On Testing the Tradeoff Theory of Capital Structure with Real Options

by

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Abstract
We explain often anomalous results of capital structure tests by infusing tradeoff theory with real options. Of course one can explain almost everything using a soft qualitative theory. This paper's addition is to use a quantitative approach to generate tradeoff theory predictions for firms with valuable real options. We are able to explain many of the results of Rajan and Zingales (1995), Welch (2004), and Flannery and Rangan (2006).

Thesis Supervisor: Stewart C. Myers
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Acknowledgements

I am extremely grateful to Stewart Myers, Wei Dou, and Bengt Holmstrom for their comments throughout numerous drafts. This paper stems from Research Assistantship work that Wei Dou and I performed for Stewart Myers and James A. Read concerning their working paper "Real Options, Taxes and financial Leverage."

Contents

1 Introduction

The more debt a firm has, the more distress and potential bankruptcy costs the firm carries. On the other hand, the more debt a firm has, the more the tax advantages of debt the firm enjoys. (For a further discussion on the benefits and costs of debt, see the survey paper Graham and Leary (2011).) The tradeoff theory says that these are the main issues the firm faces in determining its capital structure each period. So if a firm were to only have fixed assets, such as a factory, then it would have a constant proportion of the value of the firm as debt and a constant proportion of the value of the firm as equity.

However, if the firm has growth options, then the optimal capital structure would change. Consider a firm which has a widget factory next to an open tract of land. The firm has the option to build another widget factory on the open tract of land. So if the price of widgets goes above a cutoff threshold, then the firm will build the factory. So if the factory manager increases debt at t=0, goes bankrupt at t=1, and then the price of widgets increases at t=2, he will have lost the real growth option. Hence he will decrease debt at t=0 relative to the case where there is no empty tract of land.

The tests of capital structure do not account for growth options, which can have a substantial effect on a firm's capital structure. Thus if the tradeoff model really holds, the capital structure tests can give answers that seem to reject the trade off theory in favor of another model.

We simulate the dynamic evolution of 100 firms which follow the tradeoff theory, adjusted for real growth options as in Myers and Read (2010). When evaluated on such simulated data, the target adjustment regression of Shyam-Sunder and Myers (1999) indicates that firms are slowly adjusting to a stationary target. The regression of Welch (2004) tells us that firms do not actively manage their capital structure and that the main driver of the market leverage ratio is stock return. The regression of Flannery and Rangan (2006) implies that the firm adjusts slowly to a moving target capital structure. However, the pecking order test of Shyam-Sunder and Myers (1999) rejects the pecking order theory.

Therefore, great care must be taken to account for the presence of growth options in the design of capital structure tests. More generally, the literature needs to better consider the power of capital structure tests before drawing conclusions.

2 Related Literature

The three papers explored in this section are quite relevant to this paper. Tserlukevich (2008) makes a model of capital structure which accounts for growth options, but in a less pronounced way than we do, and use some of the capital structure tests that we apply to our simulated data. Barclay et al. (2006) form a model in which growth options can force a firm to issue less total debt. Myers and Read (2010) explores the model we will use for our simulations, and shows static capital structure changes which we will incorporate into a dynamic setting.

2.1 Myers and Read (2010)

Myers and Read (2010) introduce a framework for determining the capital structure of a firm that has assets in place and real options. We will use such an environment throughout this paper. They find that when a firm has any growth options, it will be operating below its target leverage. Most of the time, when the value of the assets in place increase, the negative debt capacity, which will be defined in Section 4, from the real option overcomes the positive debt from the increased value of the asset in place, leading to a lower debt to book ratio, as well as a lower debt to market ratio. This paper explores what additional insights can be gleaned when we extend this framework to a dynamic setting with respect to capital structure tests.

2.2 Tserlukevich (2008)

Tserlukevich (2008) creates a model in which firms have an assets in place K_t which produce output $X_t K^\alpha$ for X_t a geometric Brownian motion with drift μ. The tax rates are set with a kink at zero income. There are no adjustment costs. Hence, the debt level is set so that the firm always pays exactly its income as interest to debt. If the firm were to have no growth options, then it would have a constant proportion debt and equity. In fact, if $\mu = 0$, then it would have no equity.

He includes irreversible investment. Growth options to expand capacity from K_0 to K_1 cost $P(K_1 - K_0) + FK_0$. When the firm experiences good shocks, initially the leverage ratio will decrease as the options in the denominator will increase. Then the option will be exercised and the firm will generate higher cash flow and thus have a higher leverage. The initial effect is strong enough to generate the negative relation between leverage and profitability observed in Rajan and Zingales (1995). (See Section 3.2.) However, the ratio of debt to market value of assets in place does not change in Tserlukevich's model, as it does in the model proposed in Section 6. The regression in Welch (2004) (See Section 3.3) is also run. However, the coefficient on Welch's key variable, the implied debt ratio (IDR), is very small (less than 0.08), as the increase in the option value does not affect the optimal change in debt, as it does in our model.

2.3 Barclay et al. (2006)

Barclay et al. (2006) create a 2-period, three date model to show that an increase in a firm's options cause the firm to have a lower debt level. Assume a zero interest rate. At date t=0, the firm gets funding from shareholders and bondholders. At date $t = 1$, the project returns X distributed uniformly on $[a, b], a \geq 0$. Cash flows from the initial project can be reinvested at $t = 1$ in a project with cash flow $H > 1$ for investment up to a threshold I^*, and $L < 1$ for investment above I^*. In this setting, I^* is the amount of growth options of the firm. The empire-building manager will invest all free cash flows at $t = 1$ into such an investment.

So on the one hand, if X is high, the firm would like to increase debt, so that the manager does not invest above I^*. On the other hand, the manager would like to have less debt and more free cash flow if X is large. Letting $D^*(I^*)$ denote the optimal debt level yields

$$D^*(I^*) = \max\left(b - I^*\frac{H-L}{1-L}, 0\right). \tag{2.1}$$

So as I^* increases, the debt level of the firm will decrease.

This paper differs from our model in that it does not account for the dynamic nature of real options. Furthermore, as I^* tends to zero, the manager will use all debt, as all projects at $t = 1$ will have a negative NPV. In our model, we the value of growth options tend to zero, the manager will choose proportion, $\lambda < 1$, of the firm value to be debt.

The three papers explored in this section are quite relevant to this paper. Tserlukevich (2008) makes a model of capital structure which accounts for growth options, but in a less pronounced way than we do, and use some of the capital structure tests that we apply to our simulated data. Barclay et al. (2006) form a model in which growth options can force a firm to issue less total debt. Myers and Read (2010) explores the model we will use for our simulations, and shows static capital structure changes which we will incorporate into a dynamic setting.

Tserlukevich (2008) models capital structure with growth options and applies capital structure tests, but has more drawbacks than our model. Barclay et al. (2006) introduce a setting wherein more growth options makes a firm borrow less. Myers and Read (2010) form the basis of our model.

3 Capital Structure Tests

The following four well-known papers incorporate the prevailing capital structure tests in the literature. For a survey of such tests, see Graham and Leary (2011) and Frank and Goyal (2008). We will use these papers to shed light on the pitfalls of not accounting for real growth options in tests, and how this can lead to false conclusions.

3.1 Shyam-Sunder and Myers (1999)

Shyam-Sunder and Myers (1999) provide two tests of capital structure. The pecking order theory states that firms issue and retire debt first, then issue or retire debt as a last resort, because of information asymmetry issues (see Myers and Majluf (1984)). The first is a pecking order test given in Equation 3.1.

$$\Delta D_{it} = a + b_{PO} DEF_{it} + e_{it}, \tag{3.1}$$

where DEF_{it} is the funds flow deficit, and the variables D_{it}, DEF_{it} are scaled by book value at $t-1$. So if the pecking order model is correct, then one expects $a = 0, b_{PO} = 1$.

In a target adjustment model, firms have a target capital structure. But they may not adjust fully in a given period. Rather, they only adjust part of the way to the target. The target adjustment test is given in Equation 3.2.

$$\Delta D_{it} = a + b_{TA}(D^*_{it} - D_{i,t-1}) + e_{it}, \tag{3.2}$$

where D_{it}^* is the firm's target debt ratio. The variables $D_it^*, D_{i,t-1}$ are scaled by book value at $t-1$. If the target adjustment model is correct, then we expect $b_{TA} > 0$.

Shyam-Sunder and Myers look not only at the size of the tests, but also their power. For the pecking order test, firms retire debt with all of their surplus and if there is a deficit, they issue debt to cover the whole deficit. For tests of the power of the target adjustment model, they set the target to be the mean debt book ratio, choose $b_{TA} = 0.4$, and standard deviation of error term 0.1.

Shyam-Sunder and Myers consider 157 Compustat firms from 1971-1989 with all relevant variables recorded for each year. They find that both tests perform well on the empirical data. However, they find that the pecking order test can be rejected when the data is generated by the target adjustment model, whereas the target adjustment model cannot be rejected when the data is really generated through the pecking order model. Therefore the pecking order test is more powerful, and suggests a greater confidence in this model than the target adjustment model. This implication underscores the importance of determining the power of capital structure tests in many settings, as we do in this paper.

3.2 Rajan and Zingales (1995)

Rajan and Zingales (1995) use data from the United States, Japan, Germany, France, Italy, the United Kingdom, and Canada over the period 1987-1991. They analyze how firms' size, market to book ratio, tangibility (fixed assets to total assets), and profitability relate to its capital structure. They analyze whether the financing patterns using data from American companies also hold for the international data. Furthermore, they explore differences among countries in bankruptcy law and tax rates.

Rajan and Zingales (1995) run the regression in Equation 3.3 augmented with tangability (ratio of fixed assets to total assets) and log(sales), which do not fall under our framework. Such variables are now the standard list of cross-sectional variables.

$$\begin{aligned} Leverage[Firmi] = \alpha &+ \beta_2 MarkettoBookRatio_i \\ &+ \beta_3 Profitability_i + e_i, \end{aligned} \tag{3.3}$$

where the various variables are 4 year averages. They use both book leverage and market leverage.

Rajan and Zingales get a negative relation between leverage and market to book. They account for this by suggesting a market timing theory. Also they conjecture that firms with higher market to book can have higher costs of distress.

Rajan and Zingales also find a negative coefficient on profitability. They argue for a pecking order framework to explain this phenomenon. If debt is the main form of short run financing, then the more profitable the firm is, the more debt it will pay off. Hence the lower the book leverage ratio as well as the market leverage ratio.

This argument is used in the literature to reject the tradeoff theory, as more profitable firms generate more profits with fixed assets and thus can more easily repay a given proportion of firm value debt. This effect yields lower bankruptcy costs. Thus, these firms should have higher leverage.

3.3 Welch (2004)

Welch (2004) argues that managers are slow to change capital structure towards a target and thus the main driver of capital structure is equity returns. Defining

$$IDR_{t,t+k} = \frac{D_t}{E_t \cdot (1 + x_{t,t+k}) + D_t}, \tag{3.4}$$

where $x_{t,t+k}$ is the equity return between period t and period $t+k$. $IDR_{t,t+k}$ is then the leverage ratio if the firm were to do no issuing or repurchase activity to affect its capital structure.

Welch (2004) then runs the regressions:

$$MLR_{t+k} = \alpha_0 + \alpha_1 MLR_{t,t+k} + \alpha_2 IDR_t. \tag{3.5}$$

$\alpha_1 = 1, \alpha_2 = 0$ means that the manager perfectly adjusts to the target. $\alpha_1 = 0, \alpha_2 = 1$ means that the manager does not adjust at all.

He also runs a regression on the change in debt ratios:

$$\Delta MLR_{t+k} = \alpha_0 + \alpha_1 (IDR_{t,t+k} - MLR_t). \tag{3.6}$$

He gets α_1 close to 1 in both settings, implying a great deal of manager inertia. Welch uses all firms on Compustat from 1962-2000 with initial equity equal to the

S &P level at that year multiplied by $1 million. In 1964, the S&P was at 75. So minimum market capitalization of a firm entering the sample in year 1964 would be $75 million.

He interprets the results in three ways. First, he conjectures *Dynamic Optima* in which the target moves one for one with stock returns. This could be caused by changes in the discount rate or far-away growth opportunities. Second, *Direct Transaction Costs* can lead to the manager having a flat objective function, and path dependence. However, direct transaction costs are small. Third, Welch appeals to *Indirect Costs* including the pecking order theory, where the manager does not want to issue equity with bad price movements because of the signal it will send to investors, limited memory retention, agency problems, managers subjective valuation of their stock, preference of equity over debt on stock increases so that managers are harder to remove, and irrational managerial behavior. Furthermore, on the upside and downside different effects could be in play.

3.4 Flannery and Rangan (2006)

Flannery and Rangan (2006) test the target adjustment capital structure model, realizing that a firm's target can change over time due to firm characteristics. They use all firms on Compustat, excluding financials and utlitities, from 1965-2001 with data for at least two consecutive years of data. Flannery and Rangan find that the firm adjusts by over 30% annually, rather than 10% in prior studies. In particular, they run a target adjustment model with a moving target $MDR^* = \beta X_{i,t}$, for X firm characteristics: earnings before interest and taxes to tangible assets, market to book, depreciation to total assets, log(total assets), fixed assets to total assets, research and development to total assets, and the firm's industry mean lagged debt to book ratio. The regression is given in Equation 3.7.

$$MDR_{i,t+1} - MDR_{i,t} = \lambda(MDR^*_{i,t+1} - MDR_{i,t}) + e_{i,t+1}. \tag{3.7}$$

Flannery and Rangan conclude that a partial adjustment model suits the data well. The targets do indeed depend on well-known firm characteristics X. When firms are differ from their target, they are quick to go back to their target. Short run deviations from target in the leverage ratio due to stock price changes correct in a few years.

Shyam-Sunder and Myers (1999), Rajan and Zingales (1995), Welch (2004), and Flannery and Rangan (2006) are representative of the capital structure testing literature. Hence, we will apply these tests to the data generated from our simulations.

4 Formulation of Model

The model is formulated from that of Myers and Read (2010). It extends in a natural, continuous way the tradeoff theory to account for real options, as it takes into account the implied leverage from the options. So if a firm really follows a tradeoff theory with no growth options, we should expect that firm to follow this framework when it has growth options.

The firm has a tax rate τ. It can borrow and lend at a rate of r per period. Since interest payments are tax deductible, for each extra dollar of debt the firm issues, it gets $r\tau$ in tax breaks. So the borrowing rate it considers is $r(1-\tau)$.

The market price of one unit of asset is $S(t)$, which follows a Brownian motion process with drift $-\frac{1}{2}\sigma^2$ and volatility σ. One unit of asset in place pays a continuous dividend of $yS(t)$. The firm will pay out all earnings to shareholders at each time. The firm does not hold cash. The firm has $K(t)$ assets in place at time t. Assets depreciate at a rate of δ per period. So the process for assets in place is

$$dK(t) = -log(1-\delta)K(t) + OpExed(t), \tag{4.1}$$

where $OpExed(t)$ is number of assets in place obtained through the exercise of options at time t.

If the firm were to only have assets in place, then it would choose

$$Debt(t) = \lambda K(t)S(t), \tag{4.2}$$

$$Equity(t) = (1-\lambda)K(t)S(t), \tag{4.3}$$

thus following the classical tradeoff theory. If the firm were to have an asset which follows a locally deterministic process, it would finance it exclusively through debt.

Thus, when the firm has n call options with strikes A_i, expiration dates T_i, and size of $size_i$, it will have **Synthetic Assets** $(SynK(t))$ and **Synthetic Debt**

$(SynDebt(t))$ from the real options given by the following formulas:

$$SynK(t) = \sum_{i=1}^{n} size_i \Phi(d_{i,1}) \left((1-\delta)(1+y)\right)^{-T_i} \tag{4.4}$$
$$SynDebt(t) = \sum_{i=1}^{n} size_i \Phi(d_{i,2})(1+r(1-\tau))^{-T_i} A_i,$$

where $\Phi(\cdot)$ is the cumulative distribution function for the unit normal distribution and $d_{1,i}, d_{2,i}$ are given by

$$d_{i,1} = \frac{log(\frac{S(t)}{A_i}) + log(1+r(1-\tau)) - log\left((1+y)(1-\delta)\right) + \frac{1}{2}\sigma^2 T_i}{\sigma T_i^{\frac{1}{2}}} \tag{4.5}$$
$$d_{i,2} = d_{i,1} - \sigma T_i^{\frac{1}{2}}.$$

$SynK(t)$ and $SynDebt(t)$ are thus the number of units of asset in place and amount of debt that one would need to replicate the payoff from time t to $t + dt$ of the firm's portfolio of options.

Then considering the total replicating portfolio and $SynK(t), SynDebt(t)$ as analogous to assets in place and debt, respectively, the firm will pick its $Debt(t)$ and $Equity(t)$ according to

$$Debt(t) = \lambda(SynK(t) + K(t))S(t) - SynDebt(t) \tag{4.6}$$

$$Equity(t) = (1-\lambda)(SynK(t) + K(t))S(t) \tag{4.7}$$

The approach here is based on Myers and Read (2010). It differs from standard modeling assumptions in that it does not have any adjustment cost of changing capital structure and it treats options the same way as capital stock. So if a firm really were to follow a tradeoff theory, it would follow this technique when it has options.

