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Corporate Leverage and Product Differentiation Strategy*

This article develops a model of the interplay between corporate leverage and product differentiation strategy. Leverage improves managerial discipline, but it can also raise customer concerns about a vendor's long-term viability. We argue that customer concerns about firm viability will be particularly pronounced when products are highly differentiated from competitors' products. In this context, optimal product differentiation strategies solve a trade-off between softening price competition and reducing customers' total cost of ownership. Our analysis is consistent with empirical evidence suggesting a negative correlation between corporate leverage and product uniqueness.

I. Introduction

This article aims at integrating a firm's choice of financial structure with its quest for differentiation in the marketplace. More specifically, we are interested in exploring how customer concerns about firm viability shape optimal financial and product market differentiation strategy. Our analysis is motivated by the empirical observation that financially fragile firms often face poor prospects in the product market, as customers become reluctant to engage in further transactions with them. Notably, Opler and Titman (1994) find that highly leveraged firms tend to lose market share to their less leveraged competitors in industry

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downturns. They attribute this phenomenon at least partially to customer fears of being left without after-sales service, spare parts, or product upgrades. Despite the importance of this consideration, there is very little formal analysis of the implications of customer concerns about firm viability for financial and business strategy.

At the core of our model is a trade-off between the benefits of leverage, in terms of enhancing the payout discipline of managers (see Jensen 1986; Bolton and Scharfstein 1996; Hart and Moore 1998), versus the cost imposed on customers, who are harmed by the supplier being liquidated and exiting the market. This latter consideration is particularly relevant for manufacturers of durable equipment for which customers require maintenance service and product upgrades. To the extent that after-sales service is most efficiently provided by the original supplier, liquidation can undermine its availability or make it more costly. Likewise, the liquidation of the original supplier can make it harder for customers to obtain product upgrades and repeat products. In this context, the threat of liquidation associated with debt has costs and benefits. On the one hand, it disciplines corporate managers to pay out free cash flow instead of diverting it for private benefits. On the other hand, to the extent that creditors do not internalize the costs that liquidation imposes on customers, leverage can also increase the customers' total cost of ownership, which in turn suppresses their willingness to pay (see Titman 1984).

We suggest that the trade-off between the costs and benefits of leverage has implications for the firm's optimal product differentiation strategy. Our basic premise is that customer concerns about firm viability should be particularly pronounced when the firm's product is highly differentiated from rivals' products. If a firm's product is similar to those of rivals, customers should be able to obtain after-sales service, spare parts, and product upgrades at relatively low cost from third parties. By contrast, if a firm's product is unique, customers may have to rely on the firm's continued support. Likewise, the cost of switching to another vendor's product may be substantial if products are highly differentiated. Accordingly, we argue that firms should mitigate customer concerns about their long-term viability not only by adjusting their financial structures but also by reducing the very uniqueness of their products. In doing so, firms effectively decrease the cost that customers incur in the event of liquidation. However, curtailing product differentiation has its own costs: it sharpens price competition by reducing product variety and customer lock-in. This introduces a trade-off between softening price competition and reducing customers' total cost of ownership. Based on these effects, we show that the equilibrium degree of differentiation is limited by the severity of managerial incentive problems: as agency problems call for higher leverage, the firm positions its product closer to those of competitors in order to increase customers' willingness to pay.

Our analysis is consistent with two strands of the empirical literature. A first set of studies has examined the effects of product characteristics and of research and development (R&D) intensity on leverage choices. Titman and

Wessels (1988) show that producers of durable, service-intensive goods and R&D-intensive firms tend to have less leverage than other firms. To the extent that R&D intensity is a proxy for the degree of uniqueness of a firm's product, this is consistent with the idea that firms producing highly unique goods should opt for less leverage. In a similar vein, Opler and Titman (1993) report that firms initiating leveraged buyouts tend to have lower R&D ratios than other firms and are less likely to sell durable goods, such as equipment and machinery. A second body of the empirical literature has studied the effects of leverage increases on capital expenditures and R&D intensity. Kaplan (1989) shows that leveraged buyout firms reduce capital expenditures by 33% relative to their industry peers in the 2 years following the buyout. Likewise, Hall (1990), using a large panel of U.S. manufacturing firms during the 1980s, reports that increases in leverage are followed by substantial reductions in R&D investment. These findings can be interpreted as highly leveraged firms being less tempted to waste free cash flow on unprofitable R&D projects. An alternative view is proposed in our article: highly leveraged firms deliberately engage in less drastic innovation and differentiation choices in an attempt to ease customer concerns about their viability.

Our research complements the literature on how corporate financial structure is influenced by product market considerations, and vice versa.[1] Closest to our analysis are Titman (1984) and Maksimovic and Titman (1991). Both papers argue that debt can impair the ability or willingness of a firm to honor its implicit or explicit commitments with customers. In Maksimovic and Titman (1991), this takes the form of reduced incentives to invest in reputation and high-quality goods. In Titman (1984), high leverage can threaten a firm's prospects by raising customer concerns about its long-term viability. Accordingly, producers of durable and relatively unique goods should opt for relatively low leverage in order to ease customer concerns. We draw on Titman's (1984) insight but take the analysis a step further. Titman (1984) fixes product characteristics and shows how customer concerns about a vendor's long-term viability shape leverage choices. Our analysis starts from the premise that a firm's differentiation strategy is not exogenously given, but optimally chosen. We thus argue that firms, as well as adjusting their financial structures, should address customer concerns about their viability by altering the degree of uniqueness of their products.

The present article is also related to the industrial organization literature on second sourcing. Notably, Farrell and Gallini (1988) have a model in which a monopolistic firm may be tempted to exploit customers once they have incurred product-specific investments. The authors show that the firm can resolve this holdup problem by licensing its product to competitors. This is akin to our model where the firm positions itself closer to competitors in an

1. See, among others, Titman (1984), Brander and Lewis (1986), Maksimovic (1988), Bolton and Scharfstein (1990), Maksimovic and Titman (1991), Chemla and Faure-Grimaud (2001), Kanatas and Qi (2001, 2004), and Povel and Raith (2004).

attempt to entice customers to "invest" in the firm. In our setting, however, efficiency losses do not stem from a holdup problem but, rather, from creditors seizing the firm's assets in the event of default. As a result, the most efficient provider of after-sales service, that is, the original supplier, is no longer able to provide it. This creates an ex post inefficiency, which is borne by the firm ex ante.

The article is organized as follows. Section II outlines the model. Section III explores the interplay between a firm's financial structure choice and product differentiation strategy within a vertical differentiation, reduced-form profits setting. We subsequently suggest a number of robustness checks and extensions of our base model. Section IV considers the case of horizontal product differentiation. Section V concludes. Proofs are relegated to the appendix.

II. The Model

We consider a model with two periods (and three dates, $t = 0, 1, 2$). At date 0, a principal (e.g., shareholders, owner, founder entrepreneur) needs to hire a manager to run his firm. There is a competitive supply of managers, all of whom are penniless. The firm produces a durable product and provides after-sales service. Customers buy the product in the first period, and they need after-sales service in the second period. While the firm is initially 100% equity financed, it may take on some leverage at date 0 (to be explained in more detail below). This debt issue will be equivalent to a management buyout in which the manager acquires the firm and finances the acquisition with debt. There is universal risk neutrality and no discounting.

A. *Production*

We assume that there is a representative customer with unit demand and preference for variety.[2] The firm is innovative in that it can differentiate its product offering from that of a competitive fringe. A product with "design" $\phi \in [0, \infty)$ gives the representative customer a utility of $V(\phi)$ over the two periods, with $V(0) = 0$, $V'(0) > 0$, and $V''(\phi) < 0$. We also assume that $V(\phi)$ has an interior maximum; that is, there is a $\hat{\phi}$ such that $V'(\hat{\phi}) = 0$. The competitive fringe produces a product with design $\phi = 0$ at zero marginal cost.

At date 0, the firm chooses the degree of differentiation (i.e., ϕ) and quotes a price for its product, which the representative customer accepts or rejects. Delivery of the product takes place during the first period. The firm faces uncertainty about its production costs (input costs, wages, etc.). This cost uncertainty, and hence the firm's profits, realize at date 1, that is, only after the firm has committed to deliver the product. Specifically, we consider that,

2. Alternatively, one can think of a continuum of consumers with homogenous preferences. The model developed here corresponds with a vertical product differentiation setting. See Sec. IV for an alternative framework with horizontal product differentiation and consumer heterogeneity.

with probability $1 - \theta$, the firm experiences a cost shock (low cash-flow state). For expositional convenience, we assume that the cost shock wipes out the firm's revenues.[3] With probability θ, the cost shock does not materialize, in which case production costs are zero (high cash-flow state). In other words, profits are given by the product market revenues or are equal to zero.

Customers need after-sales service in the second period. We consider long-term "warranty" contracts, so that customers are provided with after-sales service at no additional cost as long as the firm is able to supply it.[4] The firm is able to provide after-sales service if it is not closed down at date 1 (see below) and if, moreover, the manager who has been hired at date 0 continues to run the firm. Thus, we assume that the manager acquires firm-specific skills that make her indispensable for running the firm. The firm's cost of providing after-sales service is normalized to zero. If the firm cannot provide after-sales service, then customers turn to a third-party service provider.[5] Third-party service providers compete à la Bertrand, and their cost of providing the service, and thus the price charged for it, depends on the degree of differentiation of the firm's product: the more differentiated the product, the larger the third-party service provider's cost of supplying service for it. Formally, the service provider's cost of supplying the service is given by $C(\phi) = \alpha c(\phi)$, with $\alpha > 0$, $c(0) = c'(0) = 0$, $c'(\phi) > 0$, and $c''(\phi) > 0$. We will refer to α as the product's service intensity.

