

Cross-Country Variations in Capital Structures: The Role of Bankruptcy Codes¹

Viral V. Acharya
London Business School
vacharya@london.edu

Rangarajan K. Sundaram
Stern School of Business
rsundara@stern.nyu.edu

Kose John
Stern School of Business
kjohn@stern.nyu.edu

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Abstract

We investigate the impact of bankruptcy codes on firms' capital-structure choices. We develop a theoretical model to identify how firm characteristics may interact with the bankruptcy code in determining optimal capital structures. A novel and sharp empirical implication emerges from this model: that the *difference* in leverage choices under a relatively equity-friendly bankruptcy code (such as the US's) and one that is relatively more debt-friendly (such as the UK's) should be a *decreasing* function of the anticipated liquidation value of the firm's assets.

Using a large database of firms from the US and the UK over the period 1990 to 2002, we subject this prediction to extensive empirical testing, both parametric and non-parametric, using different proxies for liquidation values and different measures of leverage. We find strong support for the theory; that is, we find that our proxies for liquidation value are both statistically *and* economically significant in explaining leverage differences across the two countries. On the other hand, many of the other factors that are known to affect within-country leverage (e.g., size) cannot explain across-countries differences in leverage.

1 Introduction

A central challenge facing financial economics today is integrating finance theory with legal frameworks so that cross-country comparisons of financial data is facilitated. This paper is concerned with one such question: the impact of bankruptcy codes on firms' capital structures.

Even a casual glance at bankruptcy codes across countries indicates a remarkable degree of divergence in the rights accorded to claimholders in the event of default on debt contracts. In some countries, the code overwhelmingly favors debtholders, particularly secured debtholders. To quote Davydenko and Franks (2004) on the UK code:

In many circumstances, a secured creditor [in the UK] can liquidate the company and realize the collateral without heeding the interests of other claimants, and his actions cannot be challenged in the courts.

In other countries, equityholders are afforded substantial rights. Perhaps the most prominent example of this is Chapter 11 of the US code which allows (even a solvent) firm to suspend interest and principal payments on debt for at least 120 days during which equityholders have the exclusive right to come up with a proposal for reorganization.

Except in an idealized Coasian world, providing control rights to parties who hold non-linear claims on the firm will result in at least some inefficiencies. Debtholders with their concave claims on firm value may force "too many" liquidations, i.e., they may liquidate firms which are worth more as going concerns. Conversely, equityholders with their convex claims may induce "too many" continuations, i.e., they may continue some firms when there is greater value from termination. In either case, deadweight losses result that represent costs of financial distress.

As a leading determinant of these deadweight costs, the bankruptcy code should have a direct effect on the capital structure choices of firms. From an empirical standpoint, the question is *how* this effect operates, and what it implies for comparing capital structures across bankruptcy codes. Existing theory does not provide a clear pointer. While the *normative* question of designing optimal bankruptcy codes has been the subject of a number of papers (see below), the *positive* question of how bankruptcy codes affect capital structures does not appear to have been investigated in the theoretical literature.

The empirical evidence too is limited. A cross-country study by Rajan and Zingales (1995) finds that at an aggregate level, firms in Germany and the UK—two countries with debt-friendly codes relative to the US—are much less leveraged than US firms. However, the study finds that other G-7 countries too use more leverage than the UK and Germany, and as much or more leverage than the US, though their bankruptcy codes are not as equity-friendly as the US code. In particular, "hard" bankruptcy codes (ones that favor debtholders) do not by themselves lead to a lower use of debt.

The Main Theoretical Result: A Summary

Before undertaking empirical analysis, it is necessary to have an idea of *how* bankruptcy codes might affect capital structure choices, in particular, how firm characteristics may interact with the bankruptcy code in this process.¹ We develop a parsimonious theoretical model for this purpose. Section 2 relates our model to the literature.

A sharp and novel implication emerges from the model: that the difference in leverage chosen under a relatively equity-friendly code (such as the US's) and that under one that is more debt-friendly (such as the UK's) should, *ceteris paribus*, be a decreasing function of the anticipated liquidation value of the firm. This means any comparison of capital structures across bankruptcy codes must include a non-trivial role for the liquidation value of the firms' assets.

A simple and compelling intuition underlies this result. When firms in our model are in default on debt payments, control rights and continuation decisions are regulated by the bankruptcy code in place. The code may transfer control rights to debtholders or allow them to remain with equityholders. The *relative* debt-friendliness of a code is parametrized by the likelihood with which control is transferred to debtholders.

The non-linearity of debt and equity claims leads, in general, to inefficiencies in financial distress (too many liquidations by debtholders, too many continuations by equityholders), and so to deadweight losses.² Equityholders determine the optimal level of debt to raise initially by trading off these deadweight losses against the tax benefits of debt. The capital structure is the firm's means of "unwinding" the negative effects of distress: if the deadweight losses from distress are high, the firm acts to reduce these losses by carrying less debt.

Now, intuitively speaking, a low liquidation value makes continuation more likely to be optimal. This reduces the severity of deadweight losses from excessive continuations but increases the severity of deadweight losses from excessive liquidations. As a consequence, a relatively equity-friendly system will use more debt than one that is more debt-friendly. But as liquidation values increase, continuation becomes progressively less likely to be optimal; that is, excessive continuations begin to pose relatively more of a problem and excessive liquidations relatively less of one. This leads to a declining difference in leverage between the relatively equity-friendly and relatively debt-friendly codes. At high liquidation values, the difference eventually turns negative; liquidation is now more likely to be optimal, leading to lower deadweight losses and higher lever-

¹One can always interact country dummies in a regression with firm-specific characteristics, but without a theory it is difficult to know what to expect of the coefficients. As Rajan and Zingales (1995) note in their concluding remarks: "[A] better understanding of institutions can provide us enough inter-country variation so as to enable us to identify the fundamental determinants of capital structure."

²To be sure, renegotiations outside the code may eliminate some of these inefficiencies. We assume only that there are frictions that result in some remaining inefficiency. Theoretical models exist that validate such an assumption in related settings (e.g., Dewatripont and Tirole (1994)).

age under the relatively debt-friendly code. This monotone behavior of the difference in leverage as liquidation values increase forms the main hypothesis we test in the remainder of the paper.

The Empirical Analysis

With the theoretical foundations laid, we turn to an analysis of the data. For this purpose, we examine a large set of firms from the US and UK (viz., all US and UK firms covered by Worldscope from 1990 to 2002 except financial institutions). The US and the UK suggest themselves as natural candidates for test of our theory. Among other things, both have well-developed equity markets; banks in neither country take stakes in companies to whom they lend; and the difference between their bankruptcy codes is sharp and maps well onto our theoretical structure with the US code being more equity-friendly than the UK code.³

Under our theory, the difference in leverage between US and UK firms should be decreasing in liquidation value. We subject this hypothesis to myriad tests using multiple measures of leverage, different proxies for measuring liquidation value, and both regression-based and non-parametric approaches. Within each approach, we also examine the impact of treating cash as negative debt in computing leverage, and of controlling for other factors (size, book-to-market, profitability) that are known to affect leverage.

Our principal empirical finding is simply stated: Across the tests, and for each measure of leverage and each proxy for liquidation value, there is strong support for the theory. In particular, our proxies for liquidation value are both statistically *and* economically significant in explaining leverage differences across the two countries. Of interest, we also find that most of the other factors that are known to affect within-country leverage (e.g., size) cannot differences in leverage across countries. A more detailed description of our empirics follows.

Some preliminaries first. We measure firm leverage in two alternative ways. The first is standard book leverage. The other is to treat cash as negative debt and look at “net leverage,” leverage net of cash and cash equivalents. This correction is of obvious importance if firms react to anticipated distress costs by managing cash reserves rather than (or in addition to) altering the choice of direct leverage.

Secondly, we also proxy for anticipated liquidation value of the firm’s assets in two ways. One is through *asset-specificity*, a notion proposed by Williamson (1988) and Shleifer and Vishny (1992), and backed empirically by Berger, Ofek, and Swary (1996), Pulvino (1998), Stromberg (2000),

³An extended comment is important here. It has been argued by some authors (e.g., Skeel (2003)) that the application of the US Chapter 11 bankruptcy code has been significantly less equity-friendly since 2001 than in the past. It is important to note that this does not affect the empirical basis of our work. First, our data relates to the years 1990-2002, a period where the US code was widely acknowledged as equity-friendly. Second, as long as the US code remains *relatively* more equity-friendly than the UK code, this is all we need.

and, especially, Acharya, Bharath and Srinivasan (2003). The idea is that firms whose assets are *specific* (cannot be readily redeployed outside the industry) are likely to experience lower liquidation values because they may suffer from “fire sale” discounts in auctions for asset sales, particularly when other firms in the industry are also in distress. The second proxy is the fraction of the firm’s assets that are *intangibles*. The motivation here is just that intangible assets (such as goodwill) of a firm are not easily transferable to other firms. These proxies are discussed further in Section 5.

Both proxies are *inversely* related to liquidation values: a higher degree of either lowers the liquidation value of the firm. Thus, recast in these terms, the hypothesis we test is that the difference in leverage between US and UK firms should be an increasing function of the proxy.

Regression-Based Tests

Our first series of tests utilizes regression analysis. We pool the cross-section and the time-series of leverage levels of firms in the US and the UK, and look to explain the cross-sectional variation in leverage with an interaction effect between the bankruptcy code (country dummy) and our proxy for liquidation values (asset-specificity/intangibles). The theoretical prediction is that the coefficient on the liquidation proxy should be higher for the US than the UK.

We examine a large number of alternative specifications (32 in all), and employ both panel estimation as well as the Fama-MacBeth (1976) methodology. Throughout, we control for the other firm characteristics (size, profitability, book-to-market) that are known to affect leverage. As noted above, we use two alternative measures of leverage and two alternative proxies for liquidation value.

Throughout, we find strong support for the theory. The support is even stronger in general when when leverage is measured net of cash and when intangibles are used as the liquidation proxy. The difference in the coefficients on the proxies is positive as the theory predicts and is statistically significant. Of equal importance, the difference is also economically significant in explaining leverage differences between the US and the UK.

Two examples will help illustrate these points. Column 5 of Table 1 (see Section 5.1) reports the results of our broadest panel specification. The dependent variable is net leverage. Panel A of the table uses asset-specificity as the liquidation proxy while Panel B uses intangibles.⁴

Panel A shows that the estimated coefficients on asset-specificity for explaining net leverage in this regression are 27.40% for the US, and 16.59% for the UK. The difference of 10.89% is statistically significant. Moreover, for a firm with an asset specificity of 30% (roughly the median

⁴Similar numbers to those discussed here also obtain if we use the Fama-MacBeth methodology; see Columns 5 and 7 of Table 2.

asset-specificity in our sample), this predicts a difference in leverage of $10.89 \times 0.3 = 3.27\%$. This is over a third of the difference in median net leverage between the two countries.

Panel B shows that similar but stronger conclusions obtain when we use intangibles as the proxy. The coefficients on intangibles for explaining net leverage are 36.84% in the US and 9.81% in the UK, for a (statistically significant) difference of 27.03%. For a firm with a fraction of intangibles of 20% (roughly the median level intangibles in our sample), this implies a difference in leverage of 5.40%, about three-fifths of the difference in median net leverage in our sample.

In contrast to this role of liquidation values, we find that two of the other factors known to affect firm leverage—size and profitability—are of limited value in explaining leverage differences across the two countries. The differences in the US and UK coefficients of these factors are often not statistically significant, and, more problematically, the sign of the difference flips around being positive sometimes and negative sometimes. The third control factor, Q , is more interesting; while not always statistically significant, the difference in coefficients between the US and the UK is consistently negative, and raises some questions for future research. We discuss this in Section 5.1.

Non-Parametric “Matching” Tests

To supplement our regression results, we perform a series of non-parametric tests that is based on “matching” US firms with comparable UK counterparts, and that does not presuppose any functional-form relationship between the variables. We use a bucketing approach in which we pool all the firms in the sample in a given year, and sort the pool into five quintiles based on the proxy, with Quintile 5 representing the highest value of the proxy and Quintile 1 the lowest. Each quintile is then divided into US and UK firms. We use two measures of leverage for each quintile: the median debt-to-assets and the mean debt-to-assets for firms in that quintile.

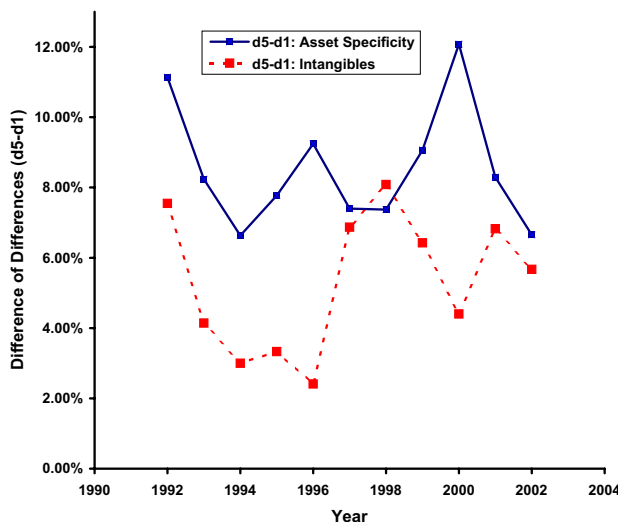
For each quintile, we compute the difference between the leverages of US and UK firms in that quintile. Call these differences d_1, \dots, d_5 . Then, our theory predicts that we should have $d_k - d_n > 0$ whenever $k > n$. We call this the “difference of differences” test.