5 Example

We present the following simple example to demonstrate how exactly relevant variables including debt to market and debt to book ratios can change when the firm has growth options with respect to time, the strike of the growth option and time to maturity. The behavior is somewhat complex and debt to market is certainly not constant.

Consider the case where $S(1) = 1$, K(1) = 3, $\sigma = .18$, $\delta = .03$. The firm has one growth option, with $size = 1$, maturity $T = 7$. Then if no change in S occurs $(S(t) = 1)$, we get the following capital structure dynamics for $A = 0.90, 1.10$.

Figures 5.1 - 5.5 give the results for $A = 0.9$. As time approaches the exercise time, the effect of an increase in option value due to not losing as much dividend yield outweighs the loss in time premium. Then for smaller time, the loss of optionality outweighs the loss in dividend yield of the option. The synthetic assets and the synthetic debt increase, as the option is more leveraged closer to expiration. Due to the synthetic debt of the option, the real debt decreases. Consequently, the debt to market ratio also decreases.

Figure 5.6 - 5.10 give the results for $A = 1.10$. As time approaches the ex-

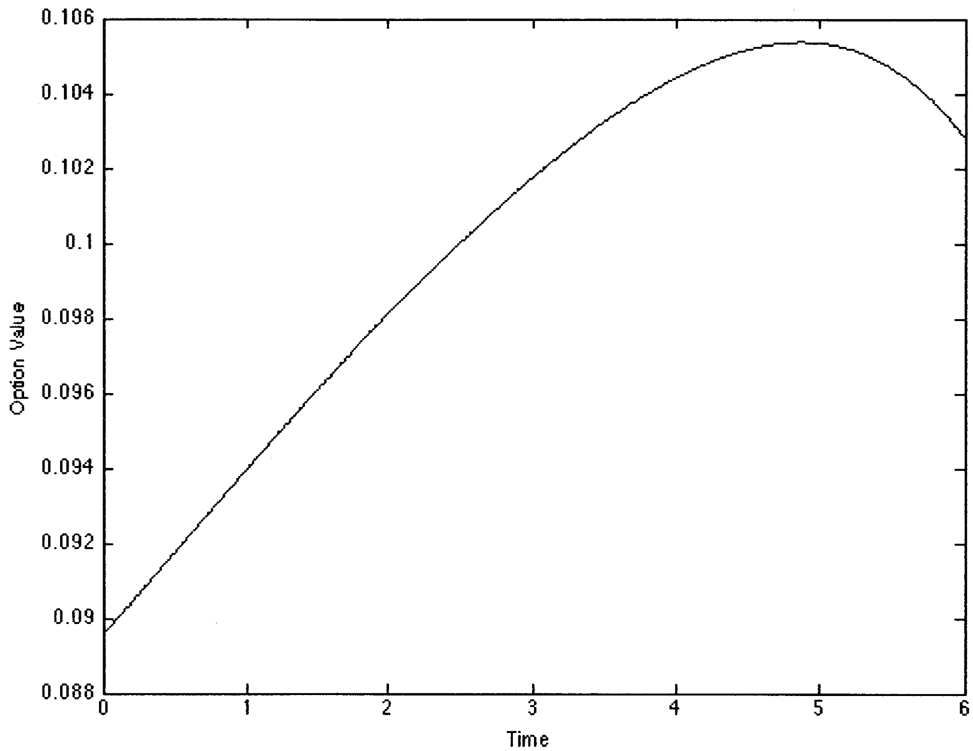

Figure 5.1: Value of the option for $K(0) = 3, A = 0.90, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

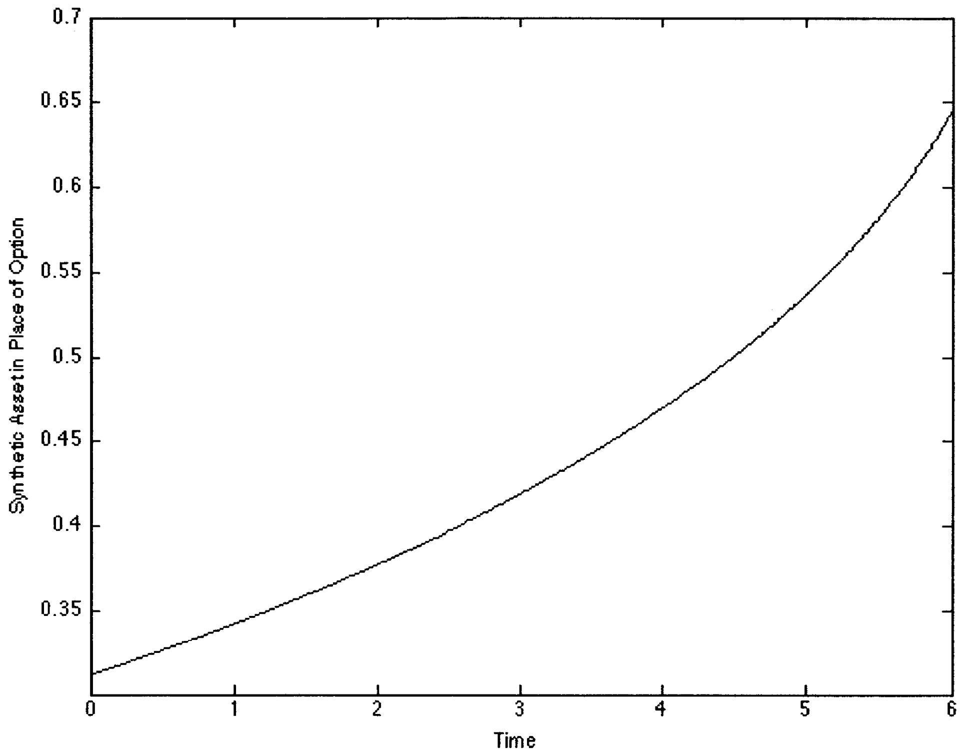

Figure 5.2: Synthetic assets for $K(0) = 3, A = 0.90, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

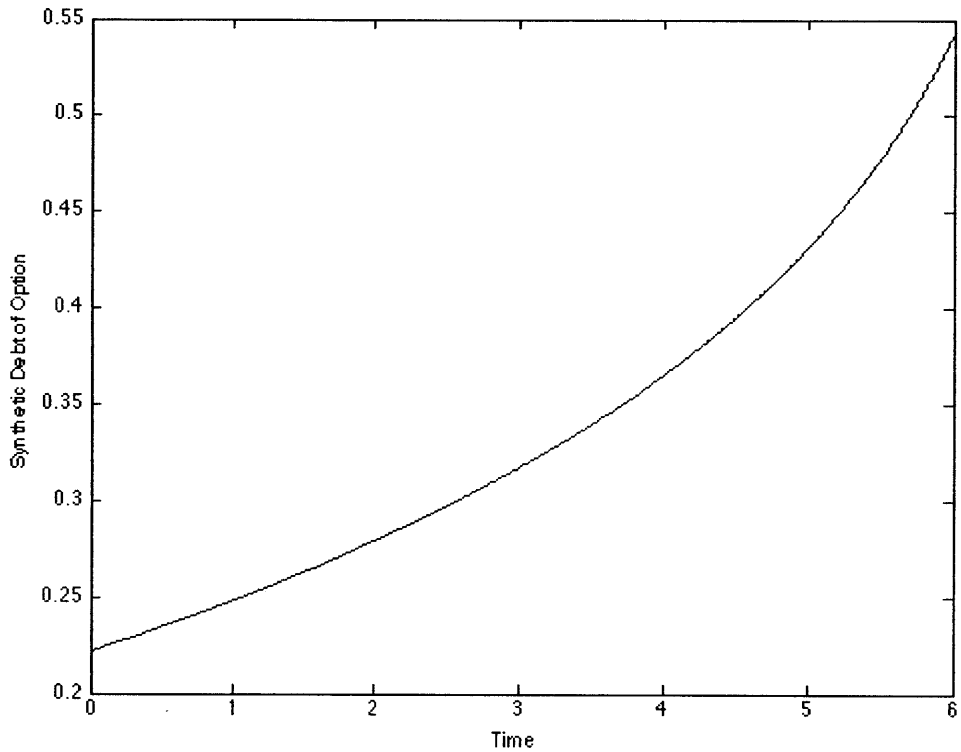

Figure 5.3: Synthetic debt for $K(0) = 3, A = 0.90, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

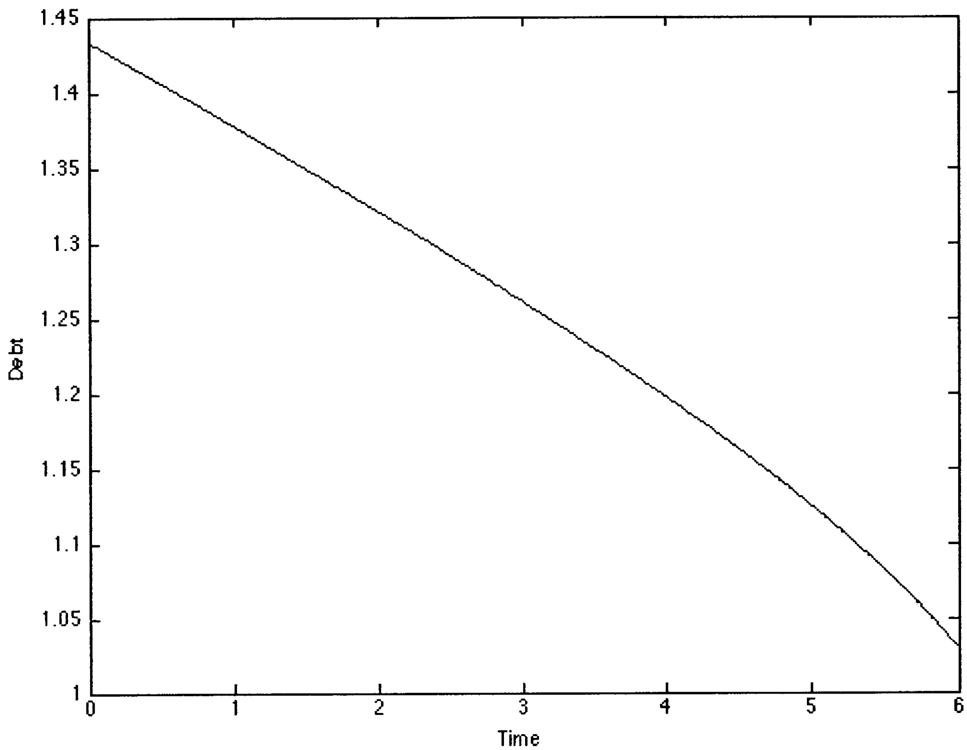

Figure 5.4: Debt for $K(0) = 3, A = 0.90, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

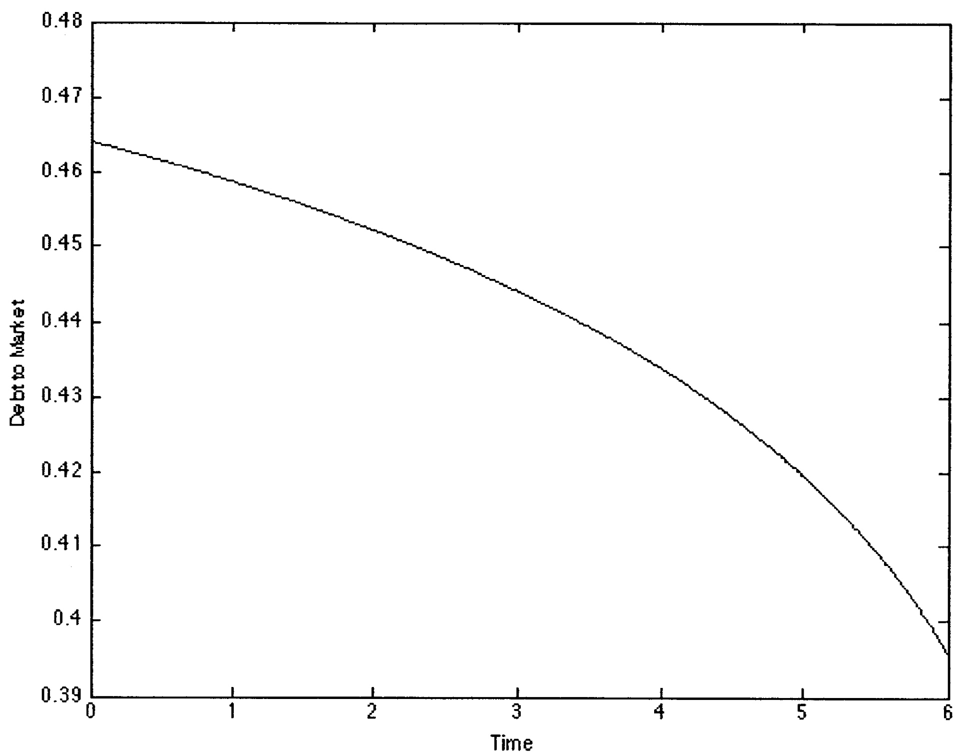

Figure 5.5: Debt to market for $K(0) = 3, A = 0.90, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

ercise time, first the option price increases, since the firm is losing less dividend yield, then the option price decreases due to being out of the money and a loss in time premium. The synthetic assets and synthetic debt from the options first increase as the option gets more levered closer to maturity, then decrease, as the option is out of the money and thus the leverage of the option decreases. Due to this effect and depreciation, the debt decreases. Consequently, the debt to market first decreases, then increases, as the synthetic debt of the option decreases close to expiration.

Figure 5.11 - 5.15 give the case for $\lambda = 0.50, K(0) = 3, A = 1, \sigma = .30, T = 2$, where S varies between 0.30 and 3.00 changes. As S increases, the option value increases, and the synthetic assets in place increase. The synthetic debt also increases, and asymptotes to 1, as when the option is far in the money, it behaves like the levered asset. The debt increases monotonically. Note that for S above 2, the option acts like the asset in place, leading to a larger slope of increase for the debt. Finally, the debt to market ratio initially decreases as the negative debt capacity of the option starts to appear. However, for larger S, the synthetic assets add more debt which counteracts that effect, leading to an increase in debt to market.

We found that debt to market and debt to book can fluctuate wildly when a firm has growth options, as we alter the maturity of the option, the value of a unit of asset in place, $S(t)$, and the strike price of the option. Certainly, these effects should be considered in any capital structure test.