B. *Agency Conflicts*

The manager is subject to moral hazard. We adopt the free cash-flow framework along the lines of Jensen (1986), Bolton and Scharfstein (1996), and Hart and Moore (1998). Specifically, we assume that cash flows are unverifiable (but observable to firm insiders and financiers), accrue to the manager in the first place, and can be diverted (e.g., through perks). Thus, being protected by limited liability, the manager may have an incentive to declare falsely that she did not generate income during the first period and to divert the cash. In this framework, the principal must devise a mechanism that induces the manager to pay out cash flow.

It turns out that in our setup an appropriate incentive scheme is to sell the firm's assets to the manager and to finance the acquisition by issuing debt on a competitive credit market.[6] As emphasized by Jensen (1986), the threat of bankruptcy and liquidation associated with debt can be a powerful device to discipline corporate managers. Gilson (1989) provides empirical evidence that bankruptcy can impose substantial costs on managers. In a large sample of

3. We show in Sec. III.C that this assumption is inessential.

4. Thus, customers pay for after-sales service up front. We show in Sec. III.C that this is indeed optimal.

5. We assume throughout the article that purchasing service is worthwhile for customers.

6. Instead of issuing debt and thereby exposing the manager to external market discipline, the principal may well impose a direct firing threat on the manager. We argue in Sec. III.C that, in our setup, such an internal incentive scheme is dominated by capital market discipline.

exchange-listed firms, he finds that more than half of the managers of financially distressed firms are replaced and not hired by comparable firms for at least 3 years. To capture this we assume that the manager derives a private control benefit $B > 0$ when the firm is continued until date 2. In this context, an increase in the control benefit B makes it more costly for the manager to lose control, which in turn helps to align her payout discipline with the principal's objectives.

Following Bolton and Scharfstein (1996), we consider debt contracts specifying a repayment R, due at date 1, and creditors' liquidation right $\beta \in [0, 1]$, meaning that if the manager fails to make her date 1 repayment obligation of R, then creditors are entitled to liquidate the firm with probability β and to seize the liquidation proceeds.[7] Conversely, if the manager pays out R, then creditors are not entitled to liquidate.[8] Assets in place have a salvage value L at date 1 and, for simplicity, zero salvage value at date 2. To make the analysis interesting, we assume that liquidation is inefficient for the manager and creditors, that is, $L < B$. Consistent with most bankruptcy codes (see, e.g., Appelbaum 1992), we consider that creditors' claims are senior to customers' warranty claims. Thus, creditors cannot be held liable for customers' warranty claims.

We allow for debt renegotiation. Thus, none of our results will be driven by an assumption that the manager and creditors can commit not to renegotiate. For the sake of simplicity, we assume that creditors have full bargaining power in contract renegotiation.

C. Sequence of Events

The sequence of events can be summarized as follows.

At date 0, the manager is hired, debt is issued, and the degree of differentiation ϕ is chosen. We assume that the differentiation is chosen ex ante by the principal and then show that the manager would have no incentive to deviate from the principal's choice if she had discretion to do so. The firm subsequently quotes a price for its product, and the representative customer makes her purchasing decision—after having observed the price, the degree of differentiation, and the firm's financial structure (R, β).[9]

At date 1, product market profits realize, and the manager either pays out

7. We thus allow for probabilistic liquidation devices. This is inessential. Alternatively, we could have considered partial liquidation mechanisms under which the firm is partially downsized; the analysis would stay the same.

8. This is optimal as long as the firm value is decreasing in β (to be formalized further below), which we will assume throughout the article. See the appendix for the optimal contract when this assumption is not satisfied.

9. By this we do not mean that the customer literally studies the firm's financial accounts before committing to a purchase. Rather, we mean that channels such as the business press allow the customer to form a well-informed opinion about the firm's financial soundness. A characterization of the equilibrium when the firm's financial structure is unobservable to customers is provided in the appendix.

R or zero.[10] The firm is then liquidated or continued. If the firm is continued, after-sales service is provided by the firm. If the firm is liquidated, customers turn to a third-party service provider.

At date 2, the firm is closed down.

III. Analysis

We now turn to the analysis. The next subsection solves the optimal debt issue, taking the firm's degree of product differentiation as a given. We subsequently explore the firm's optimal choice of product differentiation. Section III.C provides robustness checks and extensions.

A. *The Trade-Off between Managerial Discipline and Customer Concerns*

We start by deriving the representative customer's willingness to pay. Suppose that the customer rationally anticipates that the firm will continue to operate with probabilities 1 and $1 - \beta$ in the high and low cash-flow states, respectively. Thus, with probability $\theta + (1 - \theta)(1 - \beta)$, the firm provides after-sales service at zero cost, while with probability $(1 - \theta)\beta$, the customer is forced to purchase service from a third-party service provider at cost $C(\phi)$. The customer's payoff from purchasing the firm's product, denoted by $\Pi(\phi, \beta)$, is then

$$\Pi(\phi, \beta) = V(\phi) - (1 - \theta)\beta C(\phi).$$

When purchasing the competitive fringe's product, the customer derives a net payoff of zero. The customer's willingness to pay for the firm's product is thus given by $\Pi(\phi, \beta)$. We assume that the firm makes a take-it-or-leave-it price offer to the customer. The price p charged for the firm's product (and hence the firm's product market revenue) is then given by the customer's willingness to pay, $p = \Pi(\phi, \beta)$. Notice that the firm's product market income is decreasing in β. This is because an increase in β raises customer concerns about firm viability, which in turn suppresses customers' willingness to pay for the firm's product.

Firm value (excluding managerial control benefits) is given by

$$\theta[V(\phi) - (1 - \theta)\beta C(\phi)] + (1 - \theta)\beta L.$$

Notice that firm value is strictly decreasing in β if and only if

$$\theta C(\phi) > L. \tag{1}$$

To make the analysis interesting, we assume throughout the article that the asset salvage value is sufficiently low (e.g., close to zero) so that equation

10. It is easy to see that if the manager defaults strategically (i.e., pays out less than R in the high cash-flow state), then she optimally pays out zero.

(1) is satisfied in equilibrium.[11] In other words, the marginal cost of liquidation from raising customer concerns about firm viability (i.e, reducing their willingness to pay) outweighs the marginal direct benefit from capturing the asset salvage value. In view of (1), the following benchmark result is immediate.

LEMMA 1. In the absence of managerial incentive problems, the firm continues to operate with probability one, and the optimal degree of product differentiation is

$$\hat{\phi} = \arg\max_{\phi} V(\phi).$$

In what follows, we refer to $\hat{\phi}$ as the first-best degree of differentiation.

We now examine the optimal design of the debt issue when agency problems matter. Under a feasible and incentive-compatible mechanism, the manager pays out R in the high cash-flow state, while in the low cash-flow state she must default for liquidity reasons, and creditors liquidate with probability β. The present value of the creditors' claim against the firm's cash flows, and hence the proceeds of the management buyout, is then given by

$$\theta R + (1 - \theta)\beta L.$$

The optimal management buyout maximizes the proceeds of the debt issue subject to four constraints: (i) the manager's participation constraint—her payoff must not be smaller than her reservation utility (which we normalize to zero, for simplicity); (ii) the manager's incentive constraint—she must have no incentive to default strategically in the high cash-flow state; (iii) the cash constraint—the manager cannot pay out more than she has; and (iv) feasibility: $\beta \leq 1$. We derive these constraints in turn. The manager's participation constraint can be written as

$$\theta[\Pi(\phi, \beta) - R + B] + (1 - \theta)(1 - \beta)B \geq 0.$$

The right-hand side is the manager's reservation payoff, and the left-hand side is her payoff from accepting the contract. With probability θ, she generates product market income $\Pi(\phi, \beta)$, pays out R, and extracts the control benefit B with the probability of one. Conversely, with probability $1 - \theta$, the manager must default, and the firm continues only with probability $1 - \beta$.

To derive the manager's incentive constraint, suppose that the manager defaults in the high cash-flow state. Creditors are then entitled to liquidate the firm with probability β. Yet, liquidation is inefficient, and, moreover, the manager has something to offer to creditors in exchange for them waiving their liquidation rights. Let us assume (and verify later) that the manager has sufficient cash such that following renegotiation the firm continues with probability one. The manager then transfers $R' = \beta B$ to creditors. This is precisely the amount that she would lose if the creditors exercised their liquidation

11. The characterization of the optimal financial structure for the case $\theta C(\phi) < L$ is provided in the appendix.

right. In exchange, creditors continue with the probability of one. Thus, the manager has an appropriate incentive to make the prespecified debt repayment R if and only if

$$\Pi(\phi, \beta) - R + B \geq \Pi(\phi, \beta) - \beta B + B$$

or $R \leq \beta B$. This merely says that the manager cannot be enticed to pay out more than she would lose if she paid out zero and creditors exercised their liquidation rights. Finally, the cash (or limited liability) constraint is given by

$$R \leq \Pi(\phi, \beta) = V(\phi) - (1 - \theta)\beta C(\phi).$$

In summary, the optimal debt issue solves

$$\max_{R, \beta \in [0,1]} \theta R + (1 - \theta)\beta L,$$

subject to

$$R \leq \beta B, \tag{IC}$$

$$R \leq V(\phi) - (1 - \theta)\beta C(\phi), \tag{CASH}$$

$$\theta[V(\phi) - (1 - \theta)\beta C(\phi) - R + B] + (1 - \theta)(1 - \beta)B \geq 0, \tag{IR}$$

where $C(\phi) = \alpha c(\phi)$. Notice that the participation constraint (IR) is implied by the cash constraint (CASH). Thus, the participation constraint is slack.[12] Crucially, an increase in β relaxes the incentive constraint (IC) but tightens the cash constraint (CASH). This highlights the basic trade-off between enhancing managerial discipline and easing customer concerns about firm viability: giving creditors stronger liquidation rights improves managerial incentives but comes at the expense of suppressing customers' willingness to pay. We are now in the position to state the optimal debt issue.