We first check this for $d_5 - d_1$, i.e., for the firms at either end of our proxy measure. For both proxies, the test is passed strongly, though the results are stronger for asset-specificity than intangibles. Then, as a more continuous test, we look at inter-quintile differences, $d_n - d_{n-1}$ for $n = 5, 4, 3, 2$, and for each year. Again the test is met comfortably, with somewhat stronger results for asset-specificity than intangibles. As with the regression analysis, we find that the theory is even more strongly supported if we measure leverage net of cash and cash equivalents.

Finally, in our most important set of non-parametric tests, we address the concern that factors other than our proxy may be driving the results by expanding the test to control for these factors. To this end, we use the procedures suggested by Heckman, Ichimura, and Todd (1997, 1998) to

Figure 1: Difference of Differences: Time-Series Behavior

This figure plots the difference of differences between Quintiles 5 and 1 for the two proxies (asset-specificity and intangibles) after controlling for several factors using the matching procedure suggested by Heckman, Ichimura, and Todd (1997, 1998) as explained in Section 5.2. The data is from the Near Neighbor column of Table 7.



match each US firm in a given year to firms in the UK in that year. (We employ both matching algorithms described in Heckman, et al.) The matching processes utilize several factors including profitability, market-to-book and size, in addition to the proxy for liquidation values.

Once the matching is done, the difference in leverage is computed between the US firm and its matched UK firms. Sorting the US firms into quintiles, we perform all the difference-of-differences tests again. We continue to find strong support for the theory regardless of the measure of leverage, the proxy, or the matching algorithm. Figure 1 presents a time-series plot of the difference of differences (between Quintiles 5 and 1) for this case. The data is taken from Table 7 of Section 5.2.

In summary, both our regression results and non-parametric tests show that anticipated liquidation values play a significant role in understanding variations in capital structures across bankruptcy codes. The remainder of this paper is organized as follows. Section 2 indicates the related literature. Sections 3 and 4 present our theoretical model and the main theoretical result. Section 5 presents the results of our empirical analysis. Section 6 concludes. The appendix contains the proof of the paper's main theoretical result.

2 The Related Literature

On the theoretical front, a number of papers have examined the implications of bankruptcy codes on various corporate decisions (an incomplete list would include White (1994), Cornelli and Felli (1997), Povel (1999), and Bebchuk (2002)), but no paper has, to our knowledge, looked at the capital structure implications of bankruptcy codes and empirically tested these implications. Three papers which examine related *normative* issues are Dewatripont and Tirole (1994), von Thadden, Berglöf and Roland (2003), and Berkovitch and Israel (1998).

Dewatripont and Tirole (1994) study a model in which the capital structure of the firm plays a key role in resolving managerial moral hazard. There is no specific reference to a bankruptcy code in their paper. Rather, securities in their model play a dual role, not only conferring income streams on their holders, but also stipulating contingent control rights. (It is assumed that control rights may be transferred as stipulated.) For example, the optimal outcome in their model involves, under some assumptions, the transfer of control rights to debt holders following poor performance and equity holders following good performance.

In our model too, securities confer income streams on their holders and the capital structure is used to to unwind agency costs. However, a key difference is that control rights in our model are regulated by the bankruptcy code; thus, agency costs too depend on the bankruptcy code under which the firm operates. It is this feature that enables us to make predictions about optimal capital structures under different bankruptcy codes.

Von Thadden, Berglöf and Roland (2003) integrate the problem of designing corporate bankruptcy rules into a theory of optimal debt structure. Their focus is on employing multiple debtholders and designing the security rights and bankruptcy rules in an optimal fashion to maximize firm-value. In this sense, their goal too is normative. In contrast, our objective is explicitly positive and takes the allocation of control rights in bankruptcy as exogenously specified to determine capital structure effects of the bankruptcy code.

Berkovitch and Israel (1998) examine a complementary question to ours, viz., the design of the *optimal* bankruptcy code. They show that the optimal code for a country depends on a combination of whether the debt in that country is mostly bank- or market-based, and the quality of information acquisition. They identify under what conditions a creditor chapter alone is optimal and when it should be combined with a debtor chapter.

On the empirical side, there is, to our knowledge, no paper that has tested the interaction of the creditor-friendliness of a code with the anticipated liquidation costs in explaining the cross-section of leverage patterns across firms in different countries. An exception is Gianetti (2003) which examines the effect of creditor rights in seven European countries focusing on *unlisted* firms and finds that firms in countries whose bankruptcy codes favor creditor rights can obtain loans more easily against intangible assets.

There are a number of other cross-country papers, of which we already mentioned Rajan and Zingales (1995). Franks, Nyborg, and Torous (1996) present a detailed comparison of US, UK, and German bankruptcy systems along several dimensions. They note that the equity-friendly nature of the US code gives managers a strong incentive to over-invest and leads to ex-post violations of the absolute priority rule. In contrast, absolute priority is generally adhered to in the debt-friendly UK code, but at the cost of premature liquidations and underinvestment.

In other empirical work, Claessens and Klapper (2002) document the usage of bankruptcy in 35 countries over the period 1990–1999, and find that stronger creditor rights are generally associated with greater use of bankruptcy. Antoniou, Guney and Paudyal (2002) investigate the determinants of leverage for French, German and British firms using panel data with a focus on the convergence of capital structure to a target maturity structure. A historical perspective on the evolution of the US and UK codes is provided by Franks and Sussman (2000), while Franks and Davydenko (2004) analyze the effect of bankruptcy codes in France, Germany and the UK on the recovery rates and collateral requirements of bank-based contracts.

3 The Theory

We consider a firm operating a project with risky cash flows and financed by equity and debt. The firm's realized cash flow provides it both immediate cash (to service its debt) and information about continuation cash flows/liquidation values that may be expected from the project. If the cash flows generated by the project are insufficient to meet debt payments, the firm is in distress. Control rights and continuation decisions in distress are regulated by the bankruptcy code in place. The bankruptcy code may transfer control of the project to debtholders or it may allow control to remain with equityholders. All agents are risk-neutral and the risk-free rate of interest in the model is normalized to zero. A detailed description of the model follows.

Figure 2 summarizes the time line and key aspects of the model. There are three dates, $t = 0, 1, 2$. On date 0, the firm needs to make an investment of an amount I to undertake a positive net present-value project. The firm chooses the mix of debt and equity in its capital structure to fund this investment. The debt matures on date 1. Date 2 represents a summary of the continuation possibilities for the firm after maturity of the debt. If the firm has inadequate cash flows to meet debt service requirements on date 1, the bankruptcy code comes into play. Note that we do not model the optimal maturity structure of the firm's debt; rather, our focus is on the equityholders' optimal choice of the face value F of debt.

We elaborate on the model in two steps. First, we discuss the structure of cash flows on dates 1 and 2. Then, we discuss the role of the bankruptcy code in determining how control rights beyond date 1 are allocated.

Cash Flows & Liquidation Values

The firm generates random cash flows at date 1 and—in the event it is not terminated—also at date 2. The date 1 cash flow, denoted x , is distributed uniformly on an interval $[0, H]$:

$$x \sim U[0, H]. \quad (1)$$

After observing x , the decision on liquidation/continuation is taken which determines date 2 cash flows. Both continuation and liquidation values depend on x . Before we describe these cash flows, it is useful to recount what we would like them to satisfy. For inefficiency in either direction to be possible, we must have at least two possible continuation values, one of which is superior to liquidation and one of which is inferior. Second, for the “optionality” (i.e., the non-linearity) in the debtholders’ and equityholders’ claims to have a non-trivial effect on their continuation/liquidation decisions, there must be uncertainty regarding continuation cash flows.

To capture these requirements in a simple but effective manner, we adopt the following structure. If the firm is continued beyond period 1, the continuation cash flow y has the distribution

$$y = \begin{cases} Lx, & \text{with prob } q \\ 0, & \text{with prob } 1 - q \end{cases} \quad (2)$$

where $L \geq 2$. The value of the probability q is unknown at date 0, but it is also revealed at date 1 *before* continuation decisions are made. The ex-ante distribution of q is given by

$$q = \begin{cases} \bar{q}, & \text{with prob } 1/2 \\ \underline{q}, & \text{with prob } 1/2 \end{cases} \quad (3)$$

where $0 < \underline{q} < 1/2 < \bar{q} < 1$. This means there are two possible expected continuation values, $\bar{q}Lx$ and $\underline{q}Lx$.

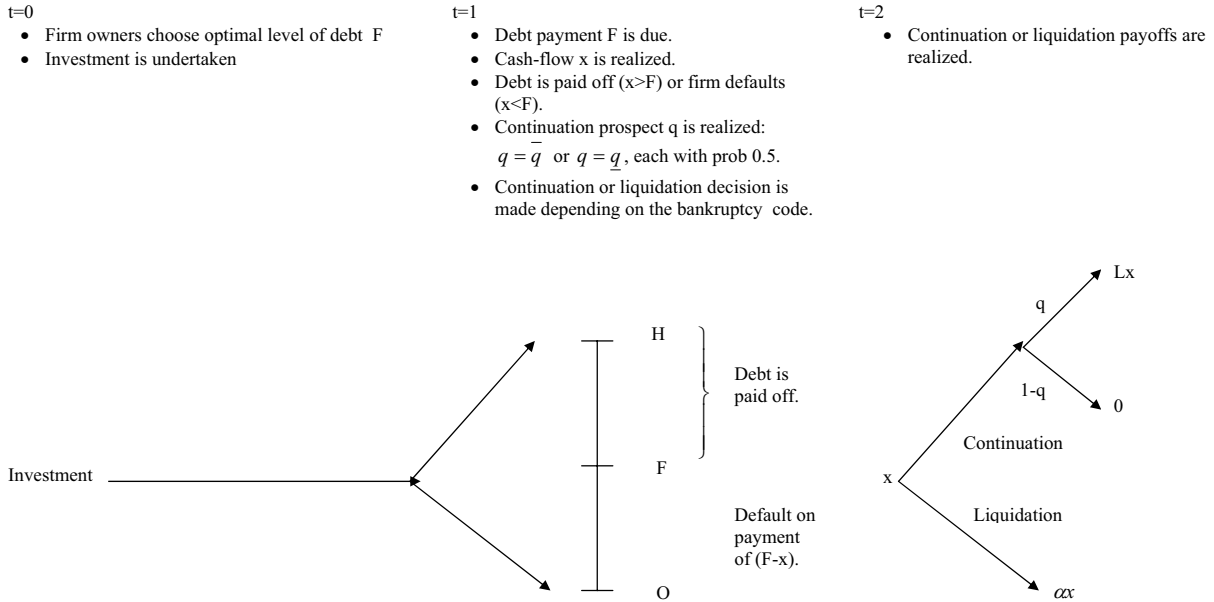
If the firm is liquidated, it realizes a value αx . The parameter α governs the liquidation value of the firm’s assets. We assume that

$$\underline{q}L < \alpha < \bar{q}L. \quad (4)$$

Thus, given any x , it is uniquely ex-post efficient to continue the firm if $q = \bar{q}$ and to liquidate the firm if $q = \underline{q}$. In particular, the degree of inefficiency from

- continuing a firm when $q = \underline{q}$ is measured by $(\alpha - \underline{q}L)$, and

Figure 2: The Timeline of Our Model



- liquidating a firm when $q = \bar{q}L$ is measured by $(\bar{q}L - \alpha)$.

As we show below, the optimal debt structures and firm values under the two codes are intimately related to these measures.

The Bankruptcy Code and Control Rights

All payments to debtholders are financed out of firm cash-flows. If $x \geq F$ on date 1, the debt is paid off and the firm becomes an all equity firm. The excess cash flow $(x - F)$, net of taxes (see below), goes to equityholders. For $x < F$, the firm cannot meet its contractual payment fully and is in financial distress or “default.” It pays the available amount x to debtholders and is in arrears for the remaining amount $(F - x)$; debtholders get first claim on any further cash flows until they have been fully paid off.

Further cash flows depend on whether the firm is continued or liquidated at this point. The bankruptcy code in place determines who gets to make this decision. With probability $\pi \in [0, 1]$, the code transfers control to debtholders; with probability $1 - \pi$, control remains with equityholders. The number π is exogenous and parameterizes the relative debt-friendliness of the code; the higher is π , the more the code favors debtholders. For example, $\pi = 1$ corresponds to

a perfectly debt-friendly code: control is transferred to creditors with certainty in distress.⁵

Finally, we denote by τ the tax rate of the firm. Taxes are paid on gross cash flows, but debt provides a tax shield to the firm. That is, at date 1, the firm pays taxes only if $x \geq F$; in this case, its tax bill is $\tau(x - F)$. For $x < F$, there are no taxes at date 1. For simplicity, we assume that there are no taxes to be paid at date 2. This simplifies notation and makes the presentation cleaner. However, this assumption is not necessary for our results. It is easy to show that our results—in particular, the central result, Proposition 1—are unaffected if the firm must pay taxes at date 2 when it is not in distress.

The Choice of Leverage

Debt provides a tax shield but creates the prospect of distress and inefficient continuations. Debtholders with their concave payoffs may liquidate firms that are worth more as going concerns. Equityholders with their convex claims may continue firms when there is more value in liquidation. There are deadweight losses that result in either case. Equityholders trade-off these deadweight losses against the tax benefits of debt in arriving at the optimal level of debt to raise initially.