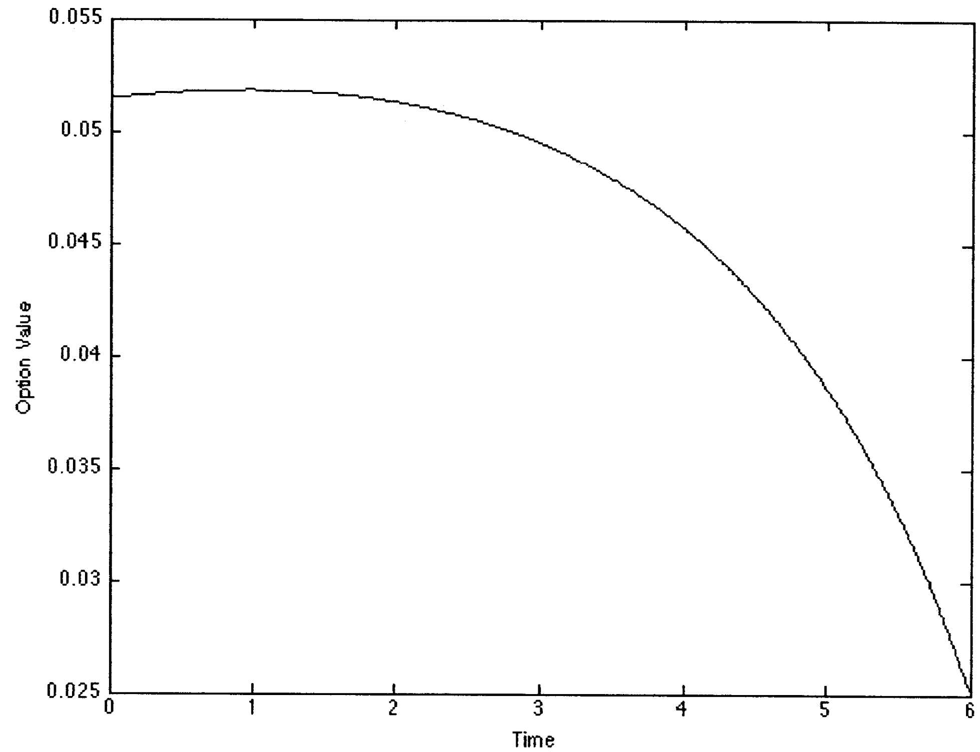

Figure 5.6: Value of the option for $K(0) = 3, A = 1.10, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

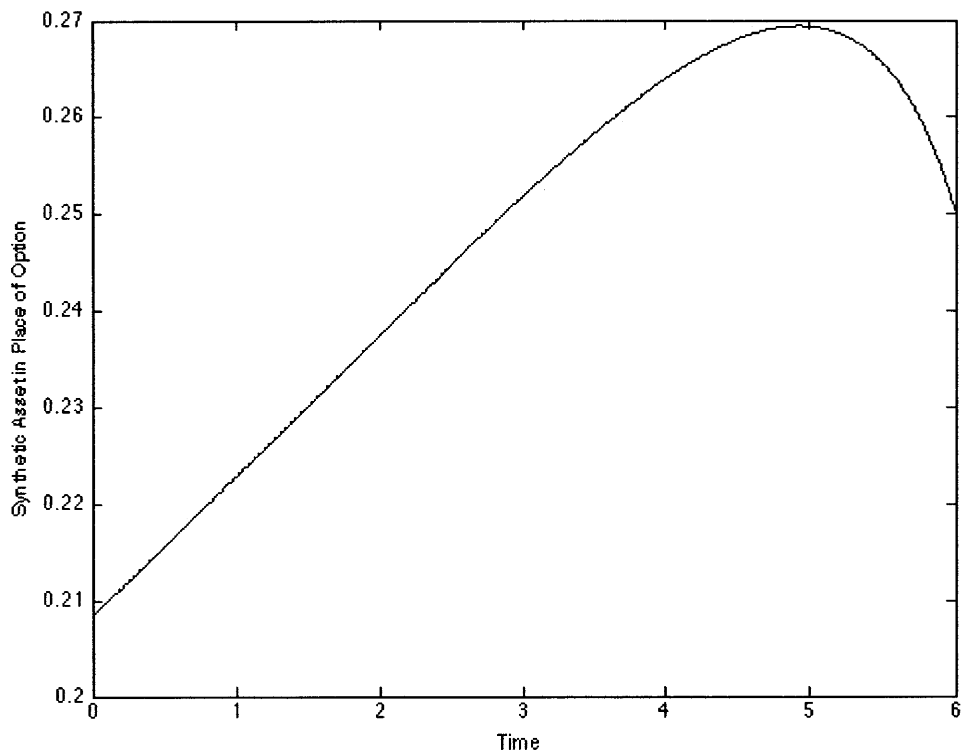

Figure 5.7: Synthetic assets for $K(0) = 3, A = 1.10, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

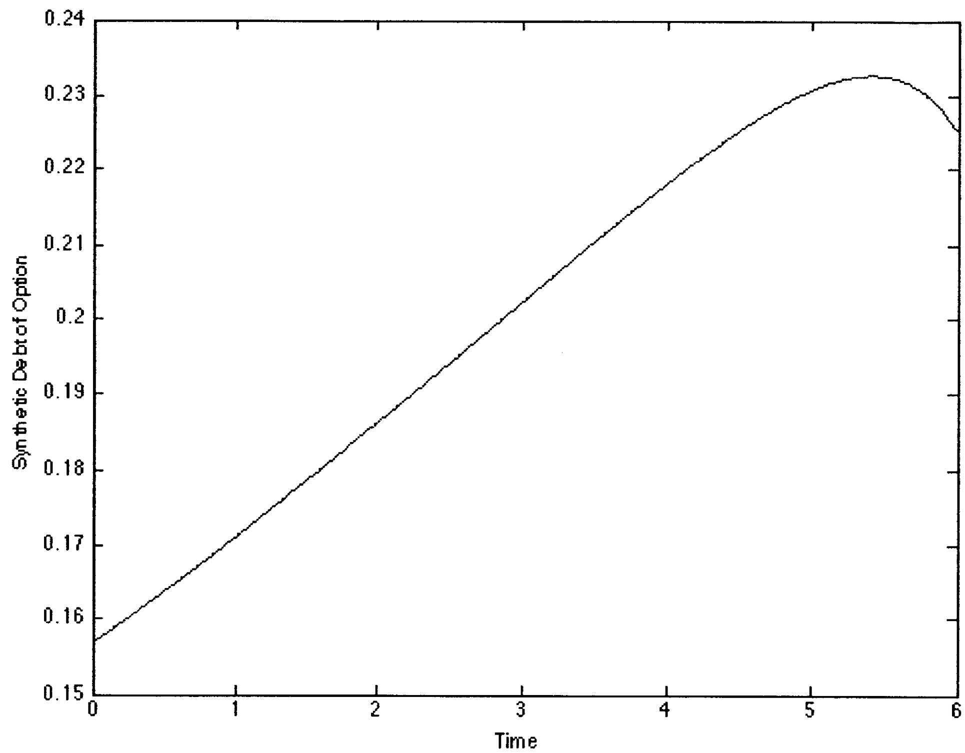

Figure 5.8: Synthetic debt for $K(0) = 3, A = 1.10, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

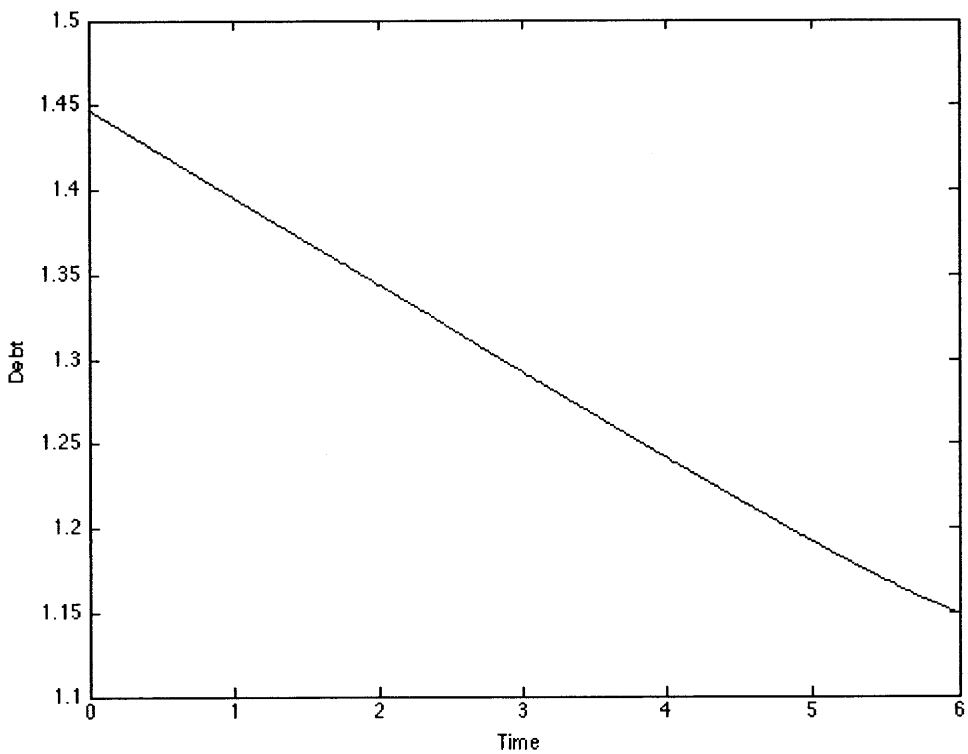

Figure 5.9: Debt for $K(0) = 3, A = 1.10, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

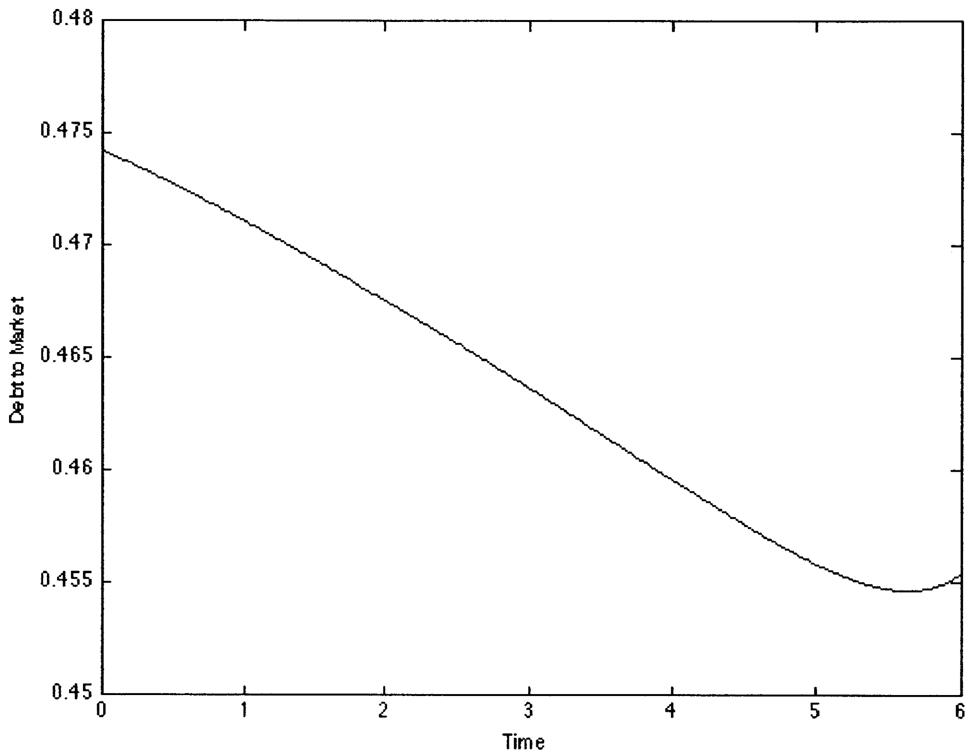

Figure 5.10: Debt to market for $K(0) = 3, A = 1.10, \sigma = .18, S(t) = 1, T = 7, \lambda = 0.50$ against time

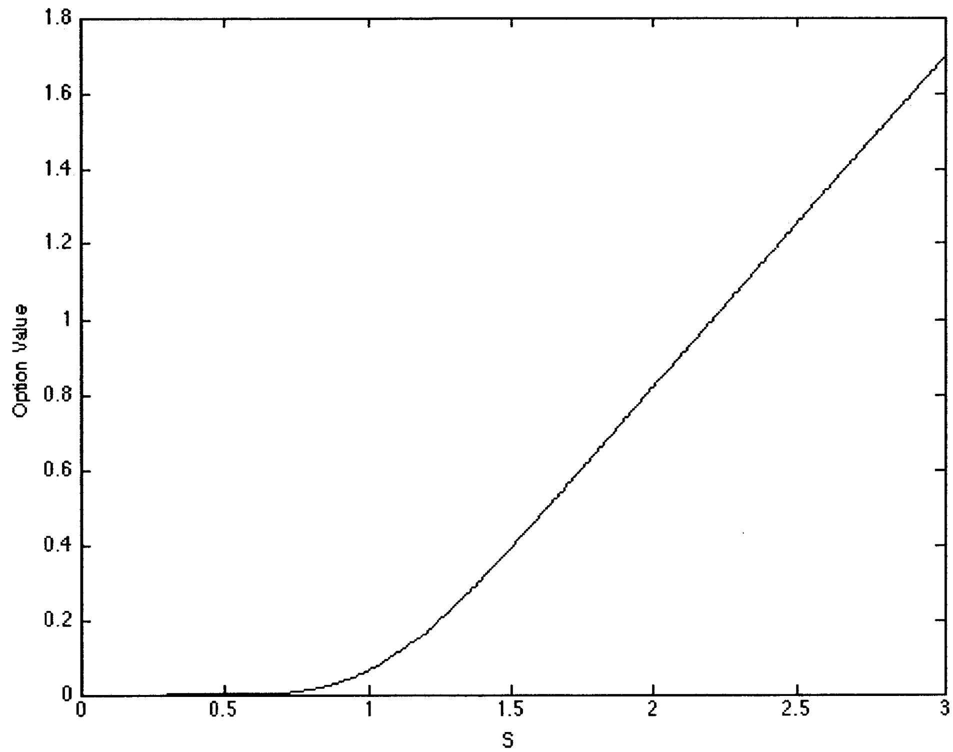

Figure 5.11: Value of option for $K(0) = 3, A = 0.90, \sigma = .18, T = 2, \lambda = 0.50$ against S

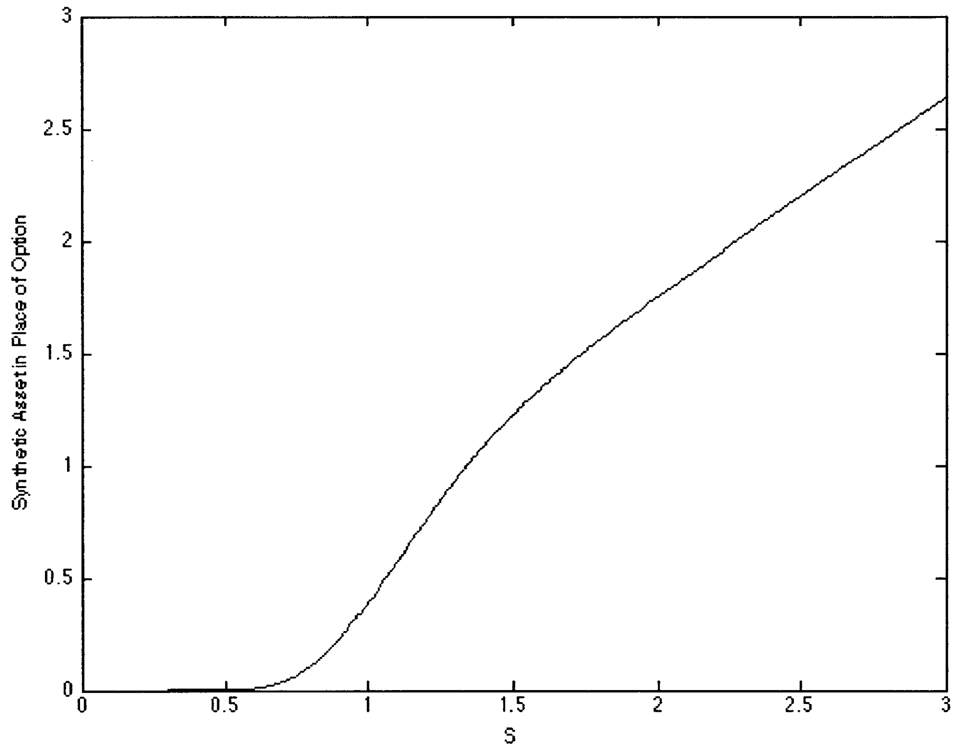

Figure 5.12: Synthetic assets in Place for $K(0) = 3, A = 0.90, \sigma = .18, T = 2, \lambda = 0.50$ against S

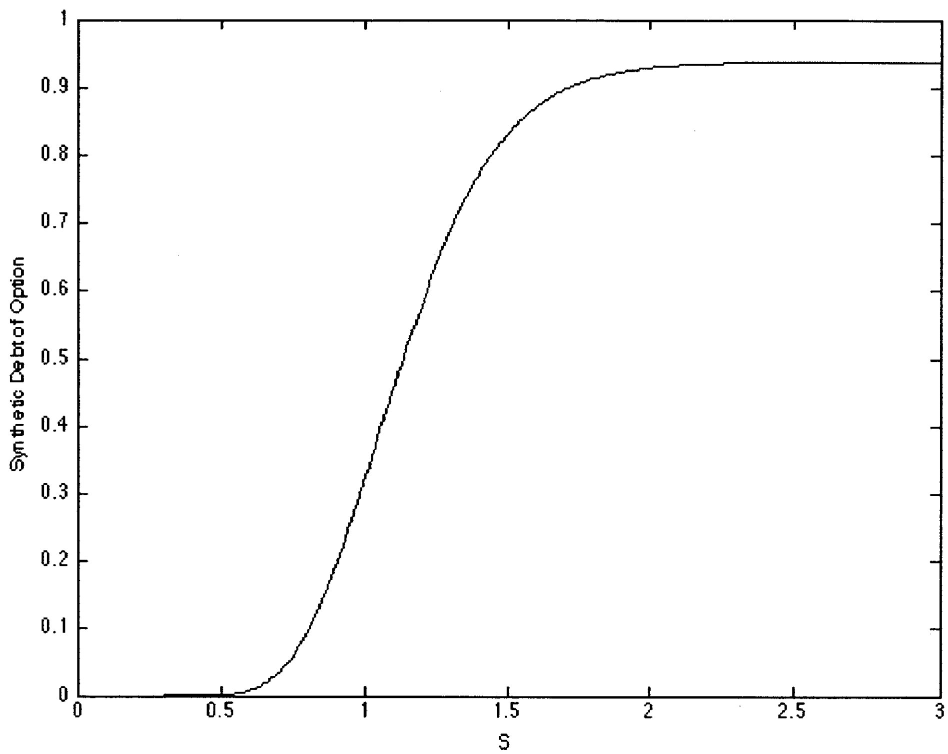

Figure 5.13: Synthetic debt for $K(0) = 3, A = 0.90, \sigma = .18, T = 2, \lambda = 0.50$ against S