Proposition 1. The optimal debt issue is the following:

a) If the managerial control benefit is small, $B \leq V(\phi) - (1 - \theta)C(\phi)$, then default is penalized as harshly as possible, that is, $\beta = 1$. The repayment is set at $R = B$.

b) If the managerial control benefit is large, $B > V(\phi) - (1 - \theta)C(\phi)$, then there is deviation from absolute priority. Specifically, the optimal debt issue entails

$$\beta = \frac{V(\phi)}{B + (1 - \theta)C(\phi)} \equiv \beta(\phi) < 1,$$

and $R = \beta(\phi)B$. Thus, creditors are pledged "weaker" liquidation rights when agency problems become less severe (B increases), the product be-

12. This would be different if the manager had some personal wealth that she could pledge. See Sec. III.C.

comes more service intensive (α increases), or default risk increases (θ decreases).

Proof. See the appendix.

If the cash diversion problem is severe (i.e., B is relatively small), then the largest payment that can be extracted from the manager is less than the firm's product market income. In this case, default should be penalized as harshly as possible, that is, $\beta = 1$. To see this, notice that if the principal eased customer concerns about firm viability by decreasing β, then the manager would divert the entire incremental profit. It is thus optimal to punish default with full liquidation and to give absolute priority to creditors. In contrast, absolute priority is violated when the control benefit is relatively large.[13] This is because the incremental profit from customers' higher willingness to pay is not diverted by the manager but passed on to creditors. This raises the proceeds of the debt issue and, hence, the principal's payoff.

The comparative statics are instructive. As the control benefit B increases, managerial incentives become more aligned with the interests of the principal. There is thus less need to impose a harsh termination threat on the manager. Since giving "strong" liquidation rights to creditors threatens the firm's prospects in the product market, creditors are pledged "weaker" liquidation rights if the agency problem becomes less severe. As default risk and the product's service intensity increases, customers become more concerned about the firm's viability and the cost that they would incur if the supplier were liquidated. The principal optimally responds by reducing creditors' liquidation right β.

To match our analysis with the empirical literature on leverage choices, we need to define what leverage is in our setting. A standard feature of cash diversion models, such as ours, is that there is no outside equity, so it is not straightforward how to define leverage in our setting.[14] Notice that, in our context, leverage matters to the extent that it threatens the firm's long-term viability. We thus associate leverage with the strength of the creditors' liquidation right β. Proposition 1 then predicts that firms producing durable, service-intensive goods (α large) should be less levered than firms producing commodities (α small). This is consistent with the empirical findings of Titman and Wessels (1988), who show that firms manufacturing machines and equipment tend to have less leverage than other firms.

One may wonder whether the manager and creditors would have an incentive to collude against the customer by opportunistically liquidating the firm once the customer made the purchasing decision. At this stage, the liquidation decision no longer affects product market revenues, and hence financial stakeholders may have an incentive to terminate the firm in order to reap the asset salvage value. To see that the continuation commitment is credible, notice that liquidation is ex post inefficient for the manager and creditors. Thus, the parties cannot possibly increase their joint payoff by closing down the firm. That is,

13. To see why absolute priority is violated, notice that $R = \beta(\phi)B > \beta(\phi)L$, but $\beta(\phi) < 1$.
14. Notable exceptions include Fluck (1998) and Myers (2000).

the manager's bias toward continuation effectively protects customers against opportunistic behavior on the part of firm insiders and financial stakeholders.

We have framed our analysis in a context where a firm issues new debt in an attempt to improve the payout discipline of its management. An alternative and complementary interpretation of our model would be to consider that the firm is already in financial distress at the initial date 0. The firm then needs to restructure its current debt in order to prevent creditors from closing down the firm at date 0. The firm's customers observe the outcome of the debt restructuring. In this context, creditors may have an interest in rolling over debt to date 1 and in partially waiving their liquidation rights. This is because making concessions (i.e., reducing β) improves the firm's prospects in the product market, which, ultimately, benefits creditors.[15]

B. *The Choice of Product Differentiation*

We now examine the firm's optimal choice of product differentiation. We assume that the principal ex ante chooses differentiation. We argue in Section III.C that the manager would have no incentive to deviate from the principal's choice if she had discretion to do so.

The optimal degree of differentiation maximizes the principal's ex ante payoff, that is, the proceeds of the debt issue. Let us assume for a moment that $\beta(\phi) \leq 1$ holds at the optimum. The principal then chooses ϕ as to

$$\max_{\phi} \beta(\phi)[\theta B + (1-\theta)L],$$

where $\beta(\phi) = V(\phi)/[B + (1-\theta)C(\phi)]$. Thus, the principal effectively maximizes the creditors' liquidation right $\beta(\phi)$. The optimal degree of differentiation ϕ^* is then uniquely characterized by the first-order condition

$$V'(\phi^*) - (1-\theta)\beta(\phi^*)C'(\phi^*) = 0. \tag{2}$$

Notice that the second term on the left-hand side is strictly positive. Thus, by concavity, we must have $\phi^* < \hat{\phi}$: relative to the unconstrained optimum $\hat{\phi}$, the firm positions its product closer to those of competitors. We show in the appendix that there is a threshold $\hat{B}$ such that $\beta(\phi^*) \leq 1$ if and only if $B \geq \hat{B}$. For $B < \hat{B}$, default is punished with full liquidation, that is, $\beta = 1$. In this case, the proceeds of the debt issue no longer depend on product differentiation, and we will simply assume that the principal selects the degree of product differentiation that maximizes firm value $V(\phi) - (1-\theta)C(\phi)$. We thus have the following result.

PROPOSITION 2. Relative to the first best, the firm positions its product closer to those of competitors: $\phi^* < \hat{\phi}$. The optimal degree of differentiation

15. This is akin to Myers's (1977) debt overhang problem, whereby a firm may fail to invest in positive net present value projects because existing debt dilutes the claims of new investors. In this situation, existing creditors may have an incentive to subordinate their claims in order to attract fresh funds. Likewise, in our setting, creditors may wish to make concessions in an attempt to entice customers to purchase from the firm.

is decreasing in default risk $1-\theta$ and in the service intensity α. Furthermore, there is a threshold $\hat{B}$ such that if the control benefit is relatively large, $B \geq \hat{B}$; then differentiation is increasing in the control benefit B. Otherwise, differentiation does not depend on the control benefit.

Proof. See the appendix.

The proposition shows how firms alter the degree of differentiation of their products in an attempt to mitigate customer viability concerns. As products become more service oriented and firms face higher default risk, firms position their products closer to those of competitors. If the firm also mitigates customer concerns by adjusting its financial structure (case $B \geq \hat{B}$), then differentiation is increasing in the control benefit B. Intuitively, when incentive problems become more severe (i.e., B decreases), creditors are pledged stronger liquidation rights, which in turn raises customer concerns about the firm's long-term viability. The firm responds by reducing the uniqueness of its product.

From the envelope theorem, we know that the comparative statics of creditors' equilibrium liquidation right $\beta(\phi^*)$ with respect to the exogenous variables are as stated in proposition 1. In particular, $\beta(\phi^*)$ is weakly decreasing in the control benefit B. Our analysis thus implies that as long as there is some variation in the severity of managerial incentive problems across firms, one should observe a negative relation between leverage and product differentiation, when controlling for default risk and service intensity. Moreover, this negative relation between leverage and differentiation should be more pronounced for firms producing durable, service-intensive goods than for firms producing nondurables.

Our prediction that leverage increases induce firms to reduce the degree of uniqueness of their products is in line with the existing empirical evidence. Notably, Kaplan (1989) finds that leveraged buyout firms reduce capital expenditures by 33% in the 2 years following the buyout. Hall (1990) considers a large panel of U.S. manufacturing firms in the 1980s and shows that leverage increases are followed by substantial reductions in R&D expenses (see also Long and Ravenscraft 1993). In highlighting the interplay between financial decisions and differentiation choices, our analysis is also consistent with Titman and Wessels (1988) and Opler and Titman (1993), who look at the effect of R&D intensity and product characteristics on leverage choices. These studies find that R&D-intensive firms operating in durable goods industries are less likely to have high leverage or to initiate leveraged buyouts than less-R&D-intensive firms. To the extent that R&D intensity is a proxy for the degree of uniqueness of a firm's product offering, this points to a negative relation between differentiation and leverage.

C. Discussion

Our basic model is built on some specific assumptions, concerning (i) the incentive scheme used to resolve the agency problem, (ii) customers paying for after-sales service up front rather than when it is provided, (iii) the nature of the cost shock, (iv) the manager having no personal wealth, (v) the contractibility of differentiation, (vi) the observability of the financial structure, and (vii) the type of agency problem under consideration. We now show how our analysis would be altered if we relaxed these assumptions. We also suggest an extension of the base model toward internal monitoring.