Let $F_{\pi}^*(\alpha)$ denote the optimal level of debt chosen given the liquidation-value parameter α and a bankruptcy code of debt-friendliness π . Our objective is to characterize the dependence of F^* on π and α . We turn to this now.

4 The Main Result

Our main theoretical result, derived under some mild restrictions on parameter values, is Proposition 1. In words, the proposition says that

- for low liquidation values α , a relatively equity-friendly code involves a greater use of debt than a relatively debt-friendly one, but at high liquidation values, the reverse is true; and
- the *difference* in debt levels between the relatively equity-friendly code and the relatively debt-friendly one decreases as liquidation value increases.

The second result forms the basis of our empirical work later in the paper.

Proposition 1 *Let $\pi_1 < \pi_2$. There is $\alpha^* \in (qL, \bar{q}L)$ such that*

⁵An earlier version of the paper considered only $\pi = 0$ (an “equity-friendly system”) and $\pi = 1$ (a “debt-friendly system”). The present version generalizes this.

1. $F_{\pi_1}^*(\alpha) > F_{\pi_2}^*(\alpha)$ if $\alpha < \alpha^*$.
2. $F_{\pi_1}^*(\alpha) < F_{\pi_2}^*(\alpha)$ if $\alpha > \alpha^*$.

Further, $[F_{\pi_1}^*(\alpha) - F_{\pi_2}^*(\alpha)]$ is strictly decreasing in α .

The Proof of Proposition 1

The intuition behind Proposition 1 was outlined in the Introduction. A detailed proof of the result is presented in Appendix A. Here, we sketch the main steps of the proof.

Step 1: Identifying the Continuation Decisions

Fix an arbitrary level of debt F . The first step in the proof is to identify the continuation/liquidation decisions that will be taken by debtholders and equityholders, respectively, given F .

Lemmas 1 and 2 in the Appendix identify these decisions. Lemma 1 shows that debtholders will always choose to liquidate the firm when $q = \underline{q}$ (which is efficient), but may also sometimes choose to liquidate the firm when $q = \bar{q}$ (which is inefficient). More precisely, when $q = \bar{q}$, debtholders will continue the firm if x is sufficiently small but for larger x will inefficiently liquidate the firm. Intuitively, if x is low relative to F , then debtholders' remaining claims are sufficiently large that all future cash flows will accumulate to them; thus, it is as if they own the firm, so the efficient continuation decision is chosen. But when x is large, the concavity of debtholders's claims kicks in, and an inefficient continuation is chosen.

Lemma 2 provides the corresponding result for the case where equityholders make the decision. In this case, the outcome is efficient when $q = \bar{q}$ (equityholders always opt to continue) but there is a region of inefficiency when $q = \underline{q}$ since equityholders sometimes choose to continue rather than liquidate. The intuition is analogous to the debtholders' case, and is driven in this case by the convexity of equityholders' payoffs.

Step 2: Firm Values

Once we have identified continuation decisions for any F , we can go back to time 0 and calculate the expected value of the firm given F . The expressions are algebraically lengthy (see Appendix A), but after some work, they simplify into a very intuitive form. Specifically define \bar{V} to be the date-0 expected value of an all-equity firm without taxes. Such a firm necessarily

involves efficient continuations (continue if $q = \bar{q}$, liquidate otherwise), so we have:

$$\bar{V} = \frac{1}{H} \left\{ \int_0^H x dx + \frac{1}{2} \int_0^H \bar{q}Lx dx + \frac{1}{2} \int_0^H \alpha x dx \right\} = \frac{H}{2} \left[1 + \frac{1}{2} \bar{q}L + \frac{1}{2} \alpha \right]. \quad (5)$$

We show in Appendix A that $V(F)$ can be expressed as

$$V(F) = \bar{V} - \frac{1}{H} \left\{ \int_F^H \tau(x - F) dx + \pi \frac{1}{2} \int_{x^*}^F (\bar{q}L - \alpha) x dx + (1 - \pi) \frac{1}{2} \int_{x_1^*}^{x_2^*} (\alpha - \underline{q}L) x dx \right\}.$$

The first term in the parenthesis represents the value loss from the taxes that a levered firm would pay at date 1. The second term corresponds to the agency costs of debt when debtholders make the continuation/liquidation decision. The value loss from excessive liquidations in this case is $(\bar{q}L - \alpha)$; the range of x values over which inefficient liquidations occur is $[x^*, F)$, where x^* is identified in Lemma 1. The third term captures the agency costs of debt when equityholders make the continuation/liquidation decision. The value loss from excessive continuations in this case is $(\alpha - \underline{q}L)$; the range of x values over which inefficient liquidations occur is $[x_1^*, x_2^*)$, where x_1^* and x_2^* are identified in Lemma 2.

Step 3: The Optimal Value of F

The next step is to identify the value of F that maximizes initial equity value. Given any F , let $D(F)$ be the time-0 present value of the expected amount received by debtholders, given the continuation policies identified in Lemmas 1 and 2. We assume debt is fairly priced, so given a promised payment of F , $D(F)$ is the amount equityholders are able to raise at time 0, so equityholders must provide the remaining investment $[I - D(F)]$. Equityholders now pick F to maximize their return net of investment, that is, to maximize $[V(F) - D(F)] - [I - D(F)]$. But this just involves maximizing the date-0 expected value of the firm, $V(F)$.

As the expression for $V(F)$ indicates, choosing the optimal F involves a trade-off. On the one hand, increasing F increases the tax benefit at date 1. On the other, increasing F increases the regions over which inefficient continuations and deadweight losses result. We show that $V(F)$ is strictly concave as a function of F , and that the optimal F , denoted $F_\pi^*(\alpha)$, is

$$F_\pi^*(\alpha) = \frac{\tau H}{\tau + \frac{1}{2} \pi (\bar{q}L - \alpha) Z_D + \frac{1}{2} (1 - \pi) (\alpha - \underline{q}L) Z_E} \quad (6)$$

where

$$Z_D = \left[1 - \frac{\bar{q}^2}{(\bar{q} + \alpha)^2} \right] \quad (7)$$

$$Z_E = \left[\frac{1}{\left(1 + \left[\frac{\alpha - \underline{q}L}{1 - \underline{q}} \right] \right)^2} - \frac{1}{(1 + L)^2} \right] \quad (8)$$

The terms $(\bar{q}L - \alpha)$ and $(\alpha - \underline{q}L)$ measure the severity of inefficient continuation/liquidation decisions made in distress, while the terms Z_D and Z_E are related to the ex-ante likelihoods of these regions of inefficiency. Thus, the denominator of (6) is τ plus the agency costs of distress. As expected, optimal leverage increases in the tax rate τ , and decreases in the agency costs of distress.

Step 4: Completing the Proof

The remaining step in the proof is to show that $F_\pi^*(\alpha)$ has the properties listed in Proposition 1. This requires extensive algebraic manipulation of the formula. The details are in Appendix A. \square

5 Empirical Analysis

Our theoretical model predicts that, ceteris paribus, the difference in leverage observed under a relatively equity-friendly code and that observed under a more debt-friendly one should decrease in liquidation values. How well does this conform to patterns of leverage seen in the data? The remainder of the paper addresses this question.

The obvious candidate countries for testing this hypothesis are the US and the UK. There are important similarities that make the comparison meaningful. Both have well-developed and well-functioning equity markets; in both countries, banks do not take equity stakes in firms to whom they lend. And, of course, one bankruptcy code (the UK's) is relatively more debt-friendly than the other (the US').⁶

⁶As noted in the Introduction, Skeel (2003) and others have argued that since 2001, the application of the US code has become significantly more debt-friendly than in past years. The Bankruptcy Reform Act of 2005 may have further hastened this movement. In the meanwhile, changes in the UK code implemented in 2004 have made that code less debt friendly than in the past. All of this means that the difference between the two codes may be narrowing. However, these changes largely occur after the period covered by our sample, which is 1990-2002. If the differences in the code continues to narrow and the codes eventually resemble each other, our theory predicts that there should be no observed difference in leverage across the two codes attributable to liquidation values.

Using a large database of firms from these countries (see below), we subject the hypothesis to a substantial number of tests. We use multiple measures of leverage, different proxies for measuring liquidation value, and, most importantly, both non-parametric and regression-based econometric approaches. Further, within each approach, we examine the impact of treating cash as negative debt in computing leverage, and of controlling for other factors (size, book-to-market, profitability) that are known to affect leverage.

Our principal empirical finding is simply stated: Across the tests, and for each measure of leverage and each proxy for liquidation value, there is strong support in the data for our model's main prediction. This support gets even stronger when cash is treated as negative debt.

A detailed description of our empirical work follows. The regression results are described first in Section 5.1 and the non-parametric tests are the subject of Section 5.2. Some preliminaries first.

The Data Set We look at all firms in the US and UK covered by Worldscope from 1990 to 2002 except financial institutions (SIC code 6). This results in around 1,100 firms a year in the UK and over 4,000 firms a year in the US.

To save space, we do not report summary characteristics of our data here, but these characteristics are similar to those reported in Rajan and Zingales (1995). For example, for 1991 (the year for which Rajan and Zingales report their results), the difference in the mean (median) Debt to Book Assets between the US and the UK is about +6% (+7%) in our data set; and the aggregate Debt to Book Assets, which is the assets-weighted average of the ratio, is greater for the US by about 9%. These numbers are comparable to those reported in Rajan and Zingales. Moreover, these differences in leverage between the US and the UK are quite stable in the time-series during the period 1990 to 2002, with the sample mean (median) Debt to Book Assets being 25% (31%) for the US and 19% (24%) for the UK.

Measuring Firm Leverage We use two basic measures of firm-level leverage. The first is the usual measure of book leverage: total book debt divided by book value of assets. (We also tried a quasi-market-value measure of leverage in which the value of assets is calculated by replacing the book value of equity with its market value, but this does not affect the results much.) The second is "net leverage," book leverage net of cash and cash equivalents. As we have mentioned earlier in the paper, this correction is necessary if firms attempt to manage financial distress costs using cash reserves rather than (or in conjunction with) the level of debt.

Proxying for Liquidation Value We proxy for expected liquidation values in two ways. Each proxy is inversely related to liquidation values. The first proxy is a firm's *asset-specificity*, the

Table 1: Regression Results 1

All variables are winsorized. The dependent variable is book leverage in Columns 1 to 4, and net-of-cash leverage in Columns 5 to 8. The independent variables are time dummies (1 to 12 out of 13 years), country dummies, and characteristics*country dummies. The firm characteristics employed are the liquidation proxy (asset specificity in Panel A and intangibles in Panel B), profitability, log sales, and Q. Leverage measures and characteristics are scaled by book value of assets. There are 4 regressions for each measure of leverage: (1) includes country and year dummies; (2) includes only year dummies; (3) includes only country dummies; and (4) includes neither country nor year dummies. Coefficients on dummies are not reported.