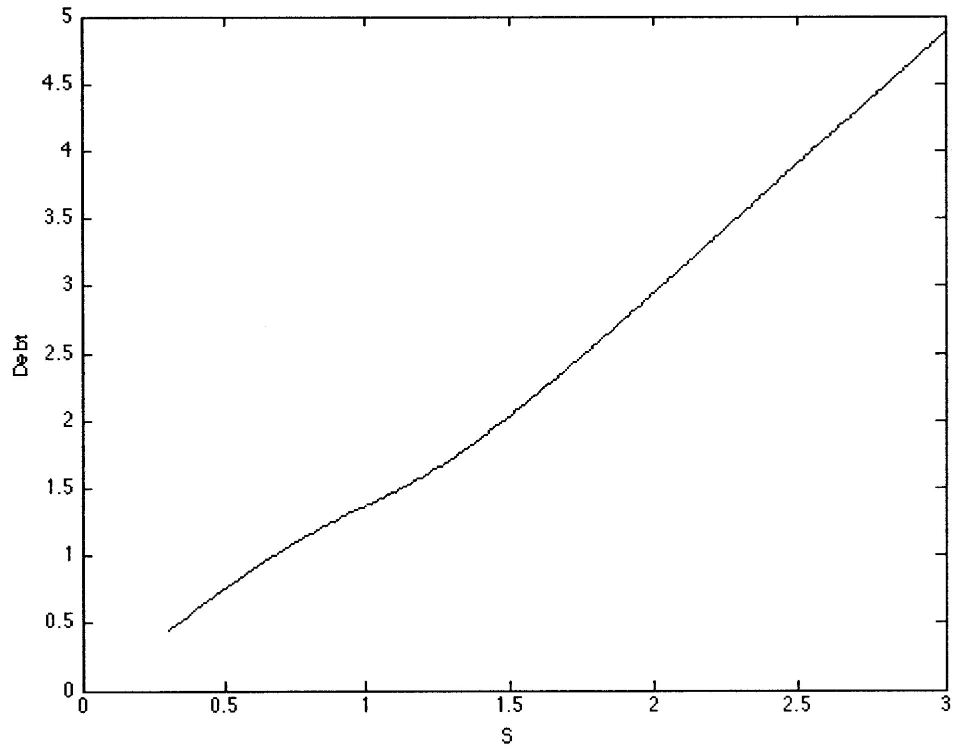

Figure 5.14: Debt for $K(0) = 3, A = 0.90, \sigma = .18, T = 2, \lambda = 0.50$ against S

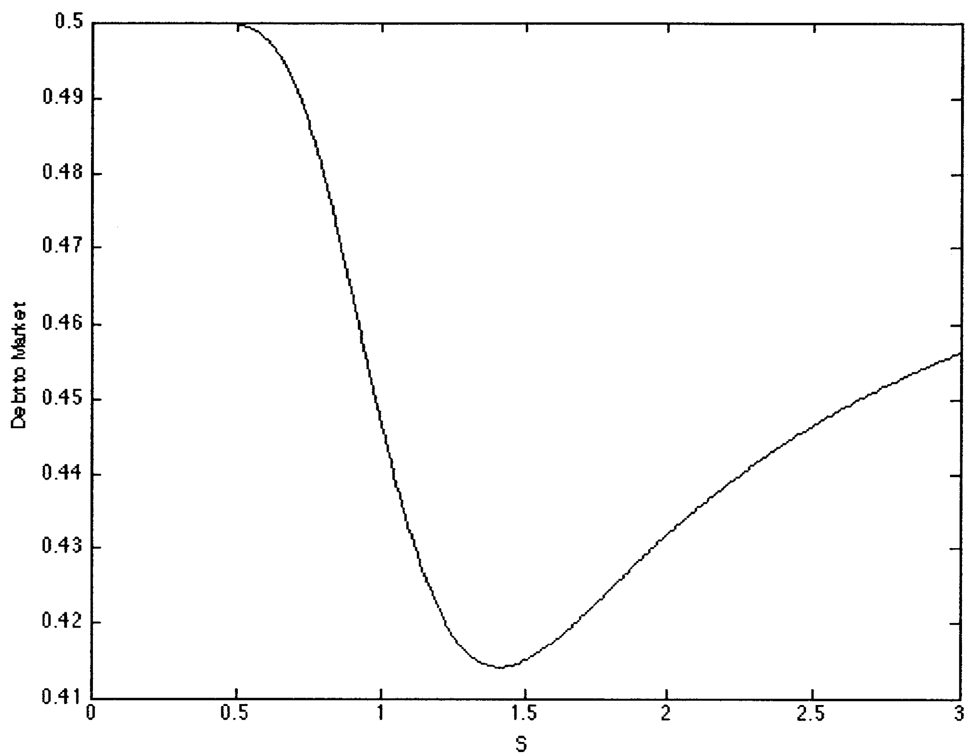

Figure 5.15: Debt to market for $K(0) = 3, A = 0.90, \sigma = .18, T = 2, \lambda = 0.50$ against S

6 Generating Sample of Firms and Capital Structure

We set the parameters of our model to so that the samples will be drawn from a reasonable stationary distribution.

At t=1, we start with N = 100 firms. The Brownian motion of the assets in place of firm i, $S_i(t)$, follows a geometric Brownian motion

$$\frac{dS_i(t)}{S_i(t)} = -\frac{1}{2}\sigma^2 + \sigma dZ_t^i. \tag{6.1}$$

$K_i(1) = 8$. We set $\sigma = .15$. Each firm gets growth options with $size = 1$, strike $A = 0.90$ which expire at every period in the future. Note that the firm cannot exercise the option in the current period. We let the capital structure evolve over time, and keep the target $\lambda = 0.5$.

At each period, with probability $p_{leave} = .07$ each firm leaves the sample. This could happen, for example, if a firm gets acquired by some un-modeled out of sample firm. The same period t in which a firm leaves, a new firm enters having the initial $K_i^{new}(t) = 8$. $S_i^{new}(t) = 1$ follows the same underlying process. The strike price of the new firm's options arriving each period remains $A = 1.10$ and the new firm can leave the sample with probability $p_{leave} = .07$ each period, being replaced by a yet newer firm, etc. In this way, we get to a stationary distribution. If we were to have looked at firms which remain in the sample indefinitely, then $S \to \infty$ for some firms, leading the firms to have a limited negative real debt capacity, and the options acting as assets in place, and other firms would have $S \to 0$, leading them to be cash cows. The interesting behavior is for intermediate values of S. We run the sample 80 years, and figure by this time, we have reached the stationary distribution. The probability that an initial firm will still be in the sample at this point is $(1 - .07)^{80} = 0.003$. We then run the sample for an additional 120 years.

We remove sample points that did very well, and have Market to Book Ratio above 4, since this removes only about 2% of our sample points, and it is somewhat unreasonable for a firm in real life being considered for capital structure tests to have such a large market to book ratio. The reasoning behind this is that these firms have had such a great shock to S that the options are so far in the the money that the negative debt capacity of the option is essentially the strike price and the firm will just treat the option like assets in place. Furthermore, since S is so large for these firms, the shock of S for these firms will make a large effect on the cross sectional distribution of the market to book and debt to book ratios, as well as on the various regressions. Such regressions will weight more highly these firms as such firms will have a larger change in the relevant variables. We will also give robustness checks in subsections for the regressions where we do not remove these firms, and also where we remove the top and bottom decile of market to book ratio.

Our simulations have the firm adjusting perfectly to the target at integral times, but not at all adjusting between periods. There are no retained earnings in our framework, so a firm will distribute any excess cash and issue debt and equity

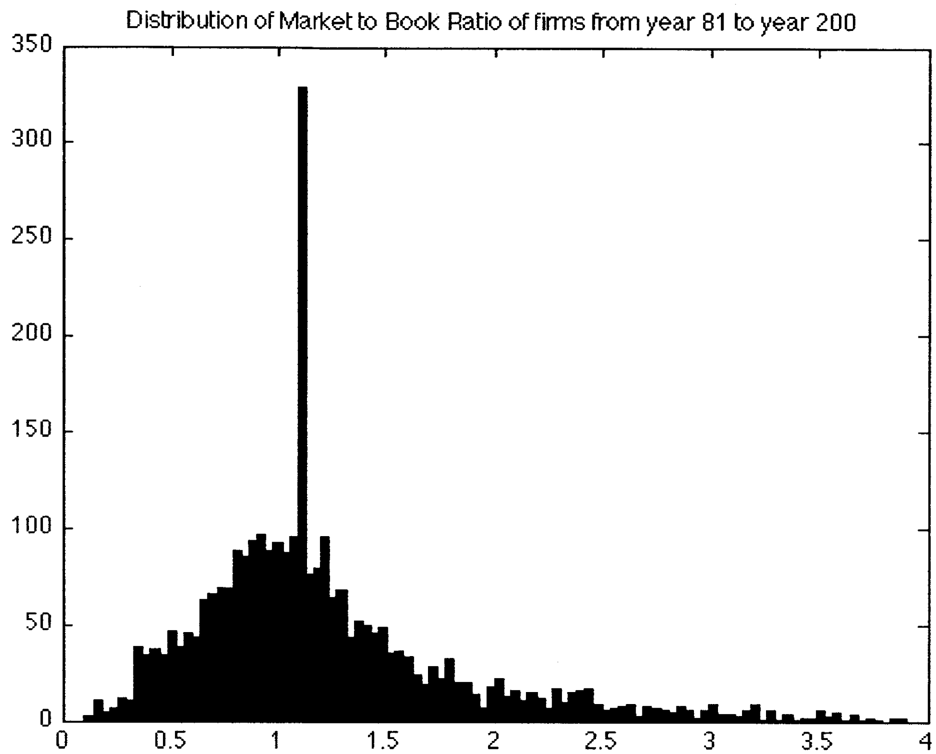

Figure 6.1: Market to book ratio for years 81 to 110

when it encounters a shortfall.

Figures 6.1 gives the distribution of the market to book ratio. The spike close to 1 occurs because all firms start identically there. The distribution is positively skewed, as the up side is unlimited, whereas the down side is limited.

Figures 6.2 gives the distribution of the debt to book ratio. The distribution is positively skewed, as when S increases, the debt tends to first increase. The spike is caused by all firms starting identically.

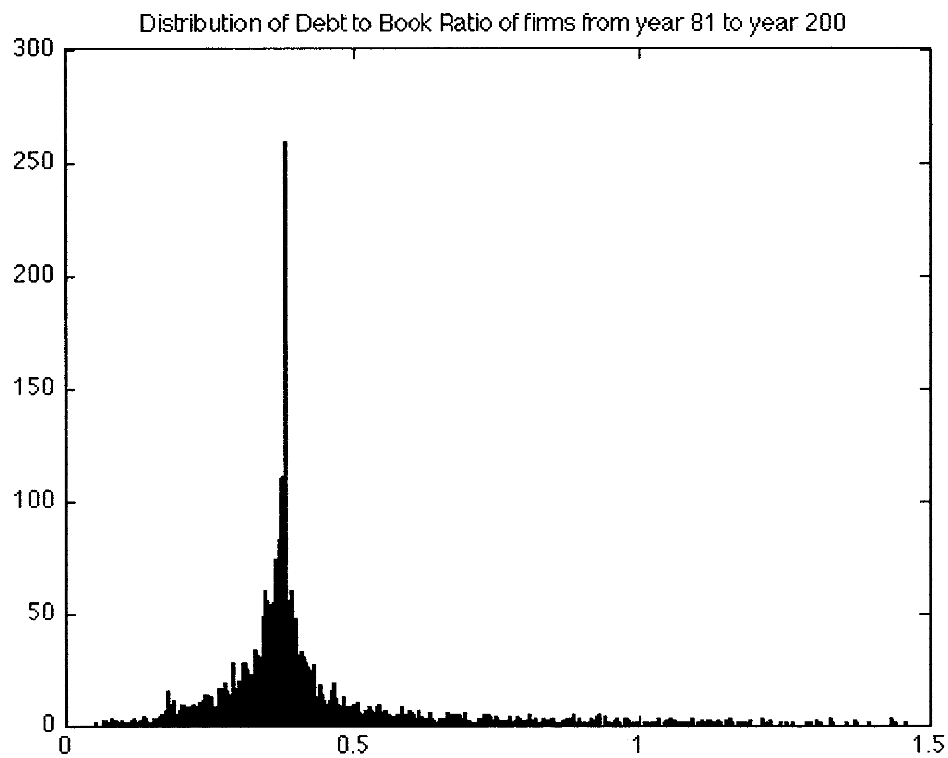

Figure 6.2: Debt to book ratio for years 81 to 110

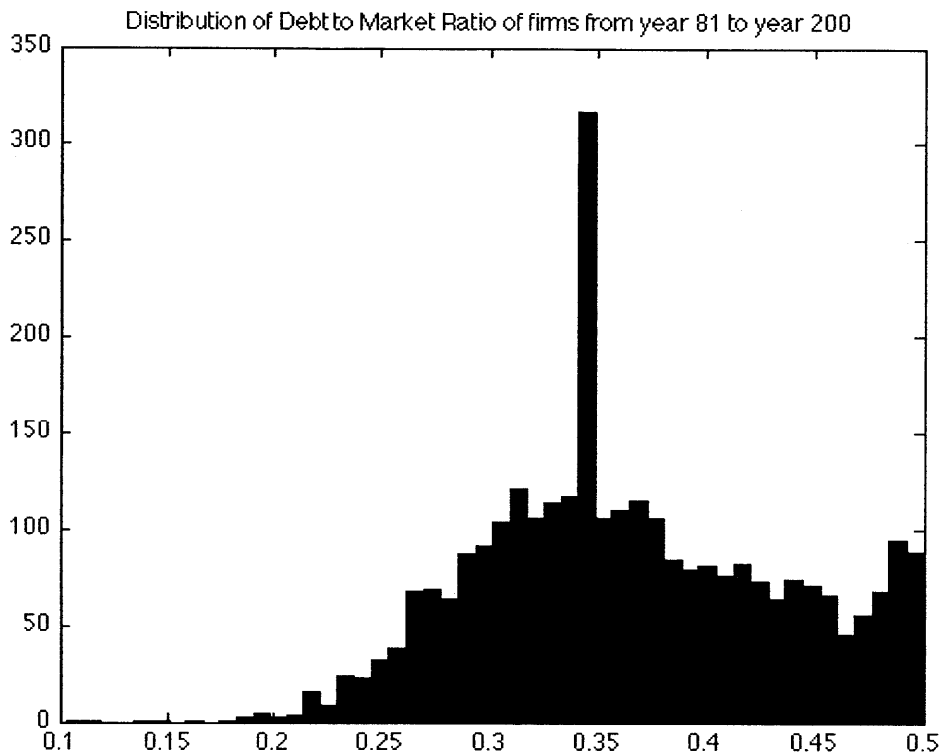

Figure 6.3: Debt to market ratio for years 81 to 110

Figure 6.3 gives the distribution of the debt to market ratio. There are two spikes. The spike around 0.5 is because firms which have done very poorly (low S) essentially lost their growth options and act like cash cows. The lower spike is because all firms start identically there. The debt to market being very low is caused by the firms which have done well enough to have a substantial synthetic debt from the growth options.

Table 6.1 gives the various summary statistics of these distributions.

	Market to Book	Debt to Book	Debt to Market
mean	1.2239	0.4191	0.3650
median	1.0948	0.3773	0.3538
std. dev.	0.6333	0.1914	0.0694

Table 6.1: Summary statistics of the distributions of market to book ratio, debt to book ratio, and debt to market ratio for the years 81-110.

	Market to Book	Debt to Book	Debt to Market
mean	1.1530	0.4020	0.3738
median	1.0625	0.3702	0.3661
std. dev.	0.6388	0.1991	0.0751

Table 6.2: Summary statistics of the distributions of market to book ratio, debt to book ratio, and debt to market ratio for the years 171-110.

As for the stability of the distribution, we calculate the distributions for both the sample years 171-200 (see Figure 6.4 - 6.6 and Table 6.2) and for the entire sample 81-200 (see Figure 6.7 - 6.9 and Table 6.3). The distributions are similar.

	Market to Book	Debt to Book	Debt to Market
mean	1.1925	0.4123	0.3693
median	1.0948	0.3754	0.3581
std. dev.	0.6402	0.1997	0.0727

Table 6.3: Summary statistics of the distributions of market to book ratio, debt to book ratio, and debt to market ratio for the years 81-200.