Capital Market Discipline versus Managerial Incentive Contracts

In the preceding analysis, the principal solved the agency problem by exposing the manager to external capital market discipline. Alternatively, the principal could have adopted an internal managerial incentive scheme, whereby the manager is fired if she behaves "opportunistically," that is, does not pay out a dividend at date 1. As the manager is indispensable for running the firm, firing the manager is then equivalent to closing down the firm and liquidating assets in place. We now discuss the effectiveness of such an internal managerial incentive scheme.

The main difference between the two incentive schemes lies in the extent to which the party in control of the liquidation decision internalizes customers' cost from liquidation. Given that creditors' claims are senior to the warranty claims of customers, creditors do not internalize ex post the costs customers bear in the event of liquidation. The initial owner, instead, would internalize at least part of these costs. This softens his commitment to penalize the manager, which in turn undermines the manager's payout discipline.

Indeed, consider the case where the principal is protected by limited liability. As warranty claims are senior to those of shareholders, the principal would realize a payoff of $\max[L - C(\phi), 0]$ if he closed down the firm at date 1. Since $C(\phi) > L$, the firing threat would lack credibility: if the principal exercised the firing threat, he would realize a payoff of zero. Anticipating the principal's lack of commitment, the manager would fully divert cash flows. This consideration would be even more pronounced if the principal were not protected by limited liability. With personal guarantees the principal would derive a strictly negative payoff if he exercised the firing threat. This underpins the key role of leverage in our setting: as creditors do not internalize the cost that liquidation imposes on customers, they are tougher vis-à-vis the manager, which in turn enhances her payout discipline. In this respect, external capital market discipline dominates managerial incentive contracts in our setup.

When Should Customers Pay for After-Sales Service?

We have assumed above that customers pay for after-sales service up front. Alternatively, we could have considered that customers pay for service when it is provided, namely, during the second period. We now explore the optimality of this strategy. Suppose that the payment for service is delayed until the second period. Customers then bargain with the firm about the provision of service and the price charged for it. Customers' outside option is to purchase service from an external provider at cost $C(\phi)$. Therefore, assuming that the firm makes a take-it-or-leave-it offer, the price charged for the service is $C(\phi)$.

Customers' willingness to pay for the product at date 0 is then given by $V(\phi) - C(\phi)$.

To ensure comparability with the base model, let us assume that the firm also experiences a cost shock in the second period: with probability ϕ, the firm generates service profits $C(\phi)$, while with probability $1 - \theta$, service profits are zero. Given this assumption, if the service payment is delayed, then the firm makes expected profits $\theta[V(\phi) - C(\phi)]$ and $\theta C(\phi)$, in the first and second period, respectively. Total expected profits thus equal $\theta V(\phi)$, which is precisely the amount the firm would raise if agency problems were not of concern and customers paid for service up front.

How does delaying the service payment alter the cash extraction problem? An immediate observation is that the second-period service revenues fully accrue to the manager, since at date 2 creditors no longer have leverage over the manager. This, however, does not necessarily imply that delaying the service payment is suboptimal. The reason is that the second-period income enhances the manager's control benefit, which in turn improves her payout discipline after the first period. It turns out that, under certain conditions, the latter effect is irrelevant.

Proposition 3. If the cash constraint is binding in the base model, that is, $\beta(\phi) \leq 1$, then delaying payment for service is strictly suboptimal.

Proof. See the appendix.

The key effect of delaying payment for service is that it shifts income from the first to the second period. Accordingly, if the cash constraint is already binding in the base model, then it must be strictly suboptimal to delay the service payment, as doing so only entails a further tightening of the cash constraint.[16] This reduces the payment that can be extracted from the manager. It is worth noting that this reasoning would still apply if the firm did not experience a second-period cost shock. To see this, suppose that the manager generates a second-period service profit of $C(\phi)$ (rather than an expected profit of $\theta C(\phi)$). In this context, the relevant cash constraint remains unaltered, as the firm's first-period income is given by $V(\phi) - C(\phi)$, regardless of whether the firm experiences a second-period cost shock. By implication, the principal prefers to have customers pay up front even when, in the absence of managerial incentive problems, payment for service would be delayed until the second period.

The Nature of the Cost Shock

In the base model, we have assumed that the cost shock wipes out product market revenues. We now relax this assumption. Consider the case in which the firm faces a fixed cost shock of size $F > 0$. To make the case interesting, let us assume that F is sufficiently small, so that profits in the low cash-flow

16. The flip side of this is that if the cash constraint holds with strict inequality in our base model, then it may be optimal to delay the service payment to the second period. In this case, shifting income to the second period makes it more attractive for the manager to continue, which in turn induces her to pay out more after the first period.

state, denoted by Π_l, are strictly positive. In this framework, profits in the low state can be viewed as the verifiable part of income, which can be extracted from the manager at zero cost. Profits in the high cash-flow state are then given by $\Pi_h = \Pi_l + F$, where F is the nonverifiable income component.

The key difference with respect to the preceding analysis is that now part of the firm's income can be extracted at zero cost. As a result, the principal may prefer to set the liquidation probability to zero in order to maximize the firm's verifiable income. The following assumption ensures that the principal does not have such an incentive:

$$\theta B + (1 - \theta)L > (1 - \theta)C(\phi). \tag{3}$$

The left-hand side of this inequality can be roughly interpreted as the marginal gain from increasing the liquidation probability in the low cash-flow state. This stems from the manager's improved payout discipline in the high cash-flow state and the additional liquidation proceeds in the low cash-flow state. The right-hand side is the marginal cost due to customers' reduced willingness to pay. We can then state the following result (we restrict attention to interior solutions, i.e., $F \leq B$).

PROPOSITION 4. *Under assumption* (3), *the optimal debt issue with a fixed cost shock of size F entails a liquidation probability of $\beta = F/B$ in the low cash-flow state (and zero in the high cash-flow state). The proceeds of the debt issue and, hence, the principal's payoff are given by*

$$V(\phi) - (1 - \theta)F - (1 - \theta)\beta[C(\phi) - L].$$

Proof. See the appendix.

To see the intuition behind the debt issue, notice that the liquidation probability in the low cash-flow state is set such that the manager just has the right incentive not to divert the nonverifiable part of income in the high cash-flow state (i.e., F). As above, the optimal degree of product differentiation maximizes the proceeds of the debt issue.

COROLLARY 1. *The optimal degree of product differentiation ϕ^* is characterized by*

$$V'(\phi^*) - (1 - \theta)\beta C'(\phi^*) = 0,$$

where $\beta = F/B$. Thus, product differentiation is decreasing in the product's service intensity α, default risk $1 - \theta$, the inverse of the control benefit B, and the magnitude of the fixed cost shock F.

Corollary 1 shows that the results of the base model remain unchanged. The additional feature of the new setup is that product differentiation is decreasing in the magnitude of the cost shock. It is worth emphasizing that, in our model, this is not due to the likelihood of default increasing in the cost shock. Rather, the negative relation between differentiation and the magnitude of the cost shock stems from the fact that the manager has a stronger incentive to divert cash when the nonverifiable part of income (i.e., F) increases. This calls for a harsher penalty, which in turn suppresses customers' willingness to pay. To mitigate this cost, the firm positions its product closer to those of competitors.

Managerial Wealth

We have assumed that the manager has zero wealth. What if the manager had some personal wealth that she could pledge? Suppose that the manager is endowed with wealth $w > 0$. Let us momentarily abstract from the fact that ϕ is endogenous and solve for the optimal contract for a given ϕ. If the manager had unlimited wealth, then she would buy the firm for $\theta V(\phi) + B$ (and, obviously, there would be no debt issue). However, as long as the manager is wealth constrained, that is, $w < \theta V(\phi) + B$, some debt will be issued. Moreover, it easy to see that under an optimal contract the manager transfers her wealth to the principal up front. The contracting problem amounts to

$$\max_{R,\beta\in[0,1]} \theta R + (1-\theta)\beta L + w,$$

subject to

$$R \leq \beta B, \tag{IC}$$

$$R \leq V(\phi) - (1-\theta)\beta C(\phi), \tag{CASH}$$

$$\theta[V(\phi) - (1-\theta)\beta C(\phi) - R + B] + (1-\theta)(1-\beta)B \geq w. \tag{IR}$$

Clearly, as long as the manager's wealth is sufficiently small, the participation constraint remains slack. In this case, the optimal financial structure is as in our base model. For a large w, however, the participation constraint is binding. Restricting attention to interior solutions (i.e., $\beta(\phi) \leq 1$), the solution to this problem is as follows.

Proposition 5. For ϕ given, there are wealth thresholds $\hat{w} = \theta V(\phi) + B$ and $\tilde{w} \in (0, \hat{w})$ such that:

a) For $w < \tilde{w}$, the participation constraint is not binding. The optimal debt issue is as specified in proposition 1.

b) For $w \in [\tilde{w}, \hat{w})$, the participation constraint is binding. The optimal debt issue entails $R = \tilde{\beta}(\phi)B$, where

$$\tilde{\beta}(\phi) = \frac{\theta V(\phi) + B - w}{B + \theta(1-\theta)C(\phi)}.$$

c) For $w \geq \hat{w}$, no debt is issued, and the first best is implemented.

Proof. See the appendix.

The key observation we wish to emphasize is that if the participation constraint is binding, then creditors' liquidation right is decreasing in the manager's wealth. As soon as the manager becomes financially unconstrained, the firm no longer issues any outside claims.