Panel A: Asset Specificity as Liquidation Value Proxy								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specificity * UK	6.71% (4.97)	6.47% (4.84)	6.84% (5.07)	6.54% (4.9)	16.59% (8.48)	18.41% (9.32)	16.98% (8.67)	18.71% (9.47)
Specificity * US	9.79% (12.98)	9.71% (12.89)	9.71% (12.89)	9.65% (12.82)	27.40% (23.78)	26.90% (23.62)	27.37% (23.76)	26.91% (23.62)
Profitability * UK	-15.19% (-6.77)	-14.18% (-6.56)	-14.66% (-6.55)	-13.43% (-6.21)	0.89% (0.19)	-6.39% (-1.42)	2.57% (0.56)	-4.53% (-1.01)
Profitability * US	-13.71% (-13.71)	-13.09% (-13.6)	-13.74% (-13.75)	-13.24% (-13.75)	-2.40% (-1.28)	1.31% (0.71)	-1.92% (-1.02)	1.56% (0.85)
Sales * UK	2.04% (11.88)	1.86% (20.32)	2.06% (12)	1.84% (20.1)	3.37% (12.28)	4.69% (31.6)	3.39% (12.37)	4.67% (31.44)
Sales * US	2.23% (25.36)	2.14% (28.66)	2.20% (25.07)	2.13% (28.5)	5.01% (34.84)	4.48% (37.66)	4.98% (34.62)	4.49% (37.59)
Q * UK	-2.18% (-9.16)	-2.29% (-10.6)	-2.10% (-8.87)	-2.24% (-10.4)	-7.13% (-16.09)	-6.27% (-14.94)	-6.96% (-15.73)	-6.14% (-14.65)
Q * US	-3.50% (-32.66)	-3.55% (-34.09)	-3.43% (-32.21)	-3.47% (-33.6)	-7.91% (-40.44)	-8.21% (-43.28)	-7.74% (-39.81)	-8.03% (-42.63)
R-squared	16.22%	15.80%	15.91%	15.49%	28.97%	28.44%	28.63%	28.12%
constant	yes	yes	yes	yes	yes	yes	yes	yes
country dummy	yes	no	yes	no	yes	no	yes	no
year dummy	yes	yes	no	no	yes	yes	no	no
H0: difference of coefficients between US and UK is zero								
	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats
Specificity	1.99	2.12	1.86	2.03	4.76	3.75	4.57	3.62
Profitability	0.60	0.47	0.38	0.08	-0.67	1.60	-0.91	1.26
Sales	0.97	4.06	0.76	4.27	5.31	-1.91	5.13	-1.65
Q	-5.13	-5.42	-5.12	-5.29	-1.60	-4.28	-1.61	-4.17
Panel B: Intangibles as Liquidation Value Proxy								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intangibles * UK	-2.45% (-0.98)	-2.36% (-0.98)	-4.10% (-1.64)	-4.11% (-1.72)	9.81% (2.67)	13.30% (3.84)	6.54% (1.77)	9.81% (2.82)
Intangibles * US	14.55% (8.82)	14.84% (9.07)	14.67% (8.98)	15.00% (9.26)	36.84% (16.66)	36.98% (17.02)	36.19% (16.58)	36.45% (16.95)
Profitability * UK	-3.24% (-1.07)	-3.24% (-1.12)	-2.36% (-0.78)	-2.33% (-0.81)	13.76% (2.43)	8.80% (1.61)	15.40% (2.71)	10.46% (1.91)
Profitability * US	-18.03% (-9.77)	-18.84% (-10.7)	-18.06% (-9.81)	-19.11% (-10.86)	-5.46% (-1.87)	-5.74% (-2.03)	-4.58% (-1.57)	-5.41% (-1.9)
Sales * UK	1.91% (8)	1.89% (16.27)	1.87% (7.81)	1.86% (16)	3.34% (10.18)	4.28% (24.96)	3.27% (9.93)	4.22% (24.68)
Sales * US	2.16% (17.42)	2.28% (24.71)	2.13% (17.19)	2.28% (24.78)	4.31% (23.9)	4.35% (32.83)	4.26% (23.68)	4.38% (33.05)
Q * UK	-3.12% (-9.6)	-3.15% (-10.58)	-2.89% (-8.9)	-2.89% (-9.74)	-7.61% (-13.52)	-6.98% (-13.17)	-7.25% (-12.88)	-6.57% (-12.4)
Q * US	-5.14% (-29.1)	-5.07% (-30)	-5.07% (-28.83)	-4.97% (-29.52)	-9.72% (-34.31)	-9.72% (-35.77)	-9.57% (-33.89)	-9.49% (-35.08)
R-squared	14.24%	14.18%	13.86%	13.75%	23.26%	23.11%	22.76%	22.52%
constant	yes	yes	yes	yes	yes	yes	yes	yes
country dummy	yes	no	yes	no	yes	no	yes	no
year dummy	yes	yes	no	no	yes	yes	no	no
H0: difference of coefficients between US and UK is zero								
	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats
Specificity	4.19	4.76	4.52	5.22	4.05	4.51	4.32	4.98
Profitability	-2.26	-3.23	-2.30	-3.46	-1.74	-2.15	-1.70	-2.33
Sales	-2.37	-2.18	-2.70	-2.11	-2.21	-3.88	-2.67	-3.63
Q	-0.05	0.95	-0.15	1.07	0.88	1.42	0.86	1.68

second is the fraction of the firm's assets that are *intangibles*.

Asset-specificity involves the intuitive idea that firms whose assets tend to be *specific* (that is, not readily redeployable outside of the industry) are likely to experience lower liquidation values because they may suffer from “fire-sale” discounts in cash auctions for asset sales, especially when firms within an industry get simultaneously into financial or economic distress. Since industry cycles are often key drivers of firm-level default, asset-specificity suggests itself as a(n inverse) proxy for expected liquidation values.

Empirical support in favor of this idea has been provided by Pulvino (1998) for the airline industry, and especially by Acharya, Bharath, and Srinivasan (2003) who look at the entire universe of defaulted firms in the US over the period 1981 to 1999; see also Berger, Ofek, and Swary (1996) and Stromberg (2000). We adopt the definition of asset specificity that has been employed in the latter three papers: asset specificity is measured by the Book Value of Machinery and Equipment divided by the Book Value of Assets. Land and Property are not considered specific assets but are viewed as being fungible across industries.

Our second proxy, the fraction of total assets comprising of Intangibles,⁷ is based on the simple thesis that liquidation proceeds are lower for firms with a large proportion of non-physical assets since these assets, for example goodwill, are not easily sold or transferable to other firms.

Since these proxies are each inversely related to liquidation value, the hypothesis we are testing is that the difference in leverage between an equity-friendly code and a debt-friendly code is an *increasing* function of the proxies.

5.1 Regression Analysis

Our first set of empirical tests employs regression analysis. We examine a large number of alternative specifications, and employ both panel estimation as well as the Fama and MacBeth (1976) methodology. We discuss the panel estimation first.

The dependent variable in the regressions is, of course, firm leverage. We measure firm leverage by both book leverage and leverage net of cash. In the broadest specification, the independent variables in the panel estimation are year dummies, country dummies, and four firm characteristics (interacted with country dummies). The four firm characteristics are: (i) the proxy for liquidation values (i.e., asset-specificity or intangibles), (ii) profitability, defined as EBITDA divided by book value of assets, (iii) logsale defined as the logarithm of net sales, and (iv) Q

⁷Intangibles are assets such as goodwill (cost in excess of net assets purchased), patents, copyrights, trademarks, formulae, franchises of no specific duration, capitalized software developments and computer programs, organizational costs, customer lists, capitalized advertising cost, licences of no specific duration, mastheads (news-papers), capitalized servicing rights, and purchased servicing rights.

Table 2: Regression Results 2

All variables are winsorized. The dependent variable is book leverage in Columns 1 to 4 and net-of-cash leverage in Columns 5 to 8. The independent variables are time dummies (1 to 12 out of 13 years), country dummies, and characteristics*country dummies. The firm characteristics employed are specificity and/or intangibles; profitability; log sales; and Q. Leverage measures and characteristics are scaled by book value of assets. There are 2 regressions for each measure of leverage, with and without country dummies. Coefficients on dummies are not reported. The coefficients are estimated cross-sectionally in each year and averaged and the t-statistics for average coefficients are computed as per Fama and MacBeth (1976) methodology.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specificity * UK	4.15%	3.43%			16.80%	17.19%		
	(0.55)	(0.41)			(2.96)	(3.00)		
Specificity * US	9.32%	9.26%			26.20%	25.82%		
	(3.50)	(3.52)			(4.71)	(4.65)		
Intangibles * UK			17.27%	17.12%			25.64%	27.29%
			(0.46)	(0.48)			(0.79)	(0.88)
Intangibles * US			21.10%	20.84%			48.12%	47.33%
			(3.91)	(3.79)			(9.24)	(9.96)
Profitability * UK	-19.68%	-17.46%	-9.80%	-11.96%	-16.58%	-19.06%	3.42%	-6.71%
	(-1.47)	(-1.46)	(-0.34)	(-0.66)	(-0.36)	(-0.52)	(0.06)	(-0.13)
Profitability * US	-16.33%	-15.85%	-17.66%	-16.84%	-7.77%	-4.83%	-9.09%	-6.61%
	(-2.02)	(-1.95)	(-1.56)	(-1.42)	(-0.45)	(-0.28)	(-0.43)	(-0.30)
Sales * UK	1.64%	1.83%	2.14%	1.59%	2.73%	4.80%	3.26%	4.29%
	(1.43)	(5.08)	(3.51)	(1.45)	(1.44)	(5.15)	(5.70)	(4.02)
Sales * US	2.15%	2.09%	2.20%	2.08%	5.00%	4.56%	4.71%	4.33%
	(8.67)	(10.13)	(8.22)	(9.70)	(8.73)	(7.84)	(12.68)	(12.99)
Q * UK	-2.41%	-1.97%	-0.52%	-0.79%	-7.73%	-5.71%	-5.18%	-4.57%
	(-2.02)	(-2.15)	(-0.07)	(-0.11)	(-3.00)	(-3.06)	(-0.67)	(-0.62)
Q * US	-3.75%	-3.78%	-4.36%	-4.43%	-8.22%	-8.49%	-8.82%	-9.06%
	(-5.20)	(-5.34)	(-6.16)	(-6.53)	(-5.99)	(-5.87)	(-8.47)	(-8.41)
R-squared	17.92%	17.50%	18.26%	17.97%	30.63%	30.04%	28.42%	27.92%
constant	yes	yes	yes	yes	yes	yes	yes	yes
country dummy	yes	no	yes	no	yes	no	yes	no
H0: difference of coefficients between US and UK is zero								
	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats
Specificity	2.74	2.65			4.93	4.90		
Intangibles			0.36	0.37			2.19	2.07
Profitability	1.42	0.74	-0.92	-1.07	0.89	1.98	-0.80	0.01
Sales	1.46	4.23	0.27	1.53	3.42	-1.64	6.36	0.12
Q	-4.18	-6.06	-1.67	-1.64	-0.60	-4.84	-1.55	-2.05

Table 3: Regression Results 3

All variables are winsorized. Dependent variable is book leverage in Columns 1 to 4, and net-of-cash leverage in Columns 5 to 8. Independent variables are time dummies (1 to 12 out of 13 years), country dummies, and characteristics*country dummies. The firm characteristics employed are Specificity, Intangibles, Profitability, (log) Sales, and Q. Leverage measures and characteristics are scaled by book value of assets. There are 4 regressions for each measure of leverage: (1) includes country and year dummies; (2) includes only year dummies; (3) includes only country dummies; and (4) includes neither country nor year dummies. Coefficients on dummies are not reported.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Specificity * UK	8.91%	8.55%	8.75%	8.29%	22.33%	24.09%	21.87%	23.45%
	(4.22)	(4.1)	(4.15)	(3.98)	(7.69)	(8.32)	(7.52)	(8.11)
Specificity * US	13.60%	13.43%	13.42%	13.29%	35.13%	34.54%	34.81%	34.31%
	(13.8)	(13.63)	(13.61)	(13.49)	(24.3)	(24.1)	(24.04)	(23.88)
Intangibles * UK	8.81%	8.21%	6.28%	5.53%	27.46%	30.21%	22.06%	24.65%
	(3.23)	(3.11)	(2.3)	(2.09)	(7.02)	(8.02)	(5.65)	(6.58)
Intangibles * US	26.77%	26.39%	26.11%	25.84%	65.50%	64.18%	63.55%	62.48%
	(19.22)	(18.97)	(18.77)	(18.6)	(33.39)	(33.03)	(32.4)	(32.14)
Profitability * UK	-6.31%	-4.70%	-5.07%	-2.95%	19.03%	10.92%	21.58%	14.28%
	(-2.02)	(-1.62)	(-1.62)	(-1.01)	(3.24)	(1.93)	(3.64)	(2.48)
Profitability * US	-14.36%	-13.25%	-13.76%	-12.96%	-5.77%	-1.95%	-4.01%	-0.83%
	(-11.16)	(-10.62)	(-10.63)	(-10.31)	(-2.6)	(-0.9)	(-1.78)	(-0.38)
Sales * UK	2.18%	1.96%	2.23%	1.93%	3.18%	4.33%	3.25%	4.28%
	(10.11)	(16.26)	(10.3)	(16.06)	(10.06)	(23.23)	(10.29)	(22.98)
Sales * US	2.05%	1.90%	2.02%	1.91%	4.16%	3.63%	4.11%	3.67%
	(19.68)	(21.22)	(19.36)	(21.32)	(26.16)	(27.18)	(25.8)	(27.35)
Q * UK	-2.30%	-2.43%	-2.00%	-2.18%	-7.03%	-6.34%	-6.45%	-5.85%
	(-7.28)	(-8.29)	(-6.31)	(-7.4)	(-12.45)	(-11.52)	(-11.3)	(-10.56)
Q * US	-3.58%	-3.68%	-3.43%	-3.50%	-7.45%	-7.78%	-7.15%	-7.44%
	(-27.25)	(-28.76)	(-26.2)	(-27.53)	(-33.89)	(-36.39)	(-32.49)	(-34.81)
R-squared	18.86%	18.30%	18.15%	17.59%	32.65%	31.97%	31.57%	30.93%
constant	yes	yes	yes	yes	yes	yes	yes	yes
country dummy	yes	no	yes	no	yes	no	yes	no
year dummy	yes	yes	no	no	yes	yes	no	no
H0: difference of coefficients between US and UK is zero								
	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats	t-stats
Specificity	2.01	2.12	2.00	2.17	3.95	3.25	3.98	3.38
Intangibles	5.88	6.13	6.47	6.83	8.73	8.13	9.50	9.05
Profitability	-2.38	-2.77	-2.57	-3.21	-3.95	-2.15	-4.04	-2.49
Sales	-0.56	-0.60	-0.88	-0.23	2.77	-4.45	2.43	-3.84
Q	-3.76	-4.01	-4.18	-4.22	-0.69	-2.49	-1.14	-2.69

or market-to-book ratio, defined as the ratio of [book value of assets – book value of equity + the market value of equity] to the book value of assets. All characteristics including leverage are measured relative to total assets of the firm.

We estimate sixteen variants of this specification based on whether (a) the proxy for liquidation value is asset-specificity or intangibles, (b) leverage is measured by book leverage or leverage net of cash, (c) whether country dummies are included, and (d) whether year dummies are included. All standard errors are corrected for heteroskedasticity as well as for clusters at the level of an individual firm.

Table 1 presents the estimates. The upper panel (Panel A) of the table pertains to the case where asset-specificity is used as the proxy for liquidation value, while the lower panel (Panel B) presents the case where intangibles are used as the proxy. Within each panel, columns 1–4 take the measure of leverage to be book leverage, while columns 5–8 use leverage net of cash. The other differences between the columns (whether country and year dummies are included are not) are described in the table.

Now, our hypothesis is that, *ceteris paribus*, the difference between US and UK leverage increases in the proxy value. In terms of the regression, this says that the estimated coefficient on the proxy should be higher for the US than for the UK. That is, the difference in these coefficients should be positive (and statistically significant).