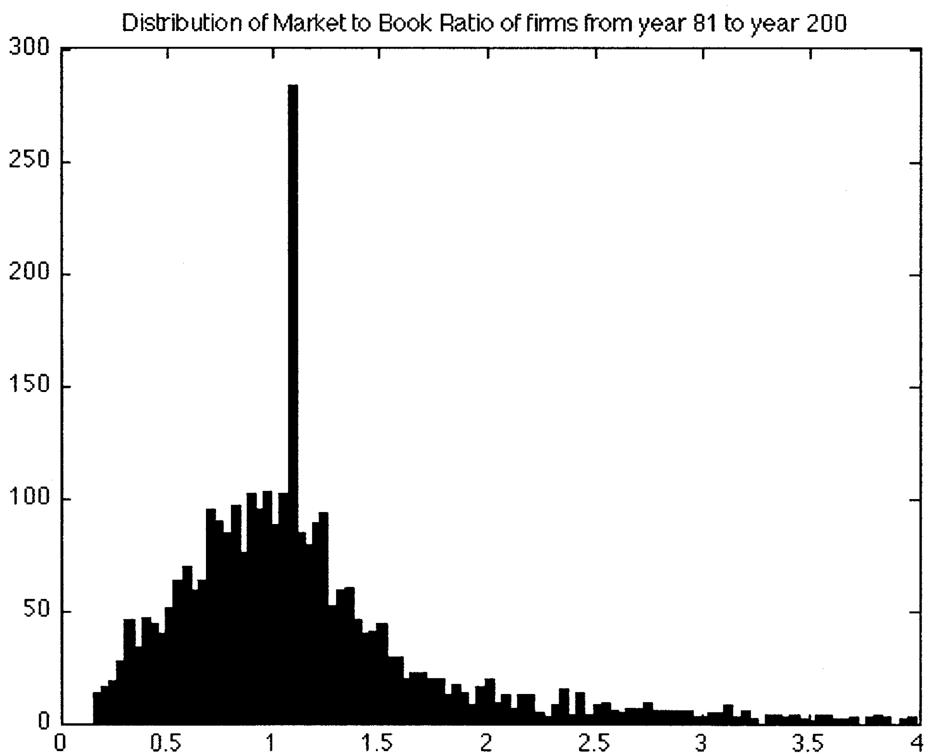

Figure 6.4: Market to book ratio for the period 171-200

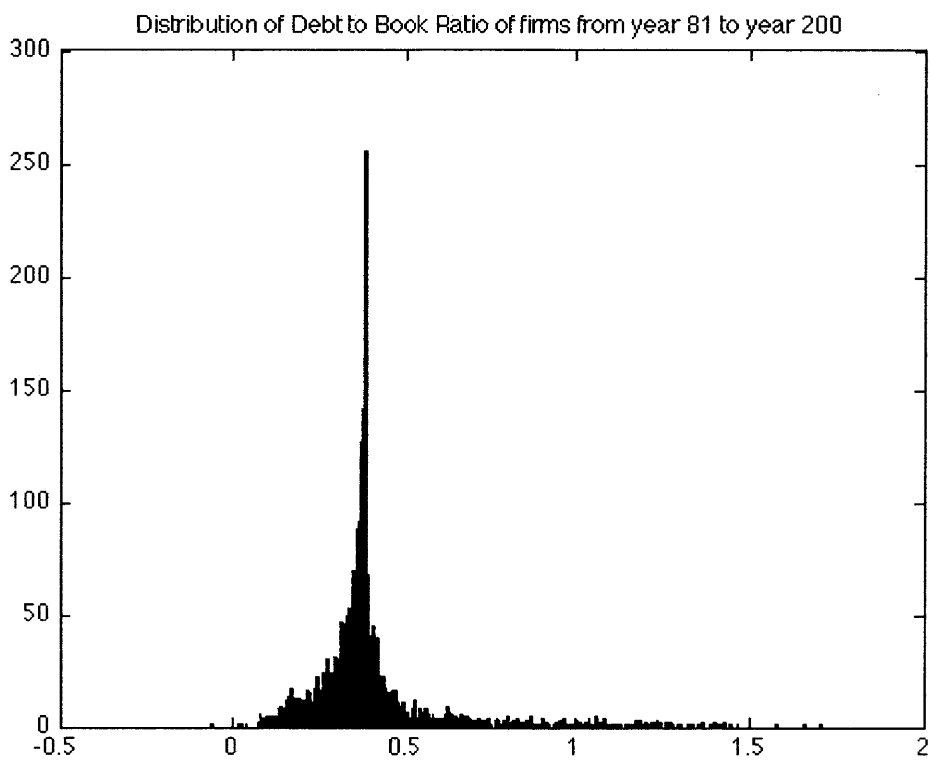

Figure 6.5: Debt to book ratio for the period 171-200

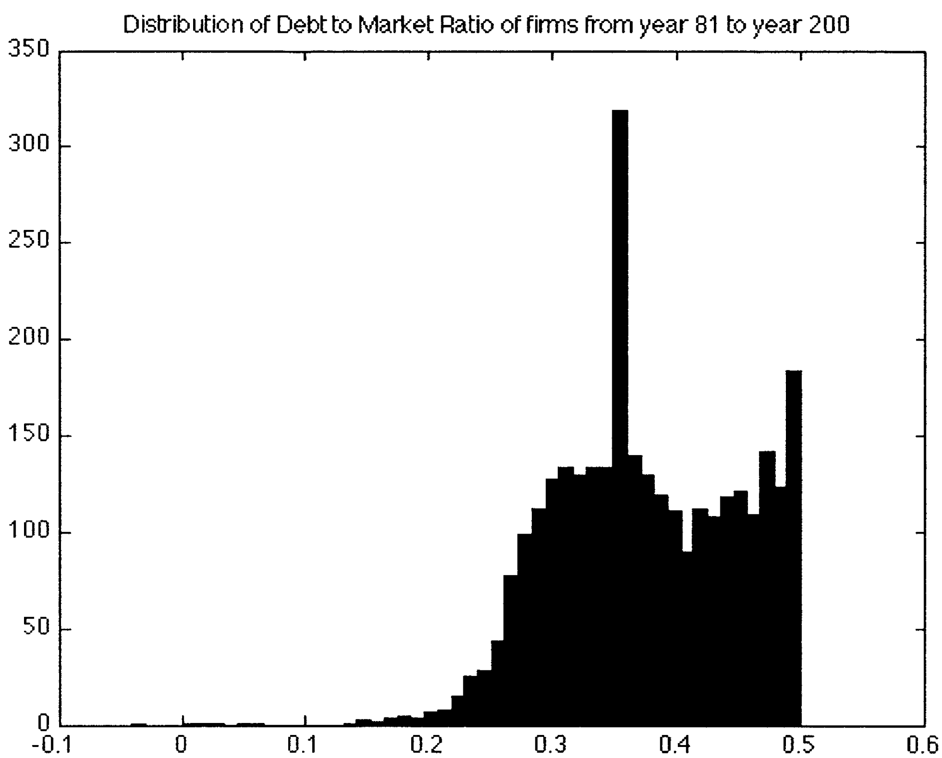

Figure 6.6: Debt to market ratio for the period 171-200

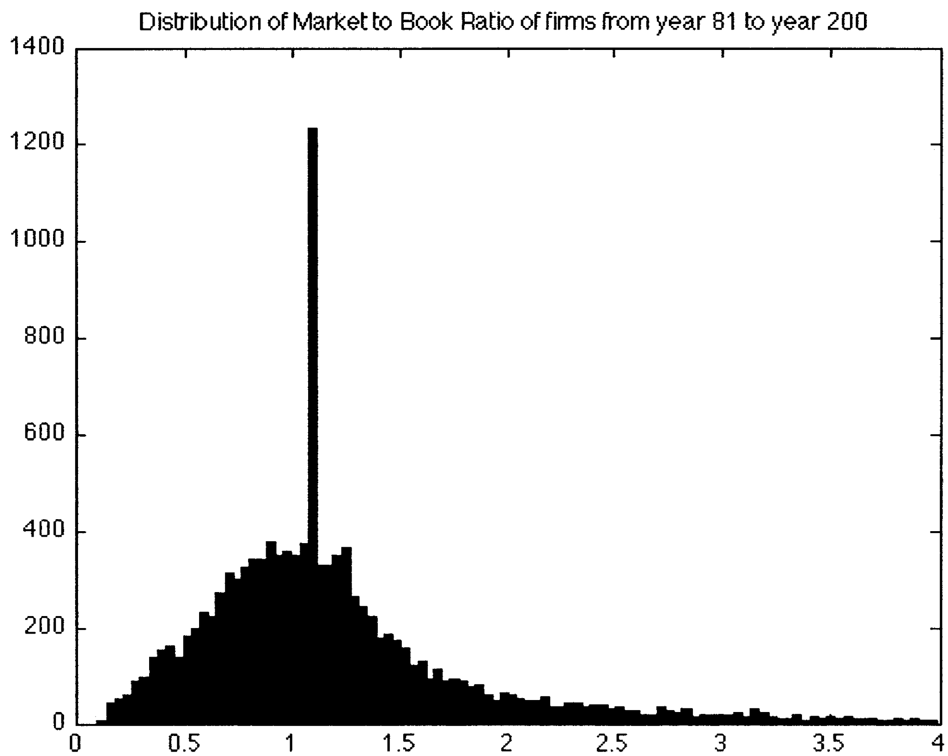

Figure 6.7: Market to book ratio for the period 81-200

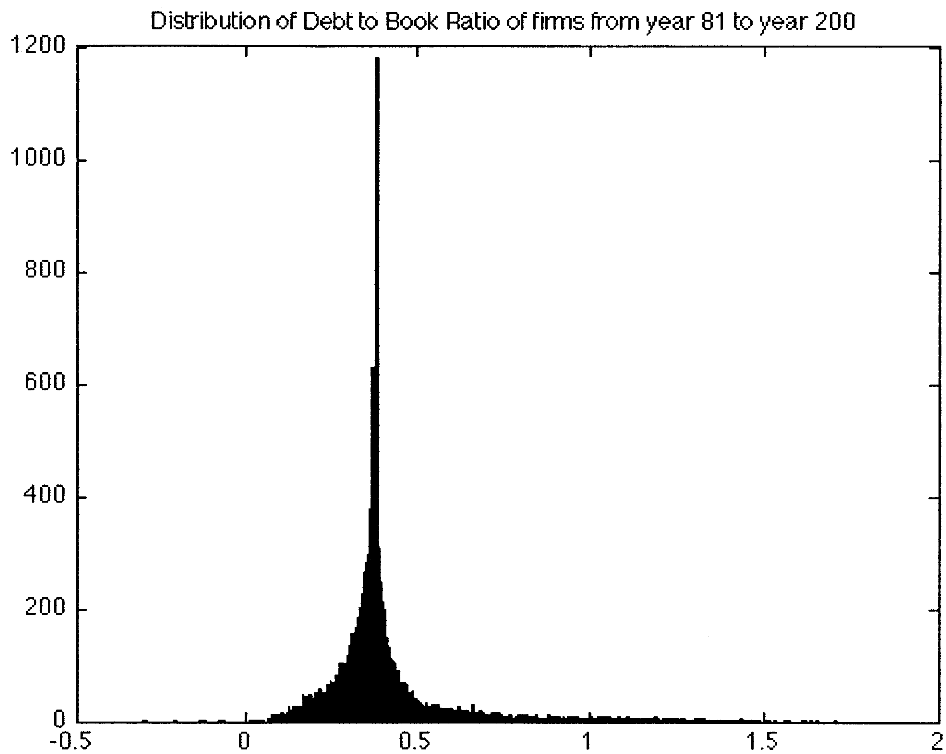

Figure 6.8: Debt to book ratio for the period 81-200

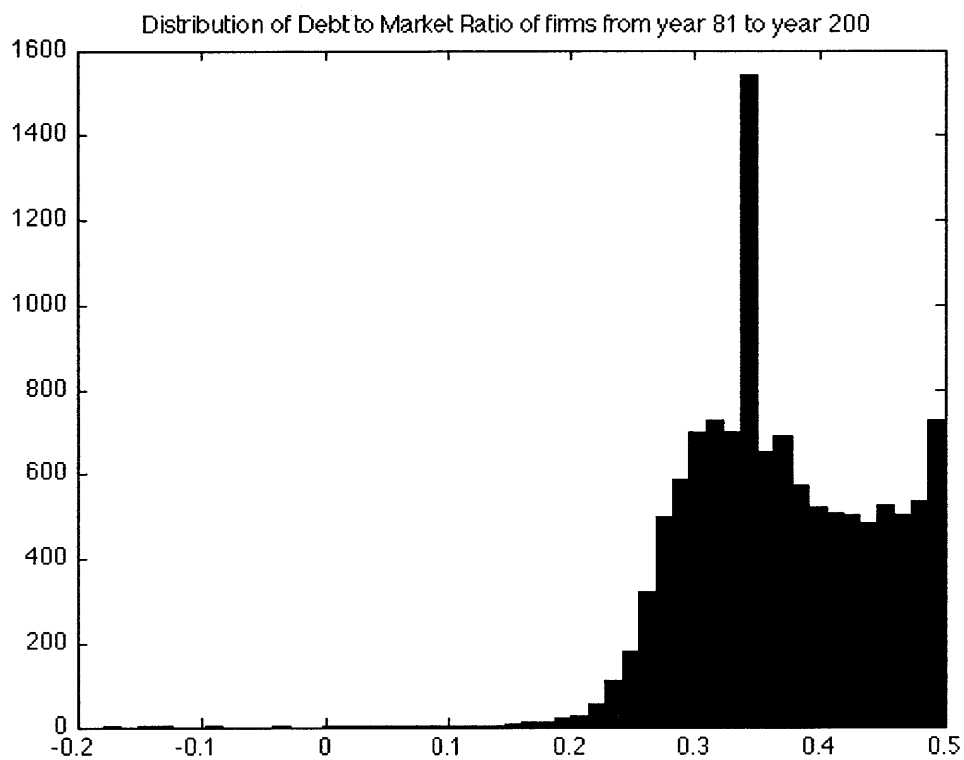

Figure 6.9: Debt to market ratio for the period 81-200

6.1 How different variables depend on the aggregate shocks

To check the robustness of our distributions, we add a market factor into the market price of a firm's asset, as in Equation 6.2 . σ_I, σ_A denote the idiosyncratic and aggregate volatility, respectively. Z_t^i is the Brownian motion specific to firm i. Z_t^A is the aggregate Brownian motion.

$$\frac{dS_i(t)}{S_i(t)} = -\frac{1}{2}(\sigma_I^2 + \sigma_A^2) + \sigma dZ_t^i + \sigma dZ_t^A. \tag{6.2}$$

We again use $N = 100$ firms. We choose $\sigma_I = .15, \sigma_A = .1$ so that $\sigma_{total} = (\sigma_I^2 + \beta^2\sigma_A^2)^{\frac{1}{2}} \approx .18$. The other parameters remain the same ($A = 0.9, \lambda = 0.5, p_leave = .07$).

We ran the sample for not only 200 years, but rather 4000 years, and looked at the last 3920 years. We took the cross-sectional means and standard deviations of market to book, debt to market, and debt to book on year t versus the aggregate shock $Z_t^A - Z_{t-1}^A$ and a constant term. The coefficients were insignificant or marginally significant. The results for the means and standard deviations are summarized in Tables 6.4 and 6.5, respectively. There are two competing effects. The first is that the market value increases and the debt should decrease because of the negative debt capacity of the option. The second is that the book value increases as more firms are above the 1.10 threshold to exercise their option.

Thus the presence of an aggregate market factor should not affect our results.

	coefficient	std dev	T statistic
Market to Book	-0.0898	0.0353	2.54
Debt to Market	0.00756	0.0030	2.52
Debt to Book	-0.0261	0.0104	-2.5

Table 6.4: Regressions of means of distributions on aggregate shock

	coefficient	std dev	T statistic
Market to Book	-0.0407	0.0145	-2.8069
Debt to Market	0.00043	0.0010	0.43
Debt to Book	-0.0142	0.0059	2.4068

Table 6.5: Regressions of standard deviations of distributions on aggregate shock

6.2 Constant Volatility of equity, and volatility for simulations

Notice that $Equity = (1 - \lambda)(K(t) + SynK(t)$, and so equity is an asset in place leveraged to the same amount each instant. Thus, the volatility of equity returns constant and given by $\frac{\sigma}{1-\lambda}$. We see what the volatility of the firm returns in our simulations discrete time approximations is, and on what variables its departure from constancy depends. We used logarithmic returns, and got $.2942$ for the volatility of equity returns and 0.1207 for the mean return. Tracking the mean and volatility of equity returns based on market to book, debt to market, and debt to book ratios yields no significant variation. Hence, the discrete time approximation used in our simulations should not affect the results.

This generates the prediction that firms with the same volatility of assets in place should have the same volatility of stock returns. One could consider earnings to book as a proxy for the return of assets in place, compute its volatility for many firms, then see if firms with similar earnings volatility indeed do have similar stock return volatility. This is an area for future research.

6.3 Effect of Time on Firm Characteristics

We should expect the distribution of firm characteristics to depend on their age. Older firms should have exercised more of their growth options, and have more dispersed size based on how well they have done. We take the distributions for years 2-200 of firm book value, debt level, and market value. See Figures 6.10 - 6.12. Since we are only looking at time series properties, using the earlier years only gives us more sample points, and does not bias the results. Firms tend to exercise more options to get more assets. Thus, book value, debt, and firm value tend to increase with age. Also, since S_i disperses with time, the variation in these variables should also increase with firm age.