Consider now the choice of product differentiation. Clearly, managerial wealth has an impact on the optimal degree of differentiation only if the wealth level is between $\tilde{w}$ and $\hat{w}$ (case b of proposition 5). As above, the optimal degree of differentiation maximizes creditors' liquidation right—here, $\tilde{\beta}(\phi)$. Assuming interior solutions, the optimum is characterized by the first-order condition

$$V'(\phi^*) - (1-\theta)\tilde{\beta}(\phi^*)C'(\phi^*) = 0.$$

Thus, we can state the following.

COROLLARY 2. As long as the manager is wealth constrained, that is, $w < \hat{w} \equiv \theta V(\hat{\phi}) + B$, the firm positions its product closer to those of competitors, relative to the first best. As the manager can pledge additional wealth, the firm's product becomes more differentiated. Moreover, $\lim_{w \to \hat{w}} \phi^* = \hat{\phi}$.

Thus, as the manager has more wealth, the firm takes a more unique approach in the marketplace. In the limit, as the manager becomes financially unconstrained, the firm's differentiation choice converges to the unconstrained optimum $\hat{\phi}$.

Managerial Discretion

We have assumed above that the principal chooses product differentiation and that the manager cannot alter this decision. The question is whether the manager would have an incentive to deviate from the principal's preferred degree of differentiation if she had discretion to do so.

PROPOSITION 6. The manager has no incentive to deviate from the principal's preferred choice of differentiation.

Proof. See the appendix.

To see the intuition behind this result, notice that if the cash constraint is binding, then the manager pays out the firm's entire product market income. By implication, maximizing the proceeds of the debt issue is equivalent to maximizing the firm's product market income. This in turn implies that any deviation from the principal's preferred choice of differentiation would drive the firm into bankruptcy even in the high cash-flow state. The manager is then strictly worse off under the deviation, as following renegotiation the firm transfers the entire income to creditors and is liquidated with some probability (see the appendix). Conversely, if the cash constraint is not binding, then the manager is the residual claimant, and hence she has no incentive to deviate from the firm-value-maximizing choice of differentiation either.

This result is, of course, specific to our framework. We do believe, however, that our main qualitative insights would still apply even if there were a binding agency conflict with regard to the choice of differentiation. Notably, we conjecture that even in this case the firm would reduce the degree of uniqueness of its product in order to ease customer concerns about its viability.

Unobservable Financial Structure

Our approach requires that the firm's financial structure is observable to potential customers. If financial structure choices were unobservable, they could not possibly influence customers' willingness to pay, and, consequently, there would be no gain to commit to a "soft" financial structure. In this situation, as we prove formally in the appendix, liquidation not only happens in the low cash-flow state but also in high cash-flow state. Customers' willingness to pay for the firm's products would be severely suppressed. This consideration suggests that firms should have an interest in voluntarily disclosing information about their financial soundness not only to influence financial market participants but also to affect customers' willingness to pay.

Costly Differentiation

Companies may refrain from adopting overly drastic product differentiation choices for reasons other than the ones considered in this article. For example, vertical product differentiation is typically associated with additional production or R&D costs. Network externalities in consumption provide another reason why a firm may not want to differentiate its product too much from rivals' product offerings. These considerations are already captured within our setting, as the value function $V(\phi)$ has an interior maximum. Thus, the firm would face a trade-off between too much and too little differentiation even if customers did not need to worry about the firm's viability. The point we make is that customer concerns about firm viability accentuate this trade-off in that they shift the balance between the costs and benefits of product differentiation toward the costs.

Cash Diversion versus Managerial Effort Moral Hazard

We have used the free cash-flow framework along the lines of Bolton and Scharfstein (1996) and Hart and Moore (1998). In this framework, managerial moral hazard arises from the noncontractibility of cash-flow states and the potential incentive of managers to divert cash. Alternatively, we could have employed a modeling framework in which cash flows are verifiable, but the manager needs to exert noncontractible effort. The manager may then have an incentive to shirk in order to economize on private effort costs. In this context, the threat of termination can act as a disciplining device, as it does in the free cash-flow framework (see, e.g., Aghion and Bolton 1992; Dewatripont and Tirole 1994). To the extent that liquidation is personally costly for the manager, the threat of liquidation induces her to work harder. What is needed for our qualitative insights is that following default or bad performance the party in control proceeds with liquidation, even though doing so is inefficient for all stakeholders, including customers. This could, for example, stem from a coordination failure among dispersed creditors or the inability of managers to bribe creditors not to exercise their intervention rights because of wealth constraints (see Aghion and Bolton 1992). Thus, as before, there is a trade-off between resolving the intrafirm agency problem and easing customer concerns about the firm's long-term viability. This shows that the qualitative insights of our analysis do not depend on the specific agency problem under consideration.

Internal Monitoring

An interesting extension of the model pertains to the possibility that the principal may resolve the agency problem by monitoring the manager. Following Diamond (1984), we posit that by expending a fixed monitoring cost K, the principal can prevent the manager from diverting cash. For example, one can think of monitoring as gathering hard evidence and making the cash-flow state verifiable (see Gale and Hellwig 1985), so that the manager could be severely punished if she expropriated the principal. Gathering such hard evidence and bringing it to court is clearly costly for the principal; this is captured by the monitoring cost K.

In this context, the principal faces the choice between two governance mechanisms: external market discipline and internal monitoring. If the principal opts for external market discipline, then his payoff is given by (we restrict attention to interior solutions)

$$\beta(\phi^*)[\theta B + (1 - \theta)L],$$

where $\beta(\phi^*) = V(\phi^*)/[B + (1 - \theta)C(\phi^*)]$ and ϕ^* is characterized by equation (2). Conversely, if the principal monitors, then there is no need to impose a liquidation threat on the manager, and hence the choice of differentiation is unconstrained optimal. The principal's payoff from monitoring is

$$\theta V(\hat{\phi}) - K,$$

where $\hat{\phi}$ is the first-best degree of differentiation. Hence the following result.

Proposition 7. Suppose that the principal can resolve the agency problem by monitoring the manager at cost $K > 0$. Then the principal monitors if and only if

$$\theta V(\hat{\phi}) - K \geq \theta V(\phi^*) \frac{\theta B + (1 - \theta)L}{\theta B + (1 - \theta)\theta C(\phi^*)},$$

that is, only if the monitoring cost is not too large, the asset salvage value is sufficiently small, default risk is sufficiently large, and the control benefit is small enough.

The proposition yields several additional empirical implications. By inspection, the principal is more "likely" to monitor if the salvage value of the firm's assets is relatively low. This suggests that firms whose assets are not worth much when deployed elsewhere opt for monitoring-intensive governance approaches (such as venture capital finance, relationship bank lending, or large shareholder monitoring). By contrast, firms whose assets have a high salvage value may prefer to impose external market discipline on their managers. In addition, the principal is more likely to monitor when managerial incentives are less aligned with his interests, that is, the control benefit B is relatively low. The choice between internal monitoring and external market discipline then has implications for the firm's differentiation strategy. Firms that are monitored take a highly differentiated approach in the product market, while those adopting market discipline deliberately reduce the degree of uniqueness of their products.

It also worth noting that only relatively risky firms (θ not too large) are monitored. More specifically, notice that as θ approaches one, market discipline becomes unambiguously more cost-efficient than monitoring. This suggests that the relation between the degree of uniqueness of a firm's product offering and its default risk should be nonmonotonic. Relatively risky firms are monitored, which allows them to adopt a highly unique approach in the product market. This is consistent with the notion that young start-up firms are often highly innovative. It is also consistent with empirical evidence suggesting that firms backed by active financiers who adopt "hands-on" governance approaches, such as venture capitalists, are often more innovative than other firms (see Hellman and Puri 2000). Safer firms rationally forgo the benefits of monitoring: they find it more cost-efficient to adopt market discipline. This, however, comes at the expense of raising customer viability concerns. Consequently, these firms position their products closer to those of competitors in an attempt to mitigate such concerns. High-quality, established firms with very little default risk again take a highly differentiated approach in the product market.

IV. A Closed-Form Setup with Horizontal Differentiation

In the previous section, we have considered a vertical product differentiation setting. Yet, in practice, firms are often faced with situations where they have to make differentiation choices not only along the vertical but also along the horizontal dimension of the product space. We now explore how our analysis extends to the case of horizontal product differentiation.

We consider a standard closed-form Hotelling setup. There is a unit mass of consumers who differ in their "taste" $x \in [0, 1]$ for a specific design $\phi \in [0, 1]$. A consumer with taste x derives a per-period payoff of $v - (x - \phi)^2$ when purchasing a product with design ϕ (we assume that v is sufficiently large so that the market is always covered). Consumers are uniformly distributed over [0, 1]. There is a competitive fringe that produces a good with design $\phi' = 0$ at zero marginal cost.[17] In the absence of default risk or liquidation costs, the optimal degree of differentiation would be given by 2/3, as is easily

17. Alternatively, one could consider a duopoly setting where the competitor chooses its location strategically. The qualitative insights of our analysis would stay the same.

verified.[18] We now show that if liquidation costs matter, the firm will position its product closer to those of competitors.