As Table 1 shows, this test is met at conventional levels of statistical confidence in *all* the specifications, with generally stronger results when cash is measured as negative debt (i.e., when net leverage is employed). Of equal importance, the numbers in the table are also of economic significance in explaining capital structure differences between the countries.

Consider, for example, the broadest panel specification where both year and country dummies are employed and leverage is measured net of cash (Column 5 in the table). The estimated coefficients on asset-specificity in this case (Panel A) are 27.40% for the US, and 16.59% for the UK. The difference of 10.89% is statistically significant with a *t*-statistic of 4.76. Moreover, for a firm with an asset-specificity of 30% (the median asset-specificity in our sample), this implies a difference in leverage of 3.27%, which is about 35% of the difference in median net leverage between the US and the UK over our sample period. As noted in the Introduction, the numbers are even stronger when we consider intangibles.

Table 2 confirms that similar results obtain when the Fama and MacBeth (1976) approach is adopted, that is, where a cross-sectional version of the panel specification is run in each year and the coefficients averaged across the years. Except for Columns 3 and 4 (i.e., the cases where the proxy is intangibles and the leverage measure is not net-of-cash), the hypothesis is uniformly met, the results generally being stronger for net debt as measure of leverage.

In Table 3, we revert to the panel specification but include both specificity and intangibles on

the right hand side as potentially orthogonal proxies for liquidation costs. The hypothesis that the difference in coefficients between the US and the UK is positive is met for both book leverage and net debt, and individually for *both* measures of liquidation costs. The effect is overall stronger for intangibles as the measure of liquidation costs.

Effect of Other Firm Characteristics It is useful to also observe and discuss the difference in coefficients on other firm characteristics – profitability, size, and Q – between the US and the UK. The first observation is that across Tables 1–3, the effect of profitability on leverage is mostly negative, that of size is positive, and that of Q is negative, consistent with the rest of the literature. However, the difference in coefficients between the US and the UK is not robust for profitability and size, the difference flipping between positive and negative signs across tables without much statistical significance. In contrast, the difference in coefficients on Q between the US and the UK is negative and often statistically significant. In other words, Q appears to lower leverage more in the US than it does in the UK.

The existing literature has not converged on a single interpretation for the effect of Q on leverage. On the one hand, Q is thought of as a proxy for growth opportunities, and thought to lower leverage along the lines of Myers' (1977) debt hangover argument. On the other hand, Q is also considered as a measure of perceived mispricing, and thought to lower leverage mechanically if managers issue equity when Q is high with the objective of timing the market for capital issuances. Rajan and Zingales (1995) find that the second interpretation bears some merit since the effect of Q on leverage largely arises from firms with very high Q with little effect for firms with moderate to low Q. It is *a priori* unclear how the effect of Q should vary between the US and the UK, and which specific institutional characteristic of these countries it is likely to interact with. Explaining the difference in the effect of Q on leverage between these countries is thus an interesting open question for future research.

Effect of Other Institutional Differences In addition to bankruptcy codes, the literature has focused on three other key institutional differences between countries: (1) taxes, (2) nature of financial system, that is, bank-oriented versus market-oriented, and (3) nature of ownership and control, that is, dispersed ownership or concentrated ownership of the firm. The US and the UK are similar along the second and the third dimension: Both countries are generally considered to be market-oriented economies with dispersed ownership. How does a difference in tax rates affect our conclusions?

As an aside, but an important one, note tying down the empirical effect of taxes on leverage is a tricky issue, rendered especially difficult by the need to identify the relevant marginal personal tax rate (a point that is developed in detail by Rajan and Zingales, 1995). Furthermore, there is an apparent puzzle in the literature as to why firms, particularly the large ones, do not increase

their leverage in order to exploit better the available tax shields (Graham, 2000). These challenges notwithstanding, we provide a qualitative discussion as to why we do not think that our results are driven solely by differences in corporate tax rates between the US and the UK.

In our model, firms choose optimal capital structure to balance the tax-shield benefits of debt with the agency costs that arise in bankruptcy and which in turn depend on the bankruptcy code. Our result is that the difference in leverage between the US and the UK is increasing in liquidation costs. Suppose for sake of argument that the corporate tax rate is greater in the US and the UK. This has indeed been the case for most of our sample period of 1991 to 2002, the statutory corporate tax rate in the US having been around 39.3%, whereas in the UK, it having declined from 33% to current levels of 30%. With such a cross-country tax structure, at high levels of liquidation costs, where firms in the US have greater leverage than firms in the UK, the difference in leverage between the US and the UK would widen even further, while at low levels of liquidation costs, the difference in leverage between the two countries would narrow. In effect, the difference of differences in leverage between extreme liquidation cost firms should in fact become larger.

Crucially, if there were no role played by differential agency costs which are influenced by the bankruptcy code, then the effect of increased tax rate in the US on leverage would be *independent* of the liquidation costs. In other words, a higher tax rate in the US can contribute partly to the observed positive difference of differences in leverage between the US and the UK, but this partial contribution arises only in the presence of a differential bankruptcy code, and, in turn, a differential nature of agency costs, between the two countries.⁸ We conclude that the primary driver of our identified cross-country pattern in leverage between the US and the UK is the differences in bankruptcy code between these countries over our sample period.

5.2 Non-Parametric “Matching” Tests

The regression analysis imposes a linear relationship between leverage and our liquidation proxy. To supplement these results, we undertake a second set of tests which is non-parametric. The tests rely on “bucketing” the firms in our sample according to the value of the proxy. We pool all firms in the sample in a given year and divide the pool into five quintiles based on the proxy. Quintile 5 represents the highest degree of the proxy and Quintile 1 the lowest. Each quintile is then broken up into US firms and UK firms. Firms are re-grouped into quintiles at the beginning of each year.

We measure the leverage of each quintile using both the *mean* leverage of firms in that

⁸Note that were the tax rate to be greater in the UK than in the US, then the net effect would be to lower the difference of differences in leverage between the two countries as a function of liquidation costs. This would bias us against finding the results we have identified.

quintile, and their *median* leverage. Employing medians has the advantage that outliers are less likely to drive the results, whereas employing means has the advantage that more cross-sectional information is utilized. This gives us two basic measures of leverage for each quintile: median debt to book assets and mean debt to book assets. Under our hypothesis, the difference in leverage between US and UK firms should be higher for higher quintiles. Thus, if we take the difference in leverage between US and UK firms in a given quintile (say, Q5) and subtract from this the difference in leverage in a lower quintile (say, Q1), this “difference of differences” should be positive. We check if this is indeed the case.

We begin with a basic check: whether the difference of differences between Q5 and Q1 (the highest and lowest values of the proxy) is positive for each of our proxies. Table 4 presents the results in this context. The upper panel of the table looks at asset-specificity as the proxy while the lower panel considers intangibles. The upper panels in each table consider the two median measures of leverage, while the lower panels consider the mean measures. The difference of differences is presented for each measure of leverage for each year from 1992 to 2002 in Panel A and from 1990 to 2002 in Panel B. (Intangibles data is available from 1990 for most firms in our sample, but data on Machinery and Equipment becomes available only from 1992.)

As Table 4 shows, the time-series average of difference of differences is 9.54% (5.13%) when median (mean) leverage is employed as the measure of leverage, and asset-specificity is the liquidation proxy. Moreover, the difference of differences is positive and of roughly similar magnitude in every single year from 1992 to 2002.⁹ The results are similar with a substantially positive time-series average of the difference of differences when intangibles are the proxy. However, the numbers are not as uniformly positive as in Table 1.

Building on these findings, we then examine a more “continuous” test. That is, rather than use only Quintiles 1 and 5, we examine the difference of differences computed using successive quintiles. For $n = 5, 4, 3, 2$, we compute the difference of differences between Quintiles n and $n - 1$. Table 5 presents these inter-quintile difference of differences. The upper panel of the table is computed using asset-specificity as the proxy, and the lower panel using intangibles. The upper panel of the table shows that the average over the sample period of the inter-quintile difference of differences is positive for both leverage measures. Indeed, 34 out of 44 inter-quintile differences have the right sign, the exceptions arising mainly in the difference between quintile 2 and quintile 1. The results are similar, but slightly weaker, for intangibles. The average of the inter-quintile differences is positive, except for the difference between quintile 2 and quintile 1. The fraction of inter-quintile differences with the correct sign (35 out of 52) is smaller than in

⁹A number of papers have argued about the “stickiness” of capital structure decisions from a theoretical as well as an empirical standpoint (Fisher, Heinkel, and Zechner, 1989; Strebulaev, 2003, Hennessy and Whited, 2004, Leary and Roberts, 2004). Hence, we present our difference of differences results in every single year of the sample for both measures of debt. Furthermore, the year-wise difference of differences is likely to be serially correlated, so we do not compute the statistical significance of the time-series average.

Table 4: Difference of Differences Tests

At the beginning of each year, all firms in US and UK are pooled and placed in quintiles based on the liquidity proxy—asset-specificity (Panel A) or intangibles (Panel B)—with Quintile 5 denoting the highest value of the proxy and Quintile 1 the lowest. Each quintile is then divided into US and UK firms. The leverage of US (resp. UK) firms within a quintile is measured in two alternative ways: using the mean leverage of all US (resp. UK) firms in that quintile, and using the median. The leverage difference for a country is then the difference between the leverage of its Quintile 5 and Quintile 1 firms. The difference of differences is calculated by subtracting the leverage difference of the UK from that of the US.

Panel A: Q5-Q1 Based on Asset-Specificity										
Observations	Median Debt to Total Asset				Difference of Differences Debt to Total Asset	Mean Debt to Total Asset				Difference of Differences Debt to Total Asset
	US		UK			US		UK		
	Q5	Q1	Q5	Q1		Q5	Q1	Q5	Q1	
1992	205	206	81	81	14.41%	205	206	81	81	11.24%
	26.09%	9.65%	20.84%	18.81%		26.91%	16.37%	20.90%	21.59%	
	379	379	177	175		379	379	177	175	
1993	24.67%	9.57%	17.56%	13.68%	11.23%	24.70%	16.45%	18.09%	17.46%	7.61%
	628	625	188	186		628	625	188	186	
1994	22.66%	9.76%	16.09%	11.38%	8.19%	23.25%	16.98%	16.68%	15.38%	4.97%
	715	711	187	185		715	711	187	185	
1995	23.25%	7.93%	16.98%	14.41%	12.74%	23.96%	17.19%	17.70%	16.99%	6.06%
	829	824	188	188		829	824	188	188	
1996	22.81%	4.51%	18.12%	13.26%	13.43%	24.59%	15.43%	18.91%	16.51%	6.76%
	918	920	179	179		918	920	179	179	
1997	24.71%	7.49%	18.66%	8.43%	6.99%	25.97%	17.92%	19.16%	14.56%	3.45%
	1108	1115	166	167		1108	1115	166	167	
1998	26.79%	8.09%	21.22%	11.91%	9.39%	27.68%	17.91%	21.37%	16.57%	4.96%
	1102	1100	153	154		1102	1100	153	154	
1999	26.39%	3.46%	21.58%	10.33%	11.68%	27.28%	14.29%	21.98%	16.43%	7.44%
	1012	1009	177	175		1012	1009	177	175	
2000	26.99%	3.13%	23.64%	5.84%	6.05%	27.47%	14.21%	22.58%	11.19%	1.87%
	879	879	186	183		879	879	186	183	
2001	26.00%	4.95%	24.78%	5.96%	2.22%	27.09%	15.79%	22.90%	11.87%	0.28%
	784	778	163	160		784	778	163	160	
2002	25.03%	6.10%	20.92%	10.56%	8.57%	26.45%	16.61%	22.17%	14.11%	1.78%
					9.54%					5.13%
					Mean				Mean	

Panel B: Q5-Q1 Based on Intangibles										
Observations	Median Debt to Total Asset				Difference of Differences Debt to Total Asset	Mean Debt to Total Asset				Difference of Differences Debt to Total Asset
	US		UK			US		UK		
	Q5	Q1	Q5	Q1		Q5	Q1	Q5	Q1	
1990	134	135	37	38	-1.88%	134	135	37	38	1.06%
	29.06%	22.52%	25.91%	17.48%		32.56%	24.03%	24.80%	17.33%	
	187	187	34	35		187	187	34	35	
1991	32.20%	19.56%	26.86%	17.92%	3.71%	33.01%	20.95%	22.59%	18.41%	7.88%
	240	239	34	34		240	239	34	34	
1992	29.50%	19.29%	26.16%	16.23%	0.28%	29.91%	21.60%	24.48%	15.47%	-0.70%
	277	276	32	33		277	276	32	33	
1993	28.84%	17.80%	21.04%	15.55%	5.55%	29.10%	20.64%	21.99%	17.41%	3.88%
	426	426	32	33		426	426	32	33	
1994	24.80%	20.03%	22.75%	13.95%	-4.03%	26.52%	20.87%	19.82%	14.46%	0.29%
	486	491	33	34		486	491	33	34	
1995	26.93%	18.54%	26.93%	16.21%	-2.34%	28.38%	20.71%	22.14%	15.96%	1.48%
	570	568	47	47		570	568	47	47	
1996	26.66%	19.44%	22.63%	17.52%	2.11%	28.04%	21.29%	21.92%	17.99%	2.82%
	653	656	54	54		653	656	54	54	
1997	29.53%	17.15%	15.20%	17.35%	14.54%	30.73%	21.16%	19.19%	16.48%	6.87%
	812	806	97	97		812	806	97	97	
1998	31.14%	16.24%	18.54%	19.20%	15.56%	31.63%	21.08%	20.96%	20.42%	10.00%
	819	820	145	148		819	820	145	148	
1999	27.75%	17.77%	17.28%	23.31%	16.01%	28.80%	21.35%	20.62%	22.88%	9.71%
	800	803	173	177		800	803	173	177	
2000	22.74%	14.12%	12.20%	16.65%	13.08%	25.74%	20.55%	16.56%	19.36%	8.00%
	736	734	184	187		736	734	184	187	
2001	24.84%	15.86%	11.49%	17.60%	15.09%	26.70%	20.73%	16.11%	20.21%	10.06%
	659	658	167	171		659	658	167	171	
2002	23.77%	15.85%	12.22%	18.24%	13.94%	25.72%	20.23%	17.06%	20.96%	9.39%
					7.05%					5.44%
					Mean				Mean	

the case of asset-specificity.