In Figures 6.13 - 6.15, we present the means and standard deviations of market to book, debt to book, and debt to market of firms of a given age plotted against their age. The means and standard deviations are taken over firm years from years 2-200, where the firm is the particular age in question. As some firms do very well and market value of assets tends to increase, the debt level of these assets will also tend to increase. The book value does not take the increase in $S_i(t)$ into account, the market to book ratio increases with firm age. Similarly, the market to book ratio tends to increase with firm age. The debt to market ratio will increase, as when a firm exercises options with time, it will have more assets in place compared to its growth options. Hence, the more assets in place will

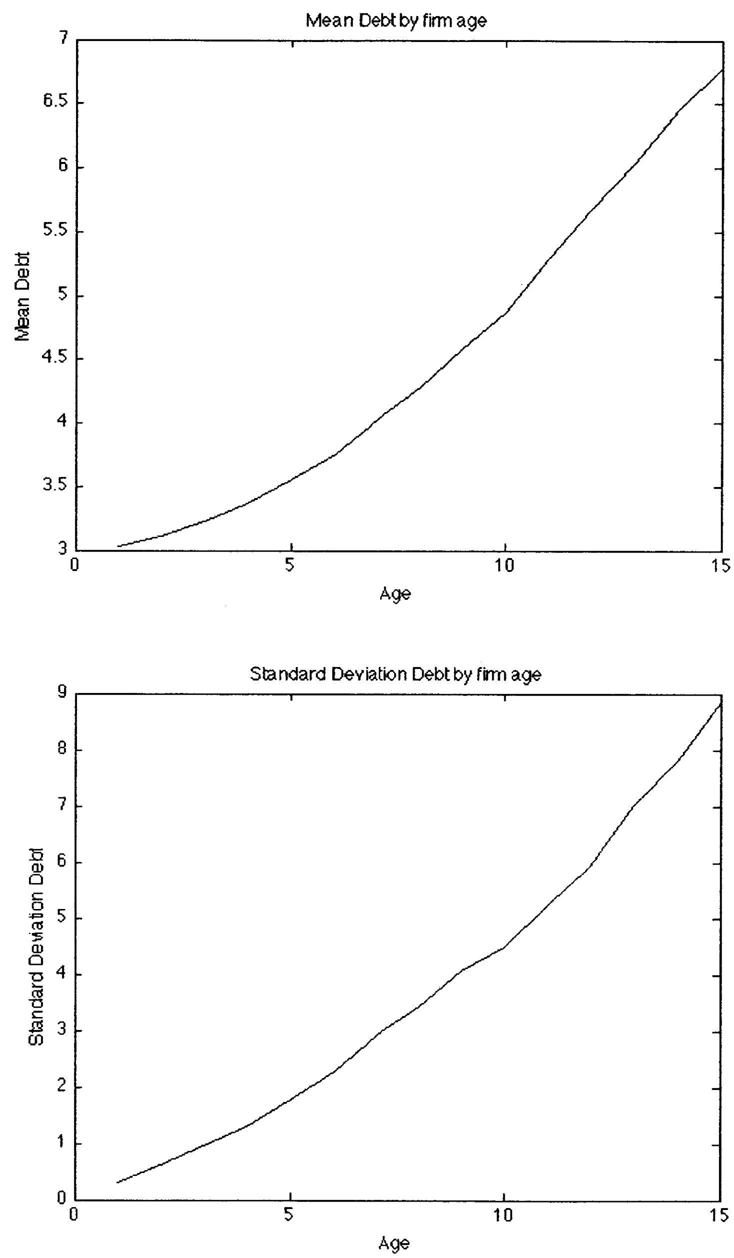

Figure 6.10: Debt mean and standard deviation vs firm age

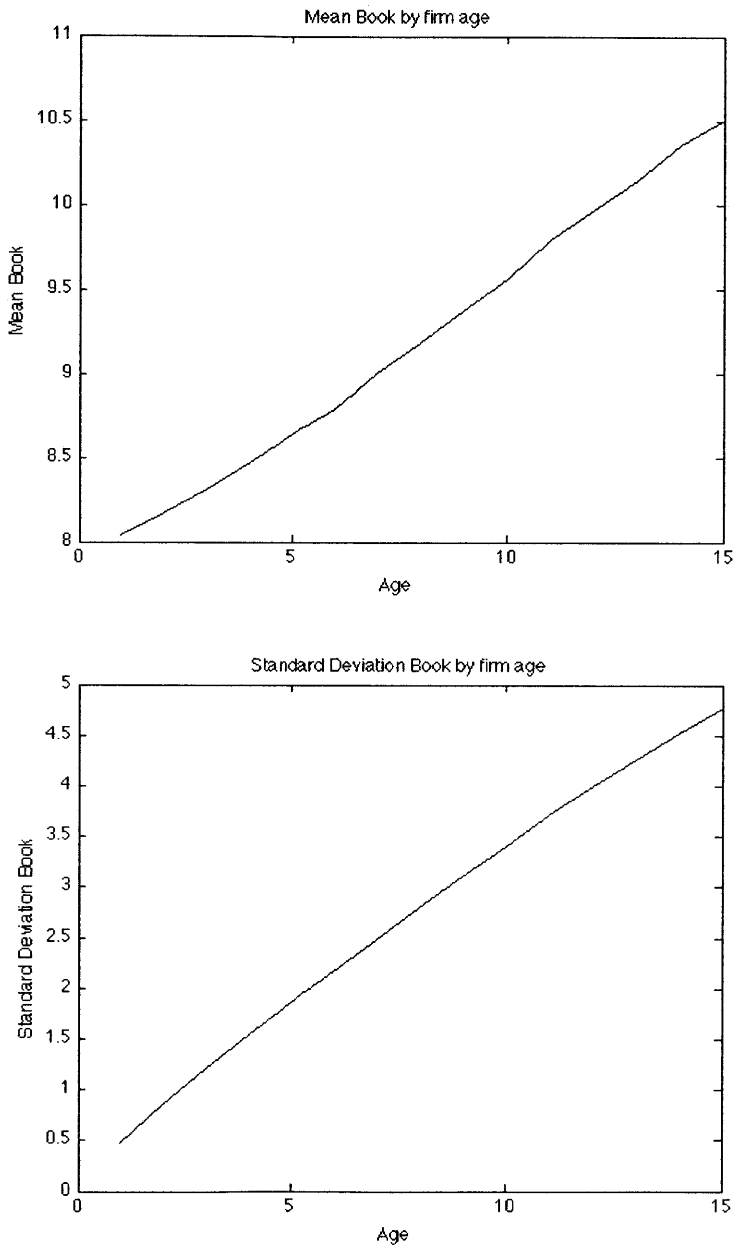

Figure 6.11: Book mean and standard deviation vs firm age

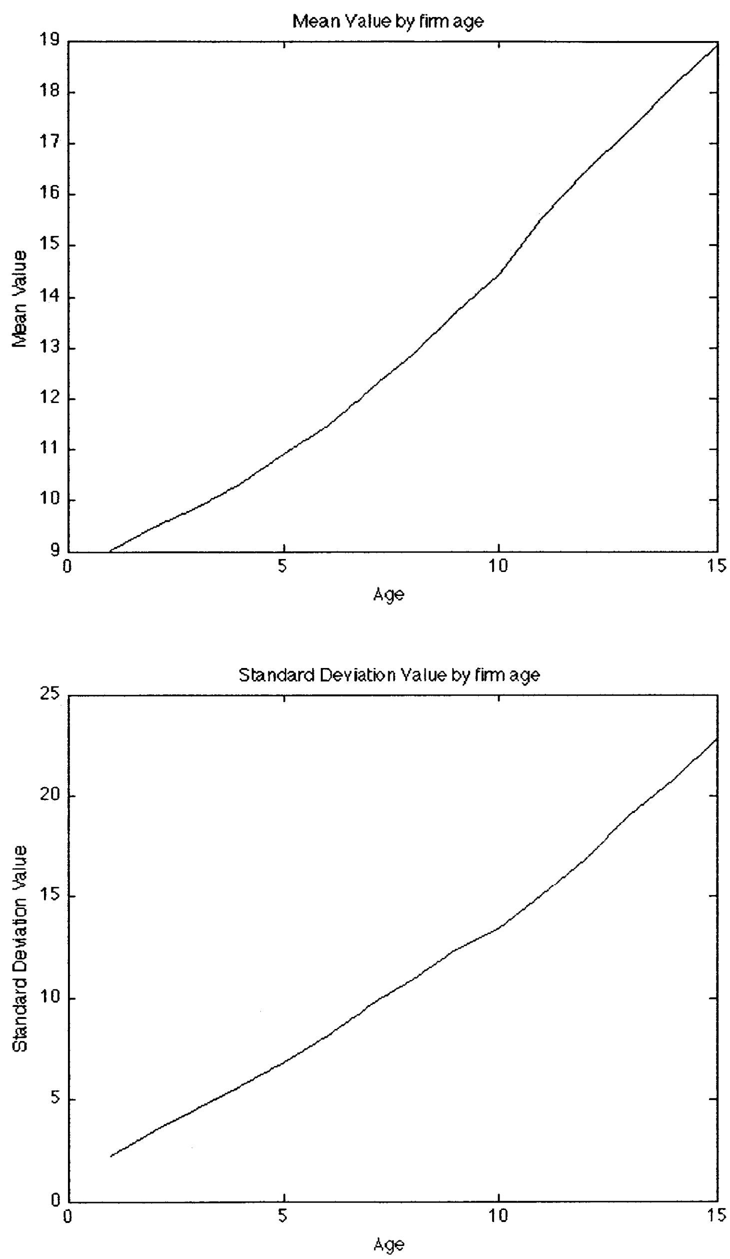

Figure 6.12: Market mean and standard deviation vs firm age

yield a higher debt compared to market value. Again, since $S_i(t)$ becomes more dispersed with time, all of these variables will tend to be more dispersed as well.

6.4 Alternate Ways to Remove Firms from Sample

In this section, we consider two alternative methods to remove firms from the sample: remove the upper and lower decile of firms according to their market to book ratio, and remove no firms from the sample. We present the distributions and summary statistics to set up for the regressions on these datasets in sections 7.1.1, 7.2.1, and 7.4.1.

We remove the upper and lower deciles of firm years according to their market to book ratio. See Figures 6.16, 6.17, 6.18 and Table 6.6. The mean market to book decreases, as we remove more firms that have done well and have a high market to book. The firms with low market to book, which we also remove, do not sufficiently counterbalance this effect, as the market to book of the good firms which we additionally remove is above double the mean market to book, whereas the market to book of the poorly performing firms is bounded below by zero. The mean debt to book ratio decreases, as firm with very low S(t), and thus low debt and high book value, as book value is a historical measure, are removed from the sample. The mean debt to market decreases, as poorly performing firms with low $S(t)$ that have high debt to market closer to $\lambda = .5$ are removed from the sample. The standard deviations of all variables decrease, as we remove more extreme points.