Since the competitive fringe firms compete à la Bertrand and produce at zero cost, they charge a price of zero for their product offering. When purchasing the fringe product, a consumer with taste x thus derives a total payoff of $2(v - x^2)$. Conversely, when purchasing the innovative firm's product, the consumer derives a net payoff of $v - (x - \phi)^2 - p$ in the first period, where p denotes the price charged for the product. With probability $\theta + (1 - \theta)(1 - \beta)$, the firm is not liquidated at date 1 and provides after-sales service. With probability $(1 - \theta)\beta$, the firm is liquidated, and after-sales service has to be supplied by the less-efficient third-party service provider at cost $C(\phi)$. The location $\hat{x}$ of the indifferent consumer is thus defined by

$$2[v - (\hat{x} - \phi)^2] - p - (1 - \theta)\beta C(\phi) = 2(v - \hat{x}^2).$$

The right-hand side is the consumer's payoff from purchasing the competitive fringe's good, and the left-hand side is her payoff from buying the innovative firm's product.[19] This reduces to

$$\hat{x}(p) = \frac{p + 2\phi^2 + (1 - \theta)\beta C(\phi)}{4\phi}.$$

At the pricing stage, the firm's problem is to

$$\max_p \, [1 - \hat{x}(p)]p.$$

This problem is solved for

$$p = \frac{2\phi(2 - \phi) - (1 - \theta)\beta C(\phi)}{2}.$$

Substituting this expression into the profit function, reduced-form profits amount to

$$\Pi(\phi, \beta) = \frac{1}{16\phi}[2\phi(2 - \phi) - (1 - \theta)\beta C(\phi)]^2.$$

To obtain closed-form solutions, we give an explicit functional form to the cost function. For convenience, let $C(\phi) = \alpha\phi^2$. Restricting attention to interior solutions, we know from the preceding analysis that creditors' liquidation right $\beta(\phi)$ solves $\beta B = \Pi(\phi, \beta)$. The optimal degree of product differentiation maximizes the proceeds of the debt issue. The principal's problem

18. While a monopolistic firm would position its product at 1/2 to match the taste of the median consumer; here, the firm would pick a higher degree of product differentiation to relieve competitive pressure from the fringe.

19. The subgame in which consumers decide whether to purchase from the firm may have multiple equilibria. In particular, consumers may fail to coordinate on the Pareto-efficient equilibrium, which minimizes the firm's default probability and maximizes gains from trade. We restrict attention to the pareto-efficient equilibrium.

is to $\max_{\phi \in [0,1]} \beta(\phi)$. One can show that this problem is solved for some $\phi^* \in (0, 2/3)$ (see the appendix for the functional form), which is increasing in B and θ and is decreasing in α. Furthermore, there exists a threshold $\hat{B}$ such that $\beta(\phi^*) \leq 1$ if and only if $B \geq \hat{B}$. Assuming that $B \geq \hat{B}$, we can state the following.[20]

Proposition 8. The firm positions its product at $\phi^* \in (0, 2/3)$ and moves closer to competitors when incentive problems become more severe (B decreases), the firm faces higher default risk (θ decreases), or the product becomes more service intensive (α increases).

Proof. See the appendix.

This is in line with our previous analysis: to restore customer confidence the firm moves closer to competitors when managerial incentive problems call for high leverage. The equilibrium price, profits, and creditors' liquidation right are given by $p = 4/3\, \phi^*$, $\Pi = 4/9\, \phi^*$, and $\beta(\phi^*) = 4/(9B)\, \phi^*$, respectively. Prices and profits thus display the same comparative statics as the optimal degree of differentiation. Creditors' liquidation right is decreasing in the default risk and in the service intensity but is increasing in the severity of managerial incentive problems.

V. Concluding Remarks

The trade-off between differentiation and total cost of ownership identified in this article sheds light on a number of critical issues faced by companies when deciding about financing and product differentiation strategies. Industrial organization theory (e.g., Tirole 1990) and the strategic management literature (e.g., Porter 1985) suggest a number of ways in which companies can differentiate their products from those of competitors. We discussed the possibility of vertical (e.g., innovation) and horizontal product differentiation. Yet another strategy is to lock in customers to a product. For example, Padilla (1995) demonstrates within a switching cost setting that customer lock-in unambiguously leads to higher profits through its softening effect on price competition. In the light of Padilla's findings, one would expect companies endogenously to design lock-in situations.

Our approach suggests that differentiation (vertical, horizontal, lock-in/endogenous switching costs) has a downside: it can increase customers' total cost of ownership. When customers rely on a supplier's continued support and the supplier has poor financial prospects, customers' willingness to pay for a highly firm-specific product may be suppressed. This suggests that in situations where leverage is needed to discipline managers, firms may deliberately refrain from differentiating their products too much from rivals' products. Conversely, one would expect highly innovative firms to be subject to disciplinary devices

20. It is worth pointing out that even for $B < \hat{B}$, the firm's equilibrium product differentiation will be less than the unconstrained optimum 2/3. However, in that case differentiation no longer depends on B. Otherwise, the comparative statics are the same as for the case $B \geq \hat{B}$.

other than arm's length debt. Our analysis thus provides a novel explanation for why innovative firms often rely on monitoring-intensive financing sources, such as venture capital (see Hellmann and Puri 2000; Kortum and Lerner 2001).

In the light of our findings, one would expect companies facing deteriorating balance sheets to "move closer" to competitors in attempt to mitigate customer concerns about the total cost of ownership. We now take two examples to illustrate our point with real cases.

During the mid-1990s, Apple experienced severe financial and operating difficulties. It piled up record losses, suffered internal turmoil, and had its debt ratings repeatedly downgraded. Anecdotal evidence suggests that these developments raised concerns among potential customers about Apple's long-term viability (see Rebello, Burrows, and Sager 1996). We argue that Apple addressed these concerns by introducing personal computer (PC)–compatible Macintoshes and providing software makers with additional incentives to develop software for the Macintosh. In 1996, Apple introduced PC-compatible Macintoshes, which were equipped with two processors: a PowerPC processor running Macintosh software and a Pentium processor running Windows software. Previously, Macintosh users could emulate a PC with either expensive hardware devices or slow-speed software solutions. In 1998, Apple removed the dual-platform machines from its product line with the introduction of the PowerPC G3 processor. The speed of this processor made it possible to rely entirely on emulation software. A potential downside of this strategy is that it reduces customer lock-in and thereby increases competitive pressure from the PC market, as Apple's core customers begin to discover the whole range of PC software and the PC itself. A potential upside is suggested in our article. Presumably, an exit of Apple from the computer market would have imposed substantial costs on Macintosh users as software makers would have refrained from developing new software applications for the Macintosh. Achieving PC compatibility with the introduction of the dual-platform solution in 1996 and the PowerPC G3 processor in 1998 reduced the degree to which Macintosh users had to rely on Macintosh-specific software. Accordingly, consumers' reluctance to purchase a Macintosh should have decreased. This is consistent with the evolution of Apple's sales figures during those years.[21]

Apple also tried to restore customer confidence by addressing software developers' reluctance to develop software for the Macintosh.[22] At a software developer conference in May 1997, Apple announced that the development

21. From 1996 to 1997, sales declined by 27%. From 1997 to 1998, sales declined only by 4%. During 1996–97, Apple made net losses of $816 million and $1,045 million, respectively, while in 1998 net income was $309 million.

22. Apple itself recognized the potential reluctance of software companies to develop applications for the Macintosh. As explained by the company in its December 22, 1999, 10-K Annual Filings (23–24): "To the extent the company's financial losses in prior years and declining demand for the company's products . . . have caused software developers to question the company's prospects . . . , developers could be less inclined to develop new application software and more inclined to devote their resources to developing and upgrading software for the larger Windows market."

platform for its future operating system would allow developers to generate and deploy applications not only for the Macintosh operating system but also for Microsoft's Windows 95 and Windows NT (*Java World* 1997). The upside of this strategy is that it expands the market for software developers and as such makes it more attractive for software makers to develop software for the Macintosh. One possible downside is that the PC becomes an attractive alternative for Apple's traditional turf, that is, the publishing and advertising industry, if there is a wide range of PC-compatible graphics and publishing software available.[23]

A second example that illustrates our findings comes from the market for enterprise resource planning (ERP) software. In 1997–98, Baan, a Dutch ERP software maker, experienced financial difficulties. In August 1998, Baan announced its intent to teamup with JDA, a rival software maker, in order to integrate Baan's enterprise software with JDA's retail management software (PR Newswire, August 24, 1998). Baan also implemented several compatibility arrangements, such as the launch of a number of interfaces allowing customers to connect easily to third-party software products (PR Newswire, October 12, 1998). This latter strategy is hard to reconcile with the notion that software companies should design customer lock-in situations in order to soften price competition. Our analysis suggests that Baan deliberately reduced customer lock-in in an attempt to mitigate customer fears of being left stranded with a specific software suite should Baan fail to continue servicing its customers.

The present article's analysis suggests a number of interesting avenues for future research. One issue from which we abstracted in this article is demand complementarities. When a firm is highly leveraged and potential customers rely on the firm's long-term viability, one can envision situations where pessimistic perceptions about the firm's viability quickly become self-fulfilling. Potential customers refrain from purchasing as they expect the vendor to fail, which in turn drives the vendor into bankruptcy and liquidation. This consideration is relevant whenever potential customers are too dispersed to coordinate their purchasing decisions. In these situations, customer confidence may be restored through steep price cuts and debt holders publicly accepting concessions.

23. There is a complementary explanation for why Apple faced deteriorating sales performance after having been hit by losses: the presence of network externalities. When current sales performance is a signal for current and future network size (and network size is important for customers), customers may be unwilling to purchase from a vendor after having observed poor sales performance. Our analysis would suggest that this consideration is of even greater importance when a vendor is highly leveraged and subject to substantial liquidation risk.