These results lend empirical support to our theory that the effect of bankruptcy codes on capital structures should interact with the anticipated liquidation values of firms.¹⁰ To bolster these findings, we perform two sets of important further tests.

Cash as Negative Debt

Table 6 illustrates that treating cash as “negative debt” makes the results substantially stronger. The time-series average of the difference of differences using Quintiles 5 and 1 on the basis of asset-specificity is 23.21% (21.02%) for median (mean) leverage. The corresponding numbers for the classification based on Intangibles are 15.30% (18.09%).

Importantly, the difference of differences is now almost uniformly positive over the sample period for *both* proxies. This suggests that violations of the theory observed to some extent for results with Intangibles (Table 4) may be due to the omission of cash in measuring the true leverage of the firm. Examining the data closely revealed that the reason for this is that firms in the UK with high Intangibles carry cash levels that are high enough to in fact leave them with negative levels of net debt. When we truncate negative values of Net Debt to zero, the difference of differences is somewhat smaller but remains almost uniformly positive for both classifications.

Controlling for Other Factors

Our final series of non-parametric tests is also our most important. It consists of ensuring that characteristics other than our proxy for liquidation values are not driving our results. A large body of empirical literature has identified a set of cross-sectional determinants that affect corporate capital structures. While some of these effects have been recently attributed to mechanical relationships arising from stickiness in capital-structure changes (Strebulaev, 2003, Hennessy and Whited, 2004), we take these determinants on face value and check if our results are affected when we control for their effect. In particular, we use the four determinants employed by Rajan and Zingales (1995): (a) Tangibility defined as the book value of property, plant and equipments (PPE) or fixed assets divided by the book value of total assets, (b) Market-to-book defined as the ratio of the book value of assets less the book value of equity plus the market value of equity all divided by the book value of assets, (c) Logsale defined as the logarithm of net sales, and (d) Profitability defined as EBITDA divided by book value of assets.

¹⁰One potential concern is that the variation in capital structures in the US is larger than that in the UK, and that therefore, the difference of differences we compute is positive due to a purely mechanical reason. To verify that this is not driving our results, we have also computed the difference of differences as $[F_{US}(\alpha_l)/F_{US}(\alpha_h)] - [F_{UK}(\alpha_l)/F_{UK}(\alpha_h)]$. This measure of difference of differences (between the extreme quintiles) is also generally positive over the sample period.

Table 5: Inter-Quintile Difference of Differences Tests

At the beginning of each year, all firms in US and UK are pooled and placed in quintiles based on their specificity (ratio of book value of Machinery and Equipment to book value of Assets) or intangibility (ratio of book value of Intangibles to book value of Assets). The inter-quintile leverage difference for a country is the difference between Book Debt to Total Assets of high asset-specificity or high intangibles firms (Quintile n) and that of low asset-specificity or low intangibles firms (Quintile $n - 1$) in that country. The difference of differences is calculated by subtracting the inter-quintile leverage difference of the UK from the leverage difference of the US. Leverage is computed using both mean and median Debt to Total Book Assets.

Panel A: Inter-quintile difference of differences based on Asset Specificity

	Median Debt to Total Assets (Book)					Mean Debt to Total Assets (Book)				
	Q5 - Q1	Q5 - Q4	Q4 - Q3	Q3 - Q2	Q2 - Q1	Q5 - Q1	Q5 - Q4	Q4 - Q3	Q3 - Q2	Q2 - Q1
1992	14.41%	-1.77%	8.12%	3.01%	5.06%	11.24%	-0.97%	4.12%	2.34%	5.75%
1993	11.23%	2.39%	2.54%	6.38%	-0.09%	7.61%	1.18%	2.06%	2.62%	1.75%
1994	8.19%	1.33%	1.53%	6.68%	-1.35%	4.97%	-0.14%	3.41%	2.00%	-0.30%
1995	12.74%	2.33%	-1.08%	6.53%	4.96%	6.06%	0.16%	1.37%	2.46%	2.07%
1996	13.43%	1.01%	3.58%	3.69%	5.16%	6.76%	-0.43%	3.53%	0.45%	3.21%
1997	6.99%	2.82%	6.69%	1.82%	-4.34%	3.45%	1.05%	3.97%	0.60%	-2.18%
1998	9.39%	3.22%	3.20%	0.07%	2.90%	4.96%	1.91%	1.68%	-0.52%	1.90%
1999	11.68%	2.29%	2.17%	6.90%	0.31%	7.44%	1.60%	1.28%	2.81%	1.75%
2000	6.05%	0.12%	3.30%	3.87%	-1.24%	1.87%	1.73%	1.03%	0.99%	-1.89%
2001	2.22%	-1.00%	-0.22%	6.56%	-3.12%	0.28%	1.93%	-0.13%	3.27%	-4.79%
2002	8.57%	0.48%	5.35%	-1.88%	4.62%	1.78%	1.18%	2.65%	-0.30%	-1.75%
Mean	9.54%	1.20%	3.20%	3.97%	1.17%	5.13%	0.84%	2.27%	1.52%	0.50%

Panel B: Inter-quintile difference of differences based on Intangibles

	Median Debt to Total Assets (Book)					Mean Debt to Total Assets (Book)				
	Q5 - Q1	Q5 - Q4	Q4 - Q3	Q3 - Q2	Q2 - Q1	Q5 - Q1	Q5 - Q4	Q4 - Q3	Q3 - Q2	Q2 - Q1
1990	-1.88%	-1.45%	0.83%	6.86%	-8.13%	1.06%	2.45%	2.47%	4.73%	-8.59%
1991	3.71%	3.21%	1.42%	-4.68%	3.76%	7.88%	9.73%	-1.47%	-1.33%	0.95%
1992	0.28%	7.19%	-2.56%	2.91%	-7.26%	-0.70%	7.78%	-2.21%	0.29%	-6.56%
1993	5.55%	10.52%	-1.89%	-2.29%	-0.78%	3.88%	7.44%	-2.18%	-0.42%	-0.95%
1994	-4.03%	-3.15%	5.72%	1.79%	-8.39%	0.29%	2.29%	3.14%	-0.22%	-4.91%
1995	-2.34%	-5.95%	0.08%	6.53%	-3.00%	1.48%	0.31%	-0.48%	2.75%	-1.10%
1996	2.11%	-1.59%	6.26%	-3.04%	0.48%	2.82%	0.32%	1.42%	0.72%	0.35%
1997	14.54%	6.60%	4.30%	7.49%	-3.84%	6.87%	2.94%	5.96%	1.36%	-3.40%
1998	15.56%	8.13%	2.41%	1.81%	3.22%	10.00%	5.30%	1.06%	3.47%	0.18%
1999	16.01%	3.76%	3.34%	5.49%	3.42%	9.71%	1.78%	2.31%	3.84%	1.79%
2000	13.08%	4.21%	8.80%	-0.34%	0.41%	8.00%	3.50%	5.23%	-1.32%	0.60%
2001	15.09%	8.17%	6.88%	1.72%	-1.68%	10.06%	5.78%	4.73%	0.51%	-0.96%
2002	13.94%	7.98%	1.70%	3.68%	0.57%	9.39%	5.32%	2.22%	0.97%	0.87%
Mean	7.05%	3.66%	2.87%	2.15%	-1.63%	5.44%	4.23%	1.71%	1.18%	-1.67%

Table 6: Robustness Check 1: Difference of Differences Using Net Debt

As in previous tables, all firms in US and UK are pooled and placed in quintiles based on their asset-specificity or intangibles. We use both mean and median leverages using both Debt to Total Book Assets and Debt to Total Market Assets, but subtract Cash and Cash equivalents in order to obtain a measure of net leverage. We also report results where the negative values of net leverage are truncated to zero. The net-leverage difference for a country is the difference between book Debt to Total Assets of high asset-specificity or high intangibles firms (Quintile 5) and that of low asset-specificity or low intangibles firms (Quintile 1) in the country. The difference of differences is calculated by subtracting the net-leverage difference of the UK from the net-leverage difference of the US.

	Liquidation costs proxied by Asset Specificity				Liquidation costs proxied by Intangibles			
	Median leverage		Mean leverage		Median leverage		Mean leverage	
	Cash as negative debt	Net debt truncated at zero	Cash as negative debt	Net debt truncated at zero	Cash as negative debt	Net debt truncated at zero	Cash as negative debt	Net debt truncated at zero
1990					23.50%	23.50%	20.93%	15.90%
1991	31.73%	-2.20%	26.22%	-0.36%	19.36%	19.36%	22.36%	12.40%
1992	31.14%	13.02%	33.80%	11.63%	6.00%	6.00%	12.20%	5.60%
1993	22.23%	12.18%	22.17%	7.81%	4.54%	4.54%	13.06%	3.57%
1994	11.64%	5.36%	15.64%	5.52%	2.06%	2.06%	12.53%	4.39%
1995	21.11%	13.06%	21.22%	7.70%	-0.15%	-0.15%	8.52%	1.59%
1996	29.23%	9.76%	26.82%	7.56%	2.34%	2.34%	9.68%	1.26%
1997	22.00%	8.89%	19.90%	5.11%	17.80%	17.80%	21.18%	10.68%
1998	21.97%	12.73%	22.60%	6.44%	22.72%	22.72%	25.18%	10.92%
1999	36.27%	8.07%	32.59%	8.75%	24.44%	24.44%	26.77%	10.12%
2000	19.78%	2.29%	11.05%	3.01%	29.37%	29.33%	21.83%	9.89%
2001	13.16%	-0.60%	6.11%	-0.25%	24.47%	24.47%	19.77%	11.55%
2002	18.26%	1.54%	14.16%	0.64%	22.45%	22.45%	21.23%	11.18%
Mean	23.21%	7.01%	21.02%	5.30%	15.30%	15.30%	18.09%	8.39%

Figure 3: Difference in Leverage between the US and the UK: Cross-sectional Behavior

This figure plots the average difference in leverage between the US and the UK for quintiles 1 through 5 for the two proxies (asset-specificity and intangibles). The data corresponds to the differences in leverage between the US and the UK used to compute the difference of differences reported in Table 7.

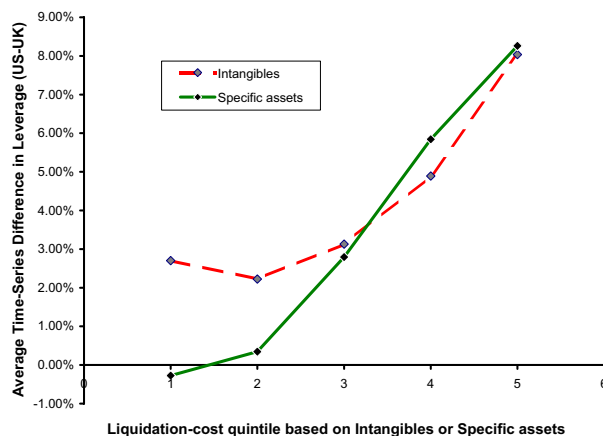


Table 7: Robustness Check 2: Controlling for Other Factors

At the beginning of each year, each firm in the US is matched to firms in the UK based on the Near-neighbour and Local-linear matching techniques of Heckman, Ichimura and Todd (1997, 1998). The matching is based on Tangibility, Profitability, Log Sales, and Market-to-Book, and either Asset-Specificity or Intangibility. Next, firms in the US are placed in quintiles based on their asset-specificity or intangibles. The inter-quintile leverage difference for the US is the difference between book Debt to Total Assets of high asset-specificity or high intangibles firms (Quintile n) and that of low asset-specificity or low intangibles firms (Quintile $n - 1$) in the country. For UK, the leverage difference is computed using the matched firms for the US firms in Quintile n and Quintile $n - 1$. The difference of differences is calculated by subtracting the inter-quintile leverage difference of the UK from the leverage difference of the US. We use mean and median leverages using Debt to Total Book Assets.