We also consider the uncut distribution. See Figures 6.19, 6.20, 6.21 and Table

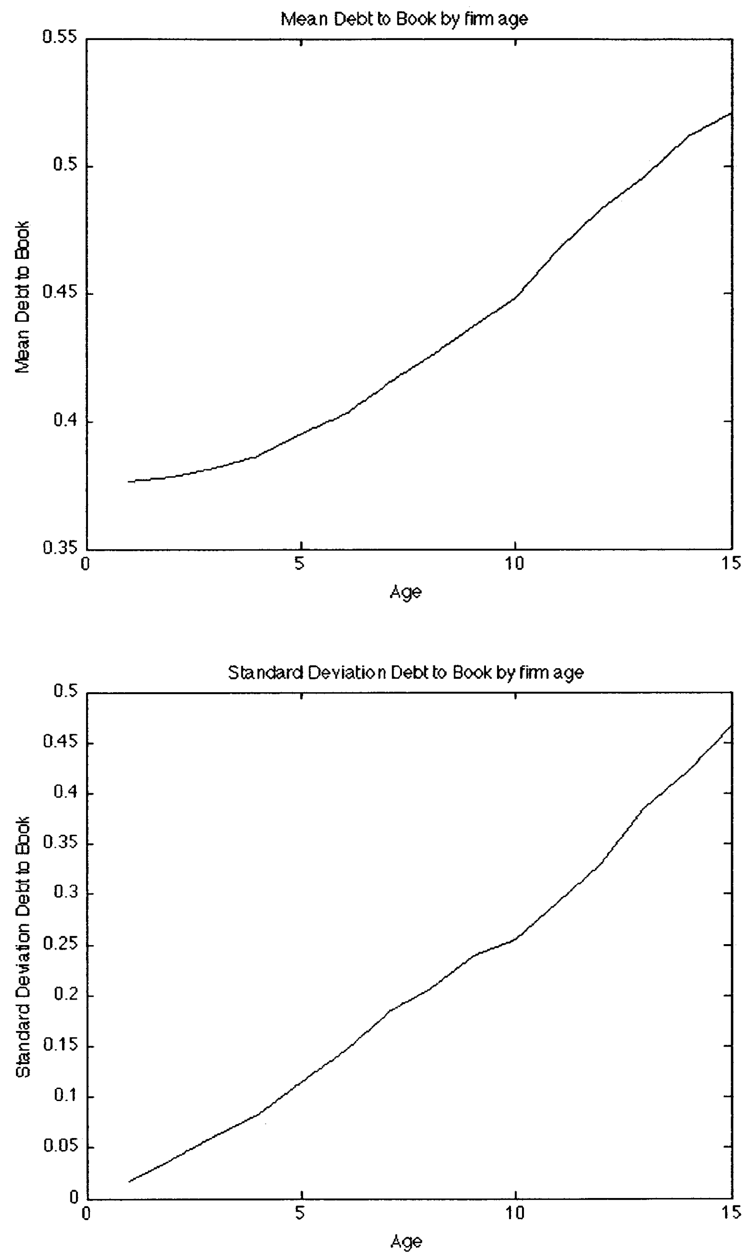

Figure 6.13: Debt to book mean and standard deviation vs firm age

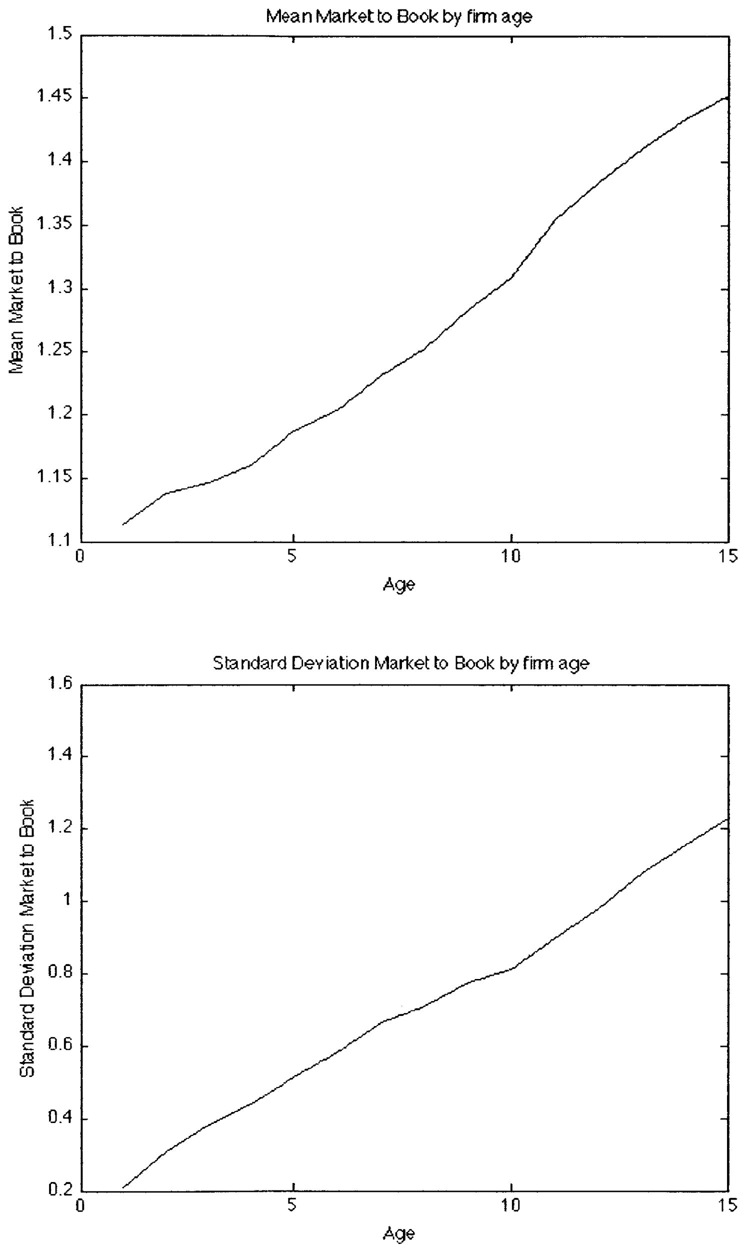

Figure 6.14: Market to book mean and standard deviation vs firm age

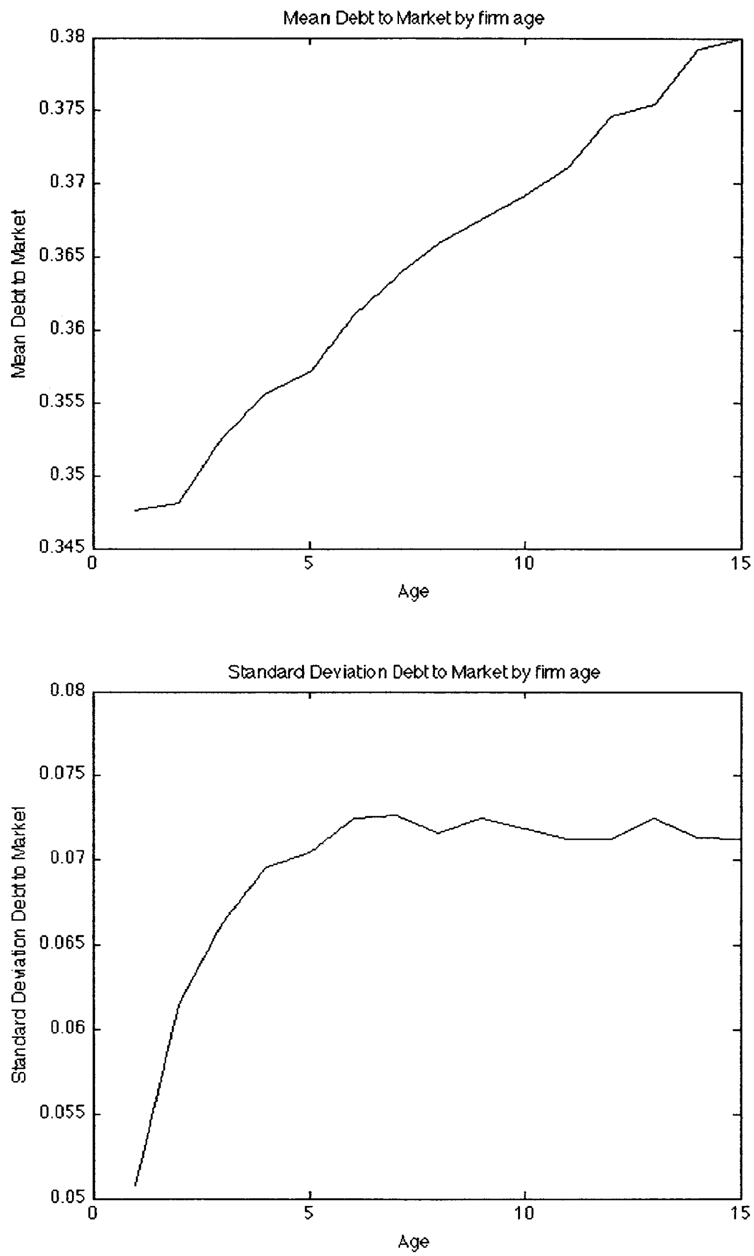

Figure 6.15: Debt to market mean and standard deviation vs firm age

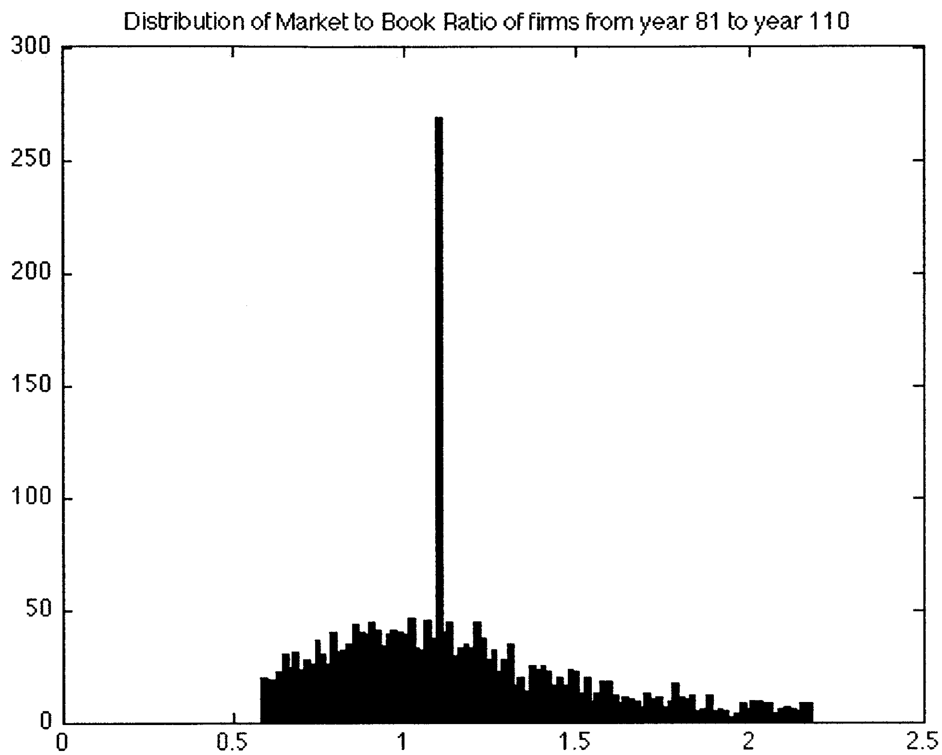

Figure 6.16: Removing upper and lower decile, market to book ratio for years 81 to 110

	Market to Book	Debt to Book	Debt to Market
mean	1.1548	0.3921	0.3542
median	1.0948	0.3775	0.3481
std. dev.	0.3553	0.0809	0.0605

Table 6.6: Removing upper and lower decile of market to book, summary statistics of the distributions of market to book ratio, debt to book ratio, and debt to market ratio for the years 81-110.

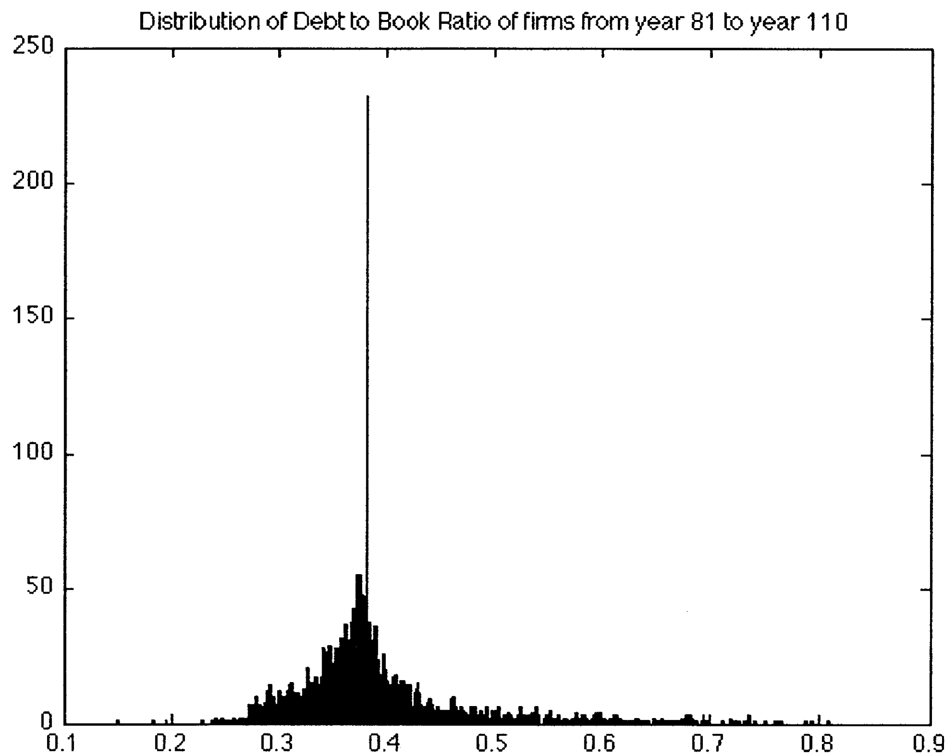

Figure 6.17: Removing upper and lower decile of market to book, debt to book ratio for years 81 to 110

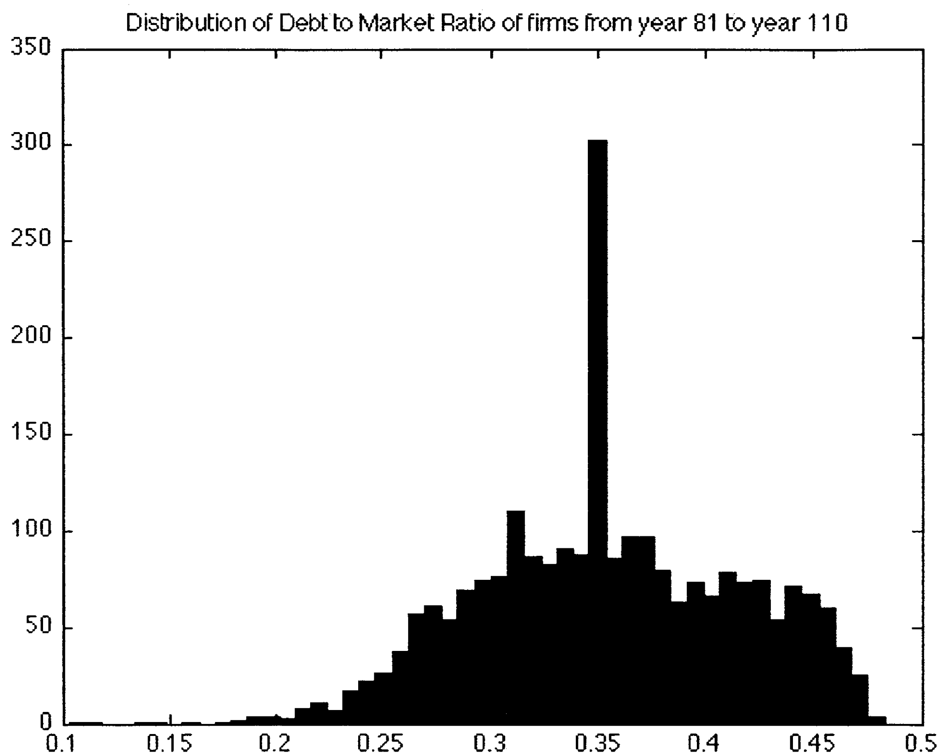

Figure 6.18: Removing upper and lower decile, debt to market ratio for years 81 to 110

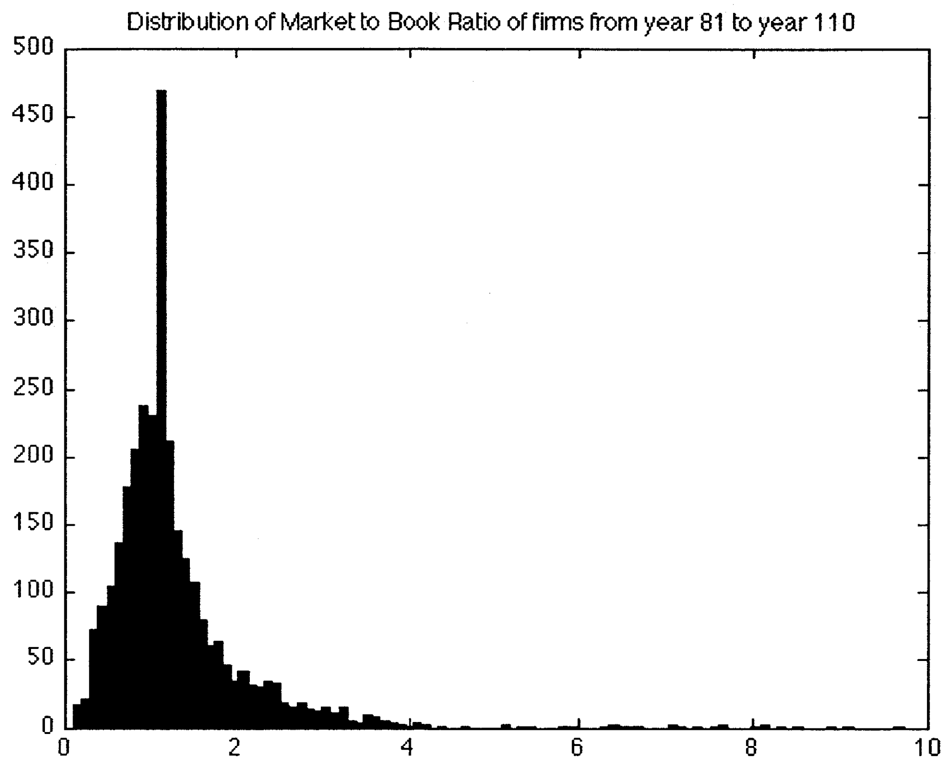

Figure 6.19: Market to book ratio for years 81 to 110 for entire distribution

6.7. The debt to book ratio gets above 4. The market to book surpasses 9 for some firms. The mean market to book ratio increases, as more firms with extremely high market to book are included. The debt to book ratio decreases somewhat as very successful firms have more much more debt, but not a commensurate increase with book value. The debt to market ratio increases slightly. The standard deviations of the market to book and debt to book ratios increase by at least 30%.

The points with extremely high market to book ratios have had extremely good

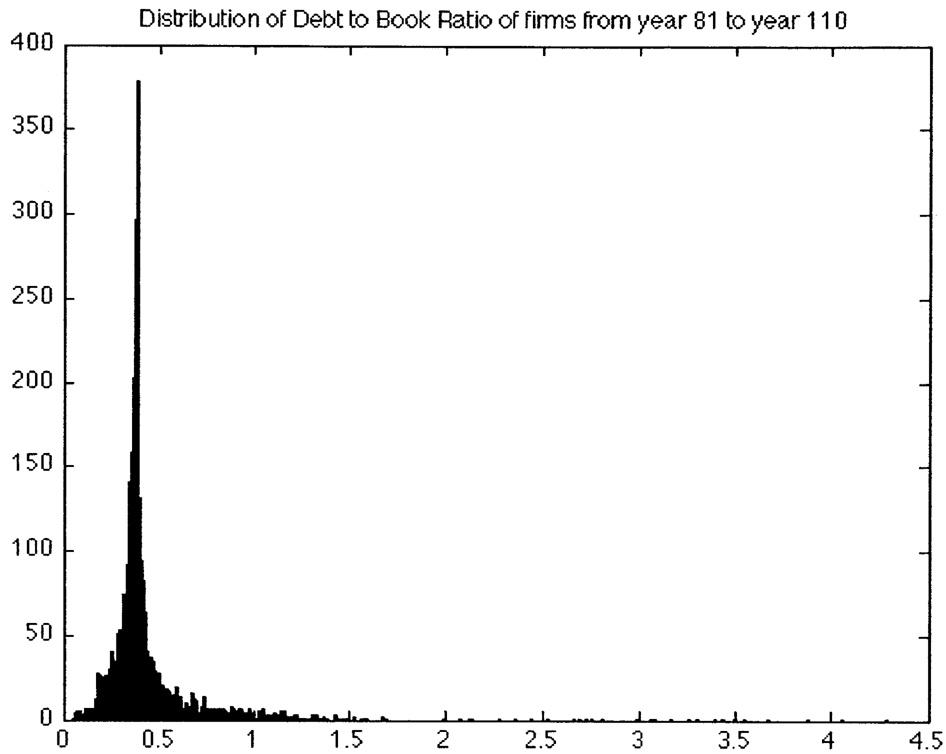

Figure 6.20: Debt to book ratio for years 81 to 110 for entire distribution

	Market to Book	Debt to Book	Debt to Market
mean	1.2860	0.4458	0.3655
median	1.0948	0.3775	0.3550
std. dev.	0.8640	0.3207	0.0692

Table 6.7: Summary statistics of the distributions of market to book ratio, debt to book ratio, and debt to market ratio for the years 81-110 for entire distribution

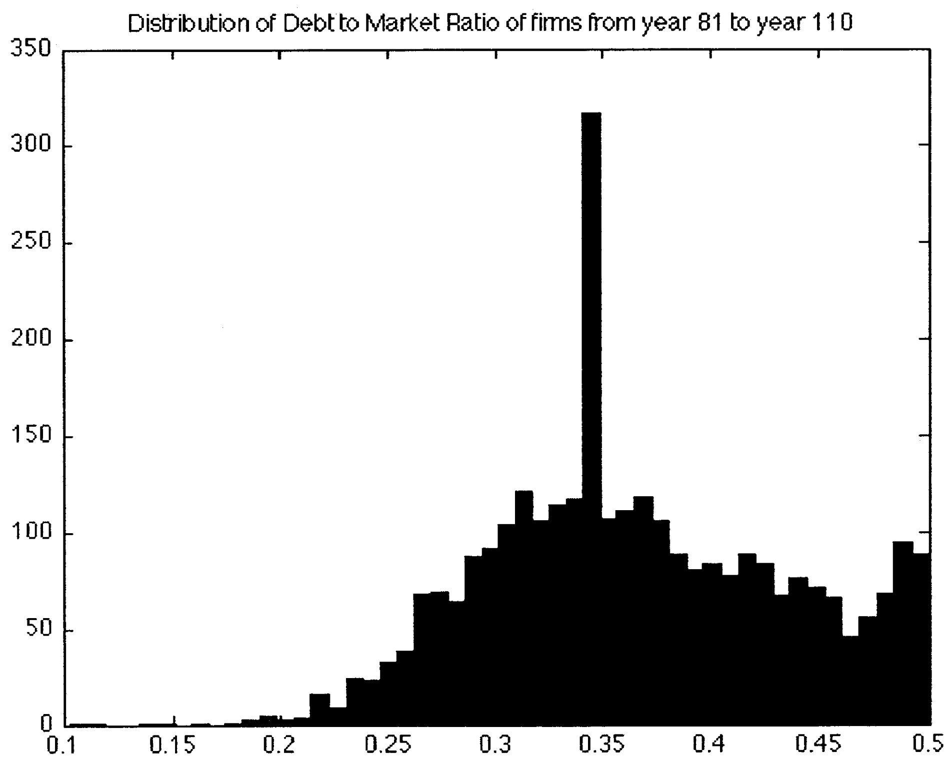

Figure 6.21: Debt to market ratio for years 81 to 110 for entire distribution

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
$D^* - D_{t-1}$	.1126152	.0106321	10.59
constant	.01321	.0016655	7.93

Table 7.1: Target adjustment regression from Shyam-Sunder and Myers (1999) for the years 81-110.

shocks. Thus, the relevant variables are high. The nonlinearity means that firms which do extremely poorly do not make up for this effect when computing means. Hence, removing the upper and lower deciles of market to book decreases the means of the relevant variables as well as their standard deviation. Removing no points increases the means as well as the standard deviations of the relevant variables.