Appendix

Proof of Proposition 1 and Complementary Results

In view of the revelation principle, we can restrict without loss of generality attention to financial contracts taking the form (β_l, R_l, β_h, R_h), where R_h (R_l) is the payment in the high (low) cash-flow state, and β_h (β_l) are the corresponding liquidation probabilities. It is straightforward to show that $R_l < 0$ is not optimal. Thus, by limited liability, we have $R_l = 0$. To save on notation, let $R_h = R$ and suppress ϕ. The optimal financial contract solves the following program:

$$\max_{R,\beta_l\in[0,1],\beta_h\in[0,1]} \quad \theta(R + \beta_h L) + (1 - \theta)\beta_l L,$$

subject to

$$R \leq (\beta_l - \beta_h)B, \tag{IC}$$

$$R \leq \Pi(\beta_l, \beta_h), \tag{CASH}$$

$$\theta[\Pi(\beta_l, \beta_h) - R + (1 - \beta_h)B] + (1 - \theta)(1 - \beta_l)B \geq 0, \tag{IR}$$

where (IC) is the incentive constraint, (CASH) is the cash constraint, (IR) is the manager's participation constraint, and $\Pi(\beta_l, \beta_h) = V - \theta\beta_h C - (1 - \theta)\beta_l C$. At the optimum, we have

$$R = \min\{V - [\theta\beta_h + (1 - \theta)\beta_l]C, (\beta_l - \beta_h)B\}. \tag{A1}$$

To see this, notice that either (IC) or (CASH) must be binding at the optimum. Otherwise, one could slightly increase R without affecting any constraint and increase the objective function. Notice, too, that (IR) is not binding.

Substituting (A1) into the objective function and rearranging terms, the problem reduces to

$$\max_{(\beta_l,\beta_h)\in[0,1]^2} \min(\theta\{V - [\theta\beta_h + (1 - \theta)\beta_l]C + \beta_h L\}$$
$$+ (1 - \theta)\beta_l L, \theta[(\beta_l - \beta_h)B + \beta_h L] + (1 - \theta)\beta_l L).$$

The second expression inside the minimum operator is increasing in β_l and decreasing in β_h. The effect on the first expression is ambiguous. By inspection, the first expression is decreasing in β_l and β_h if and only if $\theta C \geq L$.

Now, suppose that $\theta C \geq L$ (proposition 1). As both expressions inside the minimum operator are decreasing in β_h, we have $\beta_h = 0$. Suppose that β_l is interior. Then β_l solves $\beta B = V - (1 - \theta)\beta C$. Thus,

$$\beta_l = \frac{V}{B + (1 - \theta)C}$$

and $R = \beta_l B$. For $B < V - (1 - \theta)C$, $\beta_l \leq 1$ is binding, that is, $\beta_l = 1$ and $R = B$. This gives proposition 1.

Next, suppose that $\theta C < L$. The first expression inside the minimum operator is increasing in β_l and β_h. As both expressions inside the minimum operator are increasing in β_l, we have $\beta_l = 1$. Suppose that β_h is interior. Then β_h solves $V - [\theta\beta + (1 - \theta)C] = (1 - \beta)B$. Thus, for $B \geq V - (1 - \theta)C$,

$$\beta_h = \frac{B - [V - (1 - \theta)C]}{B - \theta C} \geq 0$$

and $R = (1 - \beta_h)B$. For $B < V - (1 - \theta)C$, we have $\beta_l = 1$, $\beta_h = 0$, and $R = B$. Q.E.D.

We next characterize the optimal unobservable contract.

Proposition 9. Suppose that financial structure is unobservable. Then, for $B \geq V - (1 - \theta)C$, the optimal contract entails

$$\beta_h = \frac{B - [V - (1 - \theta)C]}{B - \theta C} \geq 0$$

and $R = (1 - \beta_h)B$. For $B < V - (1 - \theta)C$, the optimal contract is $\beta_l = 1$, $\beta_h = 0$, and $R = B$.

Proof. The optimal unobservable contract solves the following program:

$$\max_{\beta_h \in [0,1], \beta_l \in [0,1] R} \theta(R + \beta_h L) + (1 - \theta)\beta_l L,$$

$$R \leq (\beta_l - \beta_h)B,$$

$$R \leq \Pi = V - (\theta\beta_h^* + (1 - \theta)\beta_l^*)C,$$

where β_h^* and β_l^* are the representative consumer's (rational) beliefs about the exit probabilities in the high and low cash-flow states, respectively. Clearly, $\beta_l = 1$. The problem reduces to

$$\max_{\beta_h \in [0,1]} \min [(1 - \beta_h)B + \beta_h L, \Pi + \beta_h L].$$

This is solved for $\beta_h = \max [0, 1 - \Pi/B]$. In equilibrium, $\beta_l = \beta_l^*$, and $\beta_h = \beta_h^*$. Hence, for $B \geq V - (1 - \theta)C$, we have

$$\beta_h = \frac{B - [V - (1 - \theta)C]}{B - \theta C} \geq 0$$

and $R = (1 - \beta_h)B$. For $B < V - (1 - \theta)C$, we have $\beta_l = 1$, $\beta_h = 0$, and $R = B$. Q.E.D.

Proof of Proposition 2

Suppose that $\beta(\phi^*)$ is interior. The optimal degree of differentiation solves

$$\max_{\phi} \frac{V(\phi)}{B + (1 - \theta)C(\phi)}.$$

The first-order condition is

$$\frac{V'(\phi^*)[B + (1 - \theta)C(\phi^*)] - V(\phi^*)(1 - \theta)C'(\phi^*)}{[B + (1 - \theta)C(\phi^*)]^2} = 0,$$

which is equivalent to

$$\varphi(\phi^*) = V'(\phi^*)[B + (1-\theta)C(\phi^*)] - V(\phi^*)(1-\theta)C'(\phi^*) = 0.$$

To see that ϕ^* is an optimum, notice that $\varphi'(\phi) < 0$. Next, by the envelope theorem, we have

$$\frac{d\beta(\phi^*)}{dB} = -\frac{V(\phi^*)}{[B + (1-\theta)C(\phi^*)]^2} < 0.$$

Moreover, for B close to L, we must have $\beta(\phi^*) > 1$, since

$$\frac{V(\phi^*)}{L + (1-\theta)C(\phi)} > \frac{V(\phi^*)}{\theta C(\phi^*) + (1-\theta)C(\phi^*)} > 1$$

by $\theta C(\phi^*) > L$ and $V(\phi^*) > C(\phi^*)$. Thus, there is a threshold $\hat{B} > L$ such that $\beta(\phi^*) \leq 1$ if and only if $B \geq \hat{B}$. For $B > \hat{B}$, we have $\beta = 1$, and an optimal differentiation choice is then one maximizing firm value. The first-order condition is

$$V'(\phi^*) - (1-\theta)C'(\phi^*).$$

The comparative statics follow readily from the implicit function theorem. More specifically, for $B \geq \hat{B}$, we have

$$\operatorname{sign}\frac{d\phi^*}{d\theta} = \operatorname{sign} - V'(\phi^*)C(\phi^*) + V(\phi^*)C'(\phi^*) > 0, \tag{A2}$$

$$\operatorname{sign}\frac{d\phi^*}{d\alpha} = \operatorname{sign} V'(\phi^*)c(\phi^*) - V(\phi^*)c'(\phi^*) < 0, \tag{A3}$$

$$\operatorname{sign}\frac{d\phi^*}{dB} = \operatorname{sign} V'(\phi^*) > 0,$$

where (A2) and (A3) follow from the first-order condition. Conversely, for $B < \hat{B}$, we have

$$\operatorname{sign}\frac{d\phi^*}{d\theta} = \operatorname{sign} C'(\phi^*) > 0,$$

$$\operatorname{sign}\frac{d\phi^*}{d\alpha} = \operatorname{sign} - c'(\phi^*) < 0,$$

$$\frac{d\phi^*}{dB} = 0.$$

Finally, let us give a sufficient condition for ϕ^* to be the global optimum. Let U denote the principal's largest payoff conditional on choosing ϕ such that $\theta C(\phi) \leq L$. From proposition 1, we have

$$U = \theta\frac{V(\underline{\phi}) - C(\underline{\phi})}{B - \theta C(\phi)}(B - L) + L,$$

where $\underline{\phi}$ denotes the optimal differentiation choice conditional on $\theta C(\phi) \leq L$. Notice then that $\lim_{L \to 0} U = 0$, since

$$\lim_{L \to 0} V(\underline{\phi}) - C(\underline{\phi})\big|_{\theta C(\phi) \leq L} = 0.$$

Thus, L small is sufficient for ϕ^* to be the global optimum. Q.E.D.

Proof of Proposition 3

Suppose that payment for service is delayed until the second period, and let β_l and β_h denote the liquidation probabilities in the low and high cash-flow states, respectively. The optimal debt issue maximizes the proceeds of the debt issue subject to the incentive constraint and the cash constraint. Formally, the problem is to (we suppress ϕ):

$$\max_{R, \beta_h \in [0,1], \beta_l \in [0,1]} \theta(R + \beta_h L) + (1 - \theta)\beta_l L,$$

subject to

$$R \leq (\beta_l - \beta_h)(B + \theta C), \tag{IC}$$

$$R \leq V - C, \tag{CASH}$$

where R denotes the payment in the high cash-flow state (in the low cash-flow state, the manager pays out zero). Clearly, we must have $\beta_l = 1$ at the optimum. Thus, as long as $\beta_h \geq 0$ is not binding, we have

$$\beta_h = 1 - \frac{V - C}{B + \theta C}.$$

Yet, by $B \geq V - (1 - \theta)C$ (i.e., the cash constraint is binding or holds with equality in the base model),

$$V - C < V - (1 - \theta)C \leq B < B + \theta C,$$

and, hence, $\beta_h > 0$.

