low quality. Hence, $P^* = \rho^A(P^*) > \rho^A(p_1^B)$.

To see that firm B charges a lower price than firm A, note that $p_1^B < \rho^A(p_1^B)$ for $p_1^B < P^*$.

Finally, B's market share when A produces low quality is $\sigma^B = 1/2 + \frac{p_1^A - p_1^B}{2T} + \frac{r-c}{2T} > 1/2$. ■

Proof of Proposition 14.

Assume first that firm B is not levered. Notice that the difference in firm B's payoff from a predatory pricing strategy and setting the Nash price is a continuous function of π: hence, it follows from Propositions 12 and 13 that there exists a value of π, say π^*, such that firm B is indifferent between the two options (setting the Nash price and the predatory price). Since the second period profit is necessarily higher when it sets the predatory price, it follows that the first period profit must be lower, compared with setting the Nash price. Writing x_i^N and x_i^P for its profit corresponding to π^* for these two options, we have

$$x_2^P - x_2^N = x_1^N - x_1^P.$$

It therefore follows that for any $\pi_B > 0$,

$$\pi_B[x_2^P - x_2^N] < x_1^N - x_1^P,$$

and that this inequality would continue to hold for a range of π around π^*. However, this inequality implies that predation is not profitable. ■

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