Liquidation costs proxied by Asset Specificity						Local Linear matching					
Near Neighbour (10 Nearest) matching						Local Linear matching					
	Difference of difference						Difference of difference				
	Q5-Q1	Q5-Q4	Q4-Q3	Q3-Q2	Q2-Q1		Q5-Q1	Q5-Q4	Q4-Q3	Q3-Q2	Q2-Q1
1992	11.13%	0.70%	4.16%	2.40%	3.87%	1992					
1993	8.24%	1.33%	3.55%	-0.06%	3.41%	1993	6.81%	-0.07%	3.84%	-0.70%	3.73%
1994	6.63%	0.89%	2.74%	2.20%	0.81%	1994	6.62%	0.90%	2.72%	2.03%	0.97%
1995	7.77%	2.05%	2.22%	2.34%	1.16%	1995	7.54%	1.82%	2.41%	2.04%	1.27%
1996	9.24%	1.91%	3.21%	2.99%	1.13%	1996	9.34%	1.79%	3.57%	2.93%	1.05%
1997	7.40%	3.31%	4.05%	2.30%	-2.26%	1997	7.64%	3.41%	4.13%	2.29%	-2.19%
1998	7.37%	4.01%	2.35%	1.47%	-0.45%	1998	7.70%	4.25%	2.40%	1.64%	-0.58%
1999	9.06%	2.74%	1.76%	2.99%	1.57%	1999	9.30%	2.59%	2.04%	2.78%	1.89%
2000	12.08%	3.01%	4.51%	3.17%	1.40%	2000	12.30%	3.10%	4.68%	3.00%	1.51%
2001	8.29%	3.43%	2.34%	3.67%	-1.16%	2001	8.44%	3.49%	2.65%	3.55%	-1.24%
2002	6.65%	3.21%	2.65%	3.46%	-2.67%	2002	7.00%	3.60%	2.65%	3.27%	-2.52%
Mean	8.53%	2.42%	3.05%	2.45%	0.62%	Mean	8.27%	2.49%	3.11%	2.28%	0.39%

Liquidation costs proxied by Intangibles						Local Linear matching					
Near Neighbour (10 Nearest) matching						Local Linear matching					
	Difference of difference						Difference of difference				
	Q5-Q1	Q5-Q4	Q4-Q3	Q3-Q2	Q2-Q1		Q5-Q1	Q5-Q4	Q4-Q3	Q3-Q2	Q2-Q1
1992	7.55%	5.99%	1.32%	0.17%	0.07%	1992					
1993	4.14%	5.27%	-1.27%	0.02%	0.12%	1993	1.50%	4.25%	-2.06%	-0.76%	0.08%
1994	3.00%	4.56%	-0.63%	0.01%	-0.93%	1994	2.33%	3.87%	-0.61%	-0.38%	-0.55%
1995	3.33%	2.10%	1.06%	-0.72%	0.90%	1995	2.81%	2.22%	0.51%	-0.78%	0.86%
1996	2.41%	0.59%	1.51%	0.71%	-0.41%	1996	0.93%	0.63%	0.66%	0.62%	-0.98%
1997	6.87%	3.83%	3.20%	1.33%	-1.49%	1997	5.39%	3.14%	2.59%	1.01%	-1.35%
1998	8.08%	3.00%	3.58%	1.41%	0.10%	1998	7.43%	2.41%	3.74%	1.51%	-0.22%
1999	6.42%	1.28%	2.49%	4.87%	-2.22%	1999	7.18%	1.73%	2.31%	4.95%	-1.81%
2000	4.40%	1.14%	3.32%	0.78%	-0.84%	2000	4.30%	1.24%	3.14%	0.52%	-0.60%
2001	6.83%	3.77%	2.73%	0.45%	-0.13%	2001	7.06%	3.72%	2.79%	0.58%	-0.03%
2002	5.67%	3.07%	2.07%	0.94%	-0.41%	2002	5.69%	2.62%	2.56%	1.03%	-0.53%
Mean	5.34%	3.15%	1.76%	0.91%	-0.48%	Mean	4.46%	2.58%	1.56%	0.83%	-0.51%

We control for these capital-structure determinants through the matching procedures proposed in Heckman, Ichimura and Todd (1997, 1998). These procedures enable matching each firm in the US (the “treatment sample”) in a given year to firms in UK (the “control sample”) for that year, where the matching is based on the four determinants described above plus the proxy for liquidation values (asset-specificity or intangibles). We utilize both suggested by Heckman et al: the Near Neighbour technique where we employ ten nearest neighbouring firms in the UK to form the control sample for each treated firm in the US, and the Local Linear technique where a “composite” UK firm is created from the neighbouring firms for each treated firm in the US. The difference in leverage is then computed between a US firm and its matched sample of UK firms. The US firms are then sorted into quintiles on the basis of their asset-specificity or Intangibles. Finally, inter-quintile difference of differences is computed for each pair of successive quintiles and also between Q5 and Q1.

The results from this matching exercise are presented in Table 7. For brevity, the table only considers book leverage. The table shows strong support for our theory; indeed, the numbers here are as strong or even stronger than in earlier tables. For instance, the difference of differences between Quintiles 5 and 1 has an average value over the sample period of 8.53% and 8.27% respectively for the Near Neighbour and Local Linear matching techniques when asset-specificity is used to form quintiles, while the corresponding numbers are 5.34% and 4.46% when intangibles are used to form quintiles. More generally, the inter-quintile differences continue to have the right sign as well (except, as earlier, the Q2–Q1 difference for intangibles). The magnitudes of these inter-quintile differences are similar to those in Tables 3 and 4, but there are even fewer violations of the theory: negative entries occur in only 5 out of 44 observations for the asset-specificity results, and only 7 out of 44 observations for the results with Intangibles.

Figures 1 and 3 present our findings graphically. In Figure 1 (see the Introduction), we plot the time-series difference of differences between Q5 and Q1 using the Near Neighbor method. The differences are substantially positive for both proxies, especially for asset-specificity. In Figure 3, we plot directly the result for the main test of the theory that the difference in leverage between the US and the UK should decrease with liquidation values, that is, increase in our proxies. In particular, we plot the difference in leverage between the US and the UK for Quintiles 1 through 5, and illustrate that the plot is increasing for both proxies of liquidation values.

6 Conclusion

This paper has made two contributions. The first is a theoretical model relating a firm’s capital structure choice to the bankruptcy code under which a firm operates. To our knowledge, this is the first such model in the literature. The theory indicates that a key factor influencing capital structure choice is a firm’s anticipated liquidation value. More precisely, it predicts that firms

with low liquidation values will employ greater leverage under a bankruptcy code that favors equity-holders (an “equity-friendly system” or EFS) than under one that favors debt holders (a “debt-friendly system” or DFS); and that the difference in optimal debt levels under EFS and DFS should itself be a decreasing function of the degree of liquidation values.

The paper’s second contribution lies in testing the theoretical prediction using data from the US (a country with an equity-friendly bankruptcy code) and the UK (which has a debt-friendly code). We find the data backs the theory strongly. In particular, the difference between leverage ratios in the two countries depends on anticipated liquidation values in the manner predicted by the theory.

Several future directions of investigation are indicated by these results. Some of the issues that need further study are asymmetric information between equity- and debt-holders, the role of managers, and the possibility of renegotiation in bankruptcy. On the empirical front, a theoretical model encompassing some of these issues would enable extending the analysis to data from other countries whose codes cannot easily be classified currently.

A Proof of Proposition 1

Fix F . We follow the steps outlined in text.

Step 1: Identifying the Continuation Decisions

We first examine the continuation/liquidation decision at date 1 given F . Suppose first that the date-1 cash flow satisfies $x \geq F$. Then, debtholders receive the full amount F owed to them, while equityholders receive the net-of-taxes amount $(1 - \tau)(x - F)$. The firm now becomes an all-equity firm. After observing q , equityholders will thus decide to continue if and only if it is efficient to do so (i.e., if and only if $q = \bar{q}$), and will liquidate the firm otherwise. Therefore, conditional on x and q , and given $x \geq F$, the expected value of the firm at date 1 (including the date 1 cash flow x) is given by

$$\begin{aligned} x - \tau(x - F) + \bar{q}Lx, & \quad \text{if } q = \bar{q} \\ x - \tau(x - F) + \alpha x, & \quad \text{if } q = \underline{q}. \end{aligned} \tag{9}$$

For $x < F$, the firm is in default and the bankruptcy code comes into operation. Suppose first that debtholders are making the continuation/liquidation decision. If they decide to continue the firm, they have a senior claim of $(F - x)$ on date 2 cash flows. Given q and the distribution (2) of date 2 cash flows, the expected payoff of debtholders from continuation is

$$q \min(Lx, F - x). \tag{10}$$

If the debtholders decide on liquidation, their payoff is $\min(\alpha x, F - x)$. Hence, debtholders choose to continue the firm if and only if

$$q \min(Lx, F - x) \geq \min(\alpha x, F - x). \tag{11}$$

Lemma 1 *Suppose $x < F$. If debtholders are choosing between continuation and liquidation:*

1. *If $q = \underline{q}$, then debtholders always liquidate the firm. This is ex-post efficient.*
2. *If $q = \bar{q}$, then defining $x^* = \bar{q}F/[\bar{q} + \alpha]$:*
 - *debtholders continue the firm for $x \in [0, x^*]$. This is again ex-post efficient.*
 - *debtholders liquidate the firm for $x \in [x^*, F]$. This is ex-post inefficient.*

Proof The lemma is established by examining (11) for a series of cases.

Case 1 $(F - x) \leq \alpha x < Lx$, i.e., $x \geq F/[1 + \alpha]$.

In this case, debtholders receive $F - x$ in the state Lx under continuation and nothing in the other state for an expected value of $q(F - x)$. They also receive $F - x$ for certain under liquidation. Thus, debtholders choose to liquidate in this case for both $q = \bar{q}$ and $q = \underline{q}$.

Case 2 $\alpha x < (F - x) \leq Lx$, i.e., $F/[1 + L] \leq x < F/[1 + \alpha]$.

In this case, debtholders receive αx under liquidation, while under continuation, they receive $F - x$ in the state Lx and nothing otherwise. Thus, debtholders choose to continue if and only if $q(F - x) > \alpha x$, i.e., if and only if

$$x < \frac{qF}{q + \alpha}. \quad (12)$$

If $q = \underline{q}$, we have

$$\frac{qF}{q + \alpha} < \frac{F}{1 + L}. \quad (13)$$

Since the right-hand side of (13) is the lowest admissible value of x in this case, this means there is no value of x here that satisfies (12). This means debtholders always liquidate the firm for $q = \underline{q}$.

When $q = \bar{q}$, we have

$$\frac{qF}{q + \alpha} > \frac{F}{1 + L} \quad (14)$$

from our assumption that $\bar{q}L > \alpha$. This means there are values of x that satisfy (12). In particular, debtholders choose to continue the firm for

$$x \in \left[\frac{F}{1 + L}, \frac{\bar{q}F}{\bar{q} + \alpha} \right),$$

and they choose to liquidate the firm for

$$x \in \left[\frac{\bar{q}F}{\bar{q} + \alpha}, \frac{F}{1 + \alpha} \right).$$

Case 3 $\alpha x < Lx < (F - x)$, i.e., $x < F/[1 + L]$.

In this case, debtholders receive αx under liquidation, while under continuation, they receive Lx in the state x and nothing otherwise. Then, debtholders continue the firm if and only if $qLx > \alpha x$ or, what is the same thing, if and only if $q = \bar{q}$. Thus, for $q = \bar{q}$, there is continuation for $x \in [0, F/[1 + L])$ and for $q = \underline{q}$ there is liquidation over this region. \square

The next result, Lemma 2, identifies the counterpart of this result when equityholders get to make the continuation decision. We assume that if equityholders are indifferent between continuation and liquidation, they choose the decision that benefits debtholders. Given $x < F$ and q , the expected payoff to equityholders from continuing the firm is evidently

$$q \max[Lx - (F - x), 0],$$

while their payoff in liquidation is

$$\max[\alpha x - (F - x), 0].$$

Thus, equityholders choose continuation if and only if

$$q \max[Lx - (F - x), 0] > \max[\alpha x - (F - x), 0]. \quad (15)$$

Lemma 2 *Suppose $x < F$. If equityholders are choosing between continuation and liquidation:*

1. *If $q = \bar{q}$, then equityholders continue the firm. This is ex-post efficient.*
2. *If $q = \underline{q}$, then defining x_1^* and x_2^* by*

$$x_1^* = \frac{F}{1 + L} \quad \text{and} \quad x_2^* = \frac{F}{1 + \left(\frac{\alpha - \underline{q}L}{1 - \underline{q}}\right)},$$

we have:

- *For $x \in [0, x_1^*]$, the firm is liquidated. This is ex-post efficient.*
- *For $x \in (x_1^*, x_2^*]$, equityholders continue the firm, This is ex-post inefficient.*
- *For $x \in (x_2^{**}, F)$, equityholders liquidate the firm. This is ex-post efficient.*

Proof Once again, we consider three regions of x .

Case 1 $(F - x) \leq \alpha x < Lx$, i.e., $x \geq F/[1 + \alpha]$

In this case, equityholders receive positive payoffs under both liquidation and under continuation. They choose to continue iff

$$q[Lx - (F - x)] > [\alpha x - (F - x)],$$

that is, if and only if

$$x < x_2^*, \tag{16}$$

where, as in the statement of Lemma 2, we define

$$x_2^* = \frac{F}{1 + \left(\frac{\alpha - qL}{1 - q}\right)}.$$

When $q = \bar{q}$, we have $qL > \alpha$. In this case, $x < F$ implies (16) necessarily holds, so equityholders always choose to continue.

When $q = \underline{q}$, we have $qL < \alpha$. Moreover, $\alpha < L$, so $[(\alpha - qL)/(1 - q)] < \alpha$. This implies

$$\frac{F}{1 + \alpha} < x_2^*.$$

Thus, equityholders liquidate the firm for

$$x > x_2^*$$

and continue the firm for

$$x \in \left[\frac{F}{1 + \alpha}, x_2^* \right].$$

Case 2 $\alpha x < (F - x) \leq Lx$, i.e., $\frac{F}{1+L} \leq x < \frac{F}{1+\alpha}$

In this case, equityholders receive positive payoffs in the state Lx at date 2, but receive nothing under liquidation. Thus, equityholders always decide to continue.