We next show that delaying service payment is strictly suboptimal. To this end, we need to show that

$$\theta[V - (1 - \theta)\beta_l^{\text{old}} C] + (1 - \theta)\beta_l^{\text{old}} L > \theta(V - C + \beta_h L) + (1 - \theta)L,$$

where $\beta_l^{\text{old}} = V/[B + (1 - \theta)C]$, the left-hand side is the principal's payoff when service is not delayed, and the right-hand side is his payoff when it is. This expression can be rearranged as

$$\theta C[1 - (1 - \theta)\beta_l^{\text{old}}] > L[(1 - \theta)(1 - \beta_l^{\text{old}}) + \theta\beta_h].$$

Note that by assumption $\theta C > L$. Therefore, it suffices to show that

$$1 - (1 - \theta)\beta_l^{\text{old}} > (1 - \theta)(1 - \beta_l^{\text{old}}) + \theta\beta_h.$$

This expression boils down to $\beta_h < 1$, which is always the case. Q.E.D.

Proof of Proposition 4

Letting β_h and β_l denote the liquidation probabilities in the high and low cash-flow states, respectively, the firm's profits are given by (we suppress ϕ)

$$\tilde{\Pi} = \begin{cases} \Pi_l = V - \theta\beta_h C - (1-\theta)\beta_l C - F & \text{with probability } 1-\theta \\ \Pi_h = \Pi_l + F & \text{with probability } \theta \end{cases}.$$

The optimal debt issue maximizes the proceeds of the debt issue subject to the incentive constraint and the cash constraint. Formally, the problem is to

$$\max_{R,\beta_h\in[0,1],\beta_l\in[0,1]} \theta(R+\beta_h L) + (1-\theta)(\Pi_l + \beta_l L),$$

subject to

$$R \leq \Pi_l + (\beta_l - \beta_h)B, \tag{IC}$$

$$R \leq \Pi_l + F, \tag{CASH}$$

where R denotes the payment in the high cash-flow state (in the low cash-flow state, the manager pays out Π_l). To see the derivation of the incentive constraint, notice that in the high cash-flow state the manager has an incentive to pay out R (rather than only Π_l) if and only if

$$\Pi_h - R + (1-\beta_h)B \geq \Pi_h - \Pi_l + (1-\beta_l)B,$$

which reduces to (IC). This problem can be rewritten as

$$\max_{(\beta_l,\beta_h)\in[0,1]^2} \min[\theta[\Pi_l + (\beta_l - \beta_h)B + \beta_h L] + (1-\theta)(\Pi_l + \beta_l L),$$

$$\theta(\Pi_l + F + \beta_h L) + (1-\theta)(\Pi_l + \beta_l L)].$$

Both expressions inside the minimum operator are decreasing in β_h, since $\theta C > L$ by assumption (1). Hence, $\beta_h = 0$. The first expression inside the minimum operator is increasing in β_l by equation (3). The second is decreasing in β_l, since $\theta C > L$. Thus, restricting attention to interior solutions (i.e., $F \leq B$), the optimal liquidation probabilities are given by $\beta_l = F/B$ and $\beta_h = 0$. The repayment is $R = \Pi_l + F = V - (1-\theta)\beta_l C$. Q.E.D.

Proof of Proposition 5

Fix ϕ. The contracting problem is:

$$\max_{R,\beta\in[0,1]} \theta R + (1-\theta)\beta L + w,$$

such that

$$R \leq \beta B, \tag{IC}$$

$$R \leq V(\phi) - (1-\theta)\beta C(\phi), \tag{CASH}$$

$$\theta[V(\phi) - (1-\theta)\beta C(\phi) - R + B] + (1-\theta)(1-\beta)B \geq w. \qquad \text{(IR)}$$

Suppose that (IR) is not binding. Then, by proposition 1, $\beta = \beta(\phi)$ (we restrict attention to interior solutions). Thus, the participation constraint is not binding if and only if (IR) holds at $R = \beta(\phi)B$ and $\beta = \beta(\phi)$, which reduces to

$$w \leq \theta V(\phi) + B - V(\phi)\frac{B + (1-\theta)\theta C(\phi)}{B + (1-\theta)C(\phi)} \equiv \tilde{w}.$$

For $w > \tilde{w}$, the participation constraint is binding, which pins down R as a function of β. The problem reduces to

$$\max_{\beta \in [0,1]} \theta V(\phi) + B - (1-\theta)\beta\underbrace{[\theta C(\phi) - L + B]}_{>0}$$

subject to

$$\beta \geq \frac{\theta V(\phi) + B - w}{B + \theta(1-\theta)C(\phi)} \equiv \tilde{\beta}, \qquad \text{(IC)}$$

$$\beta \geq \frac{B - w}{(1-\theta)B} \equiv \hat{\beta}. \qquad \text{(CASH)}$$

It is straightforward to show that $\Delta\beta = \tilde{\beta} - \hat{\beta} = 0$ if and only if $w = \tilde{w}$. Moreover, $\Delta\beta$ is strictly increasing in w. Thus, (CASH) is not binding. Hence, if $\beta \geq 0$ is not binding, then (IC) must be binding, and therefore $\beta = \tilde{\beta}$ as long as $w \leq \hat{w} = \theta V(\phi) + B$. Finally, for $w > \hat{w}$, we have $\beta = 0$ and, hence, $R = 0$. Q.E.D.

Proof of Proposition 6

Suppose that the cash constraint is binding, that is, $\beta(\phi^*)$ is interior. In this case, if the manager picked a degree of differentiation $\phi \neq \phi^*$, then she would have default not only in the low cash-flow state but also in the high cash-flow state, since

$$R = \beta(\phi^*)B > V(\phi) - (1-\theta)\beta(\phi^*)C(\phi)$$

for any $\phi \neq \phi^*$. Yet, liquidation is inefficient, and hence renegotiation is triggered. In renegotiation, creditors offer the manager to pay her R' in exchange for a reduction of the liquidation probability from $\beta(\phi^*)$ to β'. At the optimum, the manager is kept indifferent between accepting and rejecting, that is,

$$\Pi(\phi, \beta(\phi^*)) - R' + (1-\beta')B = \Pi(\phi, \beta(\phi^*)) + (1-\beta(\phi^*))B.$$

Since liquidation is inefficient, we must have $R' = \Pi(\phi, \beta(\phi^*))$ if $\beta' > 0$. Yet,

$$\beta' = \beta(\phi^*) - \Pi(\phi, \beta(\phi^*))/B > 0$$

since

$$\beta(\phi^*)B = \Pi(\phi^*, \beta(\phi^*)) > \Pi(\phi, \beta(\phi^*)).$$

Thus, following renegotiation the manager pays out the firm's entire income, and the firm is liquidated with positive probability. Conversely, if she picks ϕ^*, then she pays out the entire income but is continued with probability one. Hence she has no incentive to deviate.

Next, suppose that the cash constraint holds with strict inequality (hence, $\beta = 1$), and let ϕ^* denote the firm-value maximizing degree of differentiation, that is,

$$\phi^* = \arg\max_{\phi} V(\phi) - (1-\theta)C(\phi).$$

Within a small neighborhood of ϕ^*, the manager's payoff from choosing ϕ is given by

$$\theta[V(\phi) - (1-\theta)C(\phi) - B + B],$$

which is maximized at ϕ^*. The manager has no incentive to pick a large deviation either, for if she did, the firm would end up transferring the entire income to creditors and being liquidated with some probability in the high cash-flow state. Q.E.D.

Proof of Proposition 8

Assume interior solutions. Creditors' liquidation right as a function of differentiation solves

$$\Pi(\beta, \phi) = \frac{1}{16\phi}[2\phi(2-\phi) - (1-\theta)\beta\alpha\phi^2]^2 = \beta B.$$

The solution is

$$\beta(\phi) = \frac{2\phi}{[(1-\theta)\alpha\phi^2]^2}\left[\sqrt{2B + (2-\phi)(1-\theta)\alpha\phi^2} - \sqrt{2B}\right]^2.$$

One can show that $\max_{\phi}\beta(\phi)$ is solved for

$$\phi^* = \frac{\sqrt{3B[16\alpha(1-\theta) + 27B]} - 9B}{4\alpha(1-\theta)}.$$

Furthermore, there is a threshold $\hat{B} = 16/\{27[2 + \alpha(1-\theta)]\}$ such that $\beta(\phi^*) \leq 1$ if and only if $B \geq \hat{B}$.

By inspection, ϕ^* is strictly positive, strictly decreasing in $\alpha(1-\theta)$, and strictly increasing in B. From L'Hôpital's rule, we have

$$\lim_{\alpha(1-\theta)\to 0} \phi^* = \lim_{\alpha(1-\theta)\to 0} \frac{6B}{\sqrt{3B[16\alpha(1-\theta) + 27B]}} = \frac{6B}{9B} = \frac{2}{3}.$$

Moreover, again from L'Hôpital's rule,

$$\lim_{B\to\infty} \phi^* = \lim_{B\to\infty} \frac{\sqrt{\frac{48\alpha(1-\theta)}{B} + 81} - 9}{\frac{4\alpha(1-\theta)}{B}} = \lim_{B\to\infty} \frac{6}{\sqrt{\frac{48\alpha(1-\theta)}{B} + 81}} = \frac{2}{3}.$$

Thus, ϕ^* is bounded above by 2/3. Q.E.D.

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