Case 3 $\alpha x < Lx < (F - x)$ i.e., $x < \frac{F}{1+L}$.

In this case, equity has zero value under both continuation and liquidation. The choice is made in debtholders' interest. This means for there is continuation for $q = \bar{q}$ and liquidation for $q = \underline{q}$.

Summarizing, for $q = \bar{q}$, equityholders decide to continue in all three cases. For $q = \underline{q}$, they continue in Case 1 only if $x \leq x_2^*$, always continue in Case 2, and always liquidate in Case 3. This is exactly the statement of Lemma 2. \square

Step 2: Identifying the Initial Firm Value

For $x < F$, if the firm is continued, then its expected value at date 1 (including the date 1 cash flow x) conditional on q and x is $x + qLx$; if it is terminated at this point, this expected value is $x + \alpha x$. Thus, from expression (9) and Lemma 1, we obtain the following expressions for the expected value of the firm on date 1 conditional on x and q , and conditional on the debtholders making the decisions in distress:

1. For $x \geq F$: the firm value is $x - \tau(x - F) + \bar{q}Lx$ if $q = \bar{q}$, and is $x - \tau(x - F) + \alpha x$ if $q = \underline{q}$.
2. For $x < F$ and $q = \underline{q}$: the firm value is $x + \alpha x$.
3. For $x \in [0, x^*]$ and $q = \bar{q}$: the firm value is $x + \bar{q}Lx$.
4. For $x \in (x^*, F)$ and $q = \bar{q}$: the firm value is $x + \alpha x$.

Similarly, when equityholders get to make the decisions in distress, Lemma 2 leads to the following expressions for the expected value of the firm on date 1 conditional on x and q :

1. For $x \geq F$: Same as above.
2. For $x < F$ and $q = \bar{q}$: $x + \bar{q}Lx$.
3. For $q = \underline{q}$ and either $x \in [0, x_1^*]$ or $x \in [x_2^*, F)$: $x + \alpha x$.
4. For $q = \underline{q}$ and $x \in (x_1^*, x_2^*)$: $x + \underline{q}Lx$.

The expected value of the firm at date 0 may now be found by integrating these continuation firm values over the ex-ante distributions of x and q . Since (a) $x \sim U[0, H]$ and \bar{q} , (b) \underline{q} are equiprobable, and (c) when in distress, continuation/liquidation decisions are made by debtholders with probability π and equityholders with probability $1 - \pi$, the expected value of the firm at date 0 is

$$\begin{aligned}
 V(F) = & \frac{1}{H} \left\{ \int_0^H x \, dx - \int_F^H \tau(x - F) \, dx + \frac{1}{2} \int_F^H \bar{q}Lx \, dx + \frac{1}{2} \int_F^H \alpha x \, dx \right. \\
 & \left. + \pi \times \frac{1}{2} \left[\int_0^{x^*} \bar{q}Lx \, dx + \int_{x^*}^F \alpha x \, dx + \int_0^F \alpha x \, dx \right] \right\}
 \end{aligned}$$

$$+ (1 - \pi) \times \frac{1}{2} \left[\int_0^{x_1^*} \alpha x dx + \int_{x_2^*}^F \alpha x dx + \int_{x_1^*}^{x_2^*} \underline{q}Lx dx + \int_0^F \bar{q}Lx dx \right] \} \quad (17)$$

This expression can be simplified and put into a very intuitive form. To this end, define, as in the text, \bar{V} to be the date-0 expected value of an all-equity firm without taxes. Such a firm necessarily involves efficient continuations, so we have:

$$\bar{V} = \frac{1}{H} \left\{ \int_0^H x dx + \frac{1}{2} \int_0^H \bar{q}Lx dx + \frac{1}{2} \int_0^H \alpha x dx \right\},$$

Some algebraic manipulation shows that (17) then reduces just to

$$V(F) = \bar{V} - \frac{1}{H} \left\{ \int_F^H \tau(x - F) dx + \pi \frac{1}{2} \int_{x^*}^F (\bar{q}L - \alpha) x dx + (1 - \pi) \frac{1}{2} \int_{x_1^*}^{x_2^*} (\alpha - \underline{q}L)x dx \right\}. \quad (18)$$

As explained in the text, (18) has a very intuitive decomposition.

Step 3: Identifying Optimal Leverage

The third step in the proof is identifying the optimal level of F . This requires us to maximize $V(F)$ over F . Differentiating (18) with respect to F , we obtain

$$\begin{aligned} \frac{dV}{dF} &= \frac{\tau}{H} \int_F^H dx - \frac{1}{2} \pi \left[\frac{(\bar{q}L - \alpha)F}{H} - \frac{(\bar{q}L - \alpha)x^*}{H} \frac{dx^*}{dF} \right] \\ &\quad - \frac{1}{2} (1 - \pi) \left[\left(\frac{(\alpha - \underline{q}L)}{H} x_2^* \right) \frac{dx_2^*}{dF} - \left[\frac{(\alpha - \underline{q}L)}{H} x_1^* \right] \frac{dx_1^*}{dF} \right] \\ &= \tau - \frac{\tau F}{H} - \frac{1}{2} \pi \left[\frac{\bar{q}L - \alpha}{H} F - \frac{(\bar{q}L - \alpha)}{H} \frac{\bar{q}F}{(\bar{q} + \alpha)} \frac{\bar{q}}{(\bar{q} + \alpha)} \right] \\ &\quad - \frac{1}{2} (1 - \pi) \frac{(\alpha - \underline{q}L)F}{H} \left(\frac{1}{\left[1 + \left(\frac{\alpha - \underline{q}L}{1 - \underline{q}} \right) \right]^2} - \frac{1}{[1 + L]^2} \right) \end{aligned}$$

$$= \tau - \frac{\tau F}{H} - \frac{1}{2} \pi \frac{(\bar{q}L - \alpha)F}{H} Z_D - \frac{1}{2} (1 - \pi) \frac{(\alpha - \underline{q}L)F}{H} Z_E \quad (19)$$

where Z_D and Z_E were defined in the text (expressions (7) and (8), respectively). The second-derivative of V with respect to F is

$$\frac{d^2V}{dF^2} = -\frac{\tau}{H} - \frac{1}{2} \pi \frac{\bar{q}L - \alpha}{H} Z_D - \frac{1}{2} (1 - \pi) \frac{\alpha - \underline{q}L}{H} Z_E < 0. \quad (20)$$

The last inequality follows since $\alpha \in (\underline{q}L, \bar{q}L)$ by assumption, and $Z_D, Z_E > 0$. (Recall the inequality pointed out earlier that $L > (\alpha - \underline{q}L)/(1 - \underline{q})$. This implies $Z_E > 0$.)

Thus, $V(F)$ is strictly concave as a function of F , so the optimal value of F is where the first-order condition equals zero. This is precisely the value of F identified in (6).

Step 4: Completing the Proof

Pick $\pi_1 < \pi_2$. We are required to show the existence of $\alpha^* \in (\underline{q}L, \bar{q}L)$ such that the conditions of Proposition 1 are met.

For simplicity, let $F_1(\alpha)$ and $F_2(\alpha)$ denote $F_{\pi_1}(\alpha)$ and $F_{\pi_2}(\alpha)$, respectively. A simple computation using (6) shows that $F_1 < F_2$ if and only if $f(\alpha) < 0$ where

$$f(\alpha) = (\bar{q}L - \alpha)Z_D - (\alpha - \underline{q}L)Z_E.$$

As $\alpha \downarrow \underline{q}L$, $f(\alpha) > 0$, so $F_1 > F_2$. As $\alpha \uparrow \bar{q}L$, $f(\alpha) < 0$, so $F_1 < F_2$. Thus, for all suitably low α , the relatively equity-friendly code π_1 involves the use of more debt than the relatively debt-friendly code π_2 , but at all suitably high α , this is reversed with the debt-friendly code using greater leverage.

To complete the proof, we will show that $f(\alpha)$ is strictly decreasing in α for $\alpha \in (0.36\bar{q}L, \bar{q}L)$. As long as $0.36\bar{q} \leq \underline{q}$ (roughly, the high state is not more than three times better than the low state—this is the mild technical condition mentioned at the top of Section 4), $f(\alpha)$ is monotone decreasing for all admissible values of α , so there is a unique crossover point α^* as mentioned in the statement of Proposition 1.

Using the definition of $f(\alpha)$, we obtain that

$$f'(\alpha) = -1 + \frac{\bar{q}^2}{(\bar{q} + \alpha)^2} + \frac{2\bar{q}^2(\bar{q}L - \alpha)}{(\bar{q} + \alpha)^3} - \frac{1}{\left(1 + \frac{(\alpha - \underline{q}L)}{(1 - \underline{q})}\right)^2} + \frac{1}{(1 + L)^2}$$

$$+ \frac{2(\alpha - \underline{q}L)}{(1 - \underline{q}) \left(1 + \frac{(\alpha - \underline{q}L)}{(1 - \underline{q})}\right)^3},$$

which can be expressed as

$$f'(\alpha) = -1 + \frac{1}{(1 + L)^2} + g(\alpha) + h(\alpha), \text{ where} \quad (21)$$

$$g(\alpha) \equiv \frac{\bar{q}^2}{(\bar{q} + \alpha)^2} + \frac{2\bar{q}^2(\bar{q}L - \alpha)}{(\bar{q} + \alpha)^3}, \text{ and} \quad (22)$$

$$h(\alpha) \equiv \frac{2(\alpha - \underline{q}L)}{(1 - \underline{q}) \left(1 + \frac{(\alpha - \underline{q}L)}{(1 - \underline{q})}\right)^3} - \frac{1}{\left(1 + \frac{(\alpha - \underline{q}L)}{(1 - \underline{q})}\right)^2}. \quad (23)$$

Consider $h(\alpha)$ first:

$$\begin{aligned} h(\alpha) &= \frac{2(\alpha - \underline{q}L)(1 - \underline{q})^2}{[(1 - \underline{q}) + (\alpha - \underline{q}L)]^3} - \frac{(1 - \underline{q})^2}{[(1 - \underline{q}) + (\alpha - \underline{q}L)]^2} \\ &= \frac{[2(\alpha - \underline{q}L) - (1 - \underline{q}) - (\alpha - \underline{q}L)](1 - \underline{q})^2}{[(1 - \underline{q}) + (\alpha - \underline{q}L)]^3} \\ &= \frac{[\alpha - \underline{q}L - (1 - \underline{q})](1 - \underline{q})^2}{[(1 - \underline{q}) + (\alpha - \underline{q}L)]^3}. \end{aligned} \quad (24)$$

Thus, we obtain that

$$h'(\alpha) = \frac{(1 - \underline{q})^2}{[(1 - \underline{q}) + (\alpha - \underline{q}L)]^4} [4(1 - \underline{q}) - 2(\alpha - \underline{q}L)]. \quad (25)$$

Hence, $h'(\alpha) = 0$ at $\alpha = 2(1 - \underline{q}) + \underline{q}L$. Furthermore,

$$\begin{aligned} h''(\alpha) &= \frac{6(1 - \underline{q})^2}{[(1 - \underline{q}) + (\alpha - \underline{q}L)]^5} [(\alpha - \underline{q}L) - 3(1 - \underline{q})] \\ &< 0 \text{ at } \alpha = 2(1 - \underline{q}) + \underline{q}L. \end{aligned} \quad (26)$$

Thus, $h(\alpha) \leq h(2(1 - \underline{q}) + \underline{q}L) = \frac{(1 - \underline{q})^3}{27(1 - \underline{q})^3} = \frac{1}{27}$. In turn,

$$f'(\alpha) \leq -1 + \frac{1}{(1 + L)^2} + g(\alpha) + \frac{1}{27}. \quad (27)$$

Consider $g(\alpha)$ next. Note that $g(\alpha)$ can be simplified to yield

$$g(\alpha) = \frac{\bar{q}^3 + 2\bar{q}^3L - \bar{q}^2\alpha}{(\bar{q} + \alpha)^3}, \quad (28)$$

which is decreasing in α . Let $\hat{\alpha}(\theta) = \theta\bar{q}L$, $\theta \in (\underline{q}/\bar{q}, 1)$. Then, $\forall \alpha \in (\hat{\alpha}(\theta), \bar{q}L)$, we obtain that

$$g(\alpha) \leq g(\hat{\alpha}(\theta)) = \frac{1 + (2 - \theta)L}{(1 + \theta L)^3}. \quad (29)$$

This, in turn, implies that $\forall \alpha \in (\hat{\alpha}(\theta), \bar{q}L)$,

$$f'(\alpha) \leq -1 + \frac{1}{(1 + L)^2} + \frac{1 + (2 - \theta)L}{(1 + \theta L)^3} + \frac{1}{27}. \quad (30)$$

It can be shown that as long as $L \geq 2$ (our maintained assumption),

$$-1 + \frac{1}{(1 + L)^2} + \frac{1 + (2 - \theta)L}{(1 + \theta L)^3} + \frac{1}{27} < 0, \quad \forall \theta \geq 0.36. \quad (31)$$

Thus, $f'(\alpha) < 0, \forall \alpha \in (0.36\bar{q}L, \bar{q}L)$.

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