7 Results of Regressions

7.1 Shyam-Sunder and Myers (1999)

First, we perform the regressions in Shyam-Sunder and Myers (1999). We exclude a firm from our regression if it has a market to book ratio above 4 for any time in our sample. The mean D^* is taken firm by firm. The results of the target adjustment model are presented in Table 7.1. We get a significant target adjustment of 11% per year.

The results of the pecking order regression are presented in Table 7.2. The coefficient on DEF_t is significantly negative, so a pecking order theory would be

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
Def	-.2185475	.0280261	-7.80
constant	-.0062895	.0031921	-1.97

Table 7.2: Pecking order regression from Shyam-Sunder and Myers (1999) for the years 81-110.

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
$D^* - D_{t-1}$	.0837563	.0130299	6.43
constant	.0147779	.0018009	8.21

Table 7.3: Upper and lower decile removed, target adjustment regression from Shyam-Sunder and Myers (1999) for the years 81-110.

rejected. The reasoning is that if the firm has a lower deficit, it is more profitable. Hence, it has a higher $S(t)$. So the assets in place are more valuable. Hence, the manager will issue more debt against these assets, as the firm's manager follows a tradeoff theory.

7.1.1 Alternative Firm Removal Techniques

We first remove the firms with at least one point in the sample period in the upper decile or lower decile of the market to book ratio.

The results of the target adjustment model are given in 7.3. The speed of adjustment decreases, although it remains significant.

The results of the pecking order model are given in Table 7.4. The pecking order model is soundly rejected.

We also consider removing no points from the sample.

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
Def	-.2655904	.0345906	-7.68
constant	-.0095417	.0037955	-2.51

Table 7.4: Upper and lower decile removed, pecking order regression from Shyam-Sunder and Myers (1999) for the years 81-110.

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
$D^* - D_{t-1}$	.0532591	.0093831	5.68
constant	.0165301	.0019815	8.34

Table 7.5: Target adjustment regression from Shyam-Sunder and Myers (1999) for the years 81-110 for entire sample

The results of the target adjustment model are given in Table 7.5. The speed of adjustment decreases, although it remains significant.

The results of the pecking order model are given in Table 7.6. The pecking order model is Soundly Rejected.

7.2 Rajan and Zingales (1995)

Next, we present the results from the Rajan and Zingales (1995) for our simulated data. We take averages of the debt to market, debt to book, market to book, and profitability for the years 81-84 for the firms which existed for all of those

Table 7.6: Pecking order regression from Shyam-Sunder and Myers (1999) for the years 81-110 for entire sample

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
Def	-.2084855	.0257865	-8.09
constant	-.0034981	.0032455	-1.08

years and had market to book at most 4 for all of those years. There are 65 firms remaining. The negative relation between market leverage and market to book from Rajan and Zingales (1995) is present (see Figures 7.1). A higher average market to book ratio means the firm has more real options, and thus a greater negative debt capacity stemming from them. Also, the negative relation between market leverage and profitability from Rajan and Zingales (1995) is present (see Figure 7.2) . A greater value of $S(t)$ increases the EBIDA, but not the book value. Hence the profitability will also increase. A greater S also means a larger negative debt capacity, and thus a lower debt to market ratio.

However, when we deal with book leverage, the relations between profitability and market to book vs book leverage go in the other direction. See Figures 7.3, and 7.4. Even though a larger market to book or profitability means more growth options, and thus a more negative debt capacity, it also means that the existing assets in place are more valuable. The increase in debt capacity from assets in place outweighs the decrease in debt capacity from the growth options.

When we run the full regression in Table 7.7 as in Rajan and Zingales (1995), we get insignificant coefficients. This can be explained by a sort of collinearity problem. Higher $S(t)$ causes both the market to book ratio and the profitability to increase.

Running the regression on the book debt ratio in Table 7.8 yields a significantly positive coefficient on market to book and an insignificant coefficient on profitability.

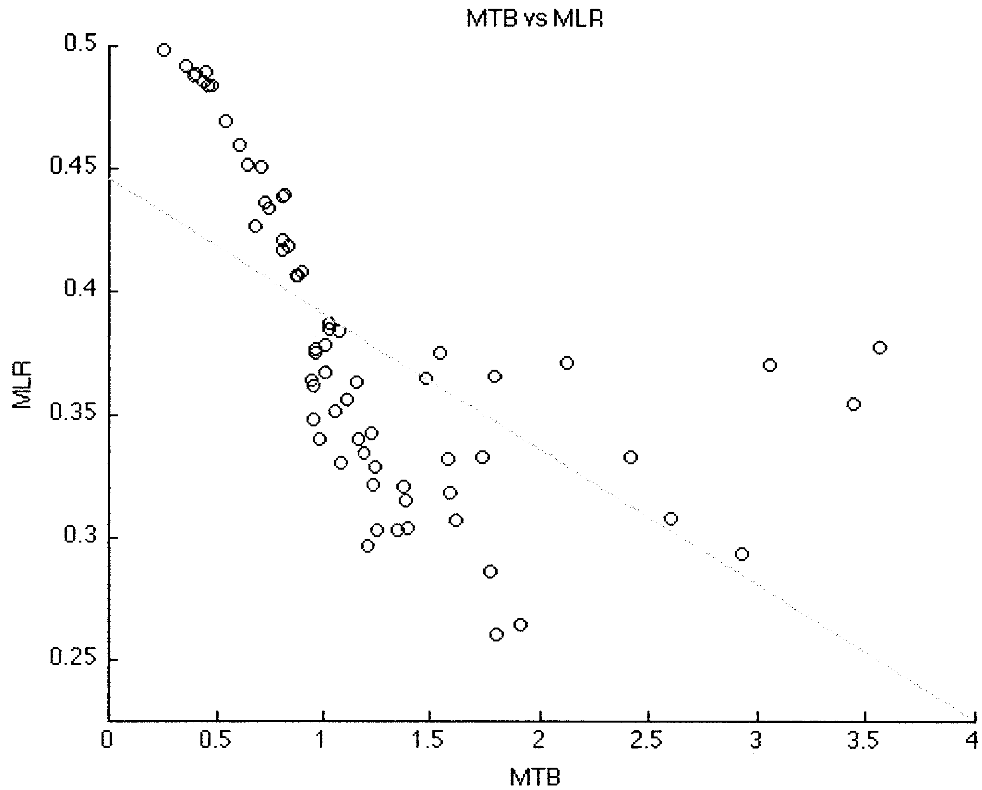

Figure 7.1: Mean market leverage ratio vs mean market to book by firm for years 81 to 84, MLR = -.0305 MTB + .4194

MLR	Coefficient	Standard Error	T Statistic
MTB	-.0375464	.0337424	-1.11
$PROF$	-.4795338	.5459744	-0.88
constant	.4716464	.0201462	23.41

Table 7.7: Leverage regressions from Rajan and Zingales (1995)

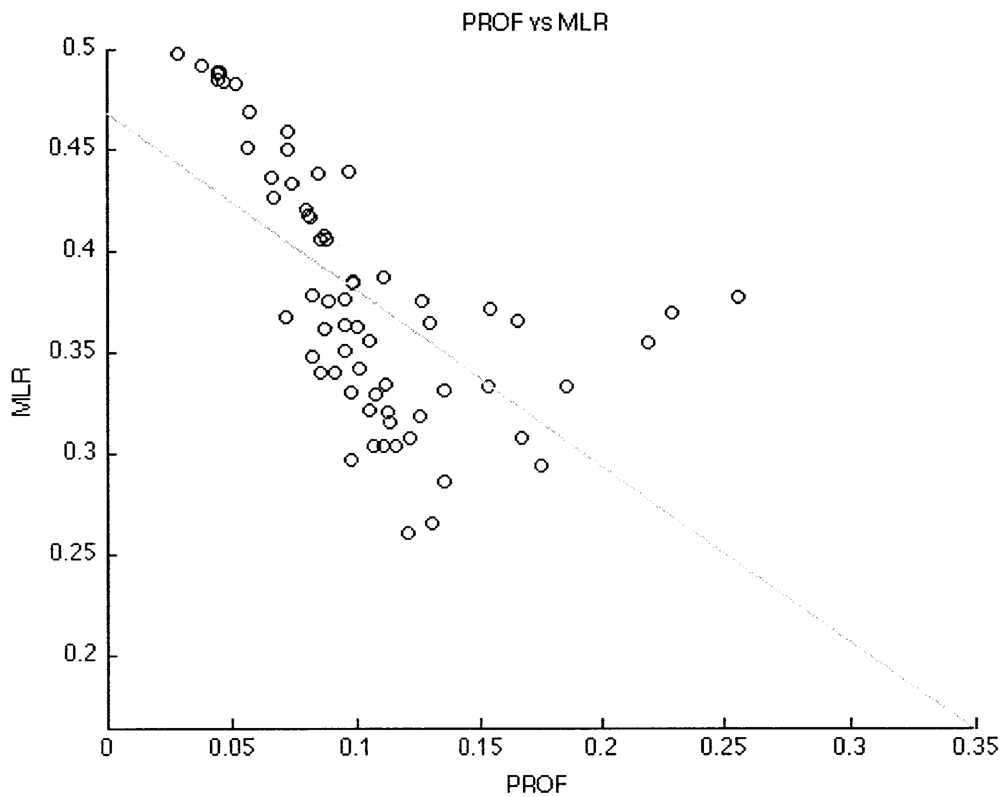

Figure 7.2: Mean market leverage ratio vs mean profitability by firm for years 81 to 84, MLR = -.4777PROF + .4294

BLR	Coefficient	Standard Error	T Statistic
MTB	.212534	.0357568	5.94
$PROF$	1.437928	.5785691	2.49
constant	.022012	.0213489	1.03

Table 7.8: Leverage Regressions from Rajan and Zingales (1995)

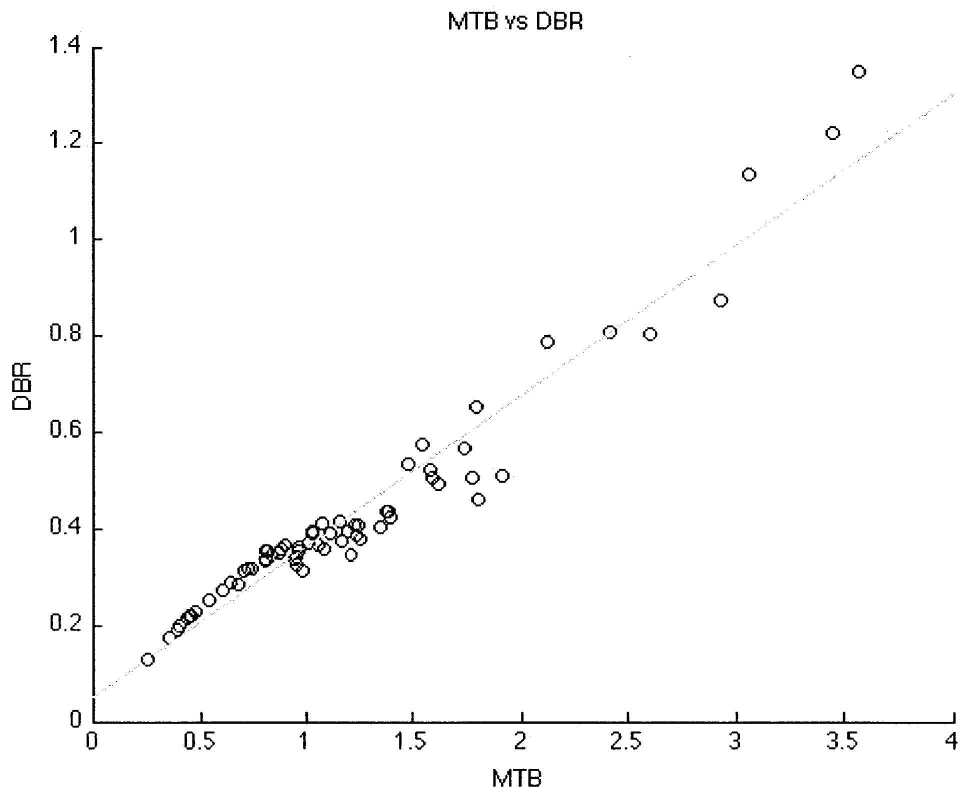

Figure 7.3: Mean book leverage ratio vs mean market to book by firm for years 81 to 84, BLR = .3464863 MTB + 0.01259

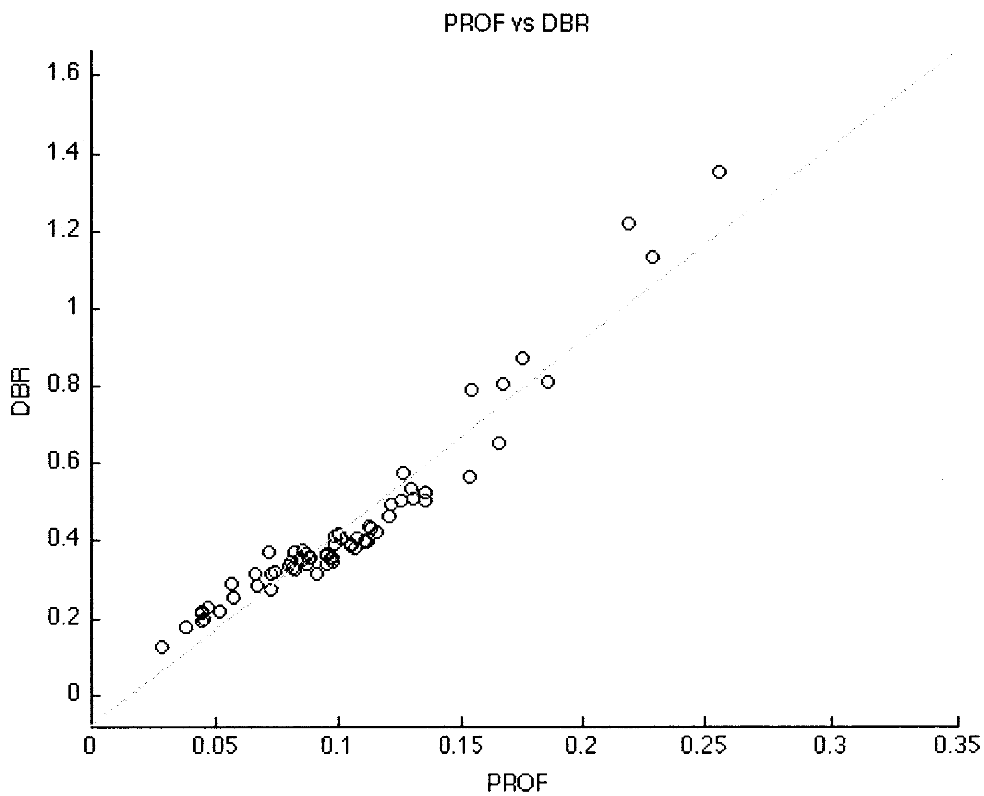

Figure 7.4: Mean book leverage ratio vs mean profitability by firm for years 81 to 84, BLR = 5.3611 PROF - 0.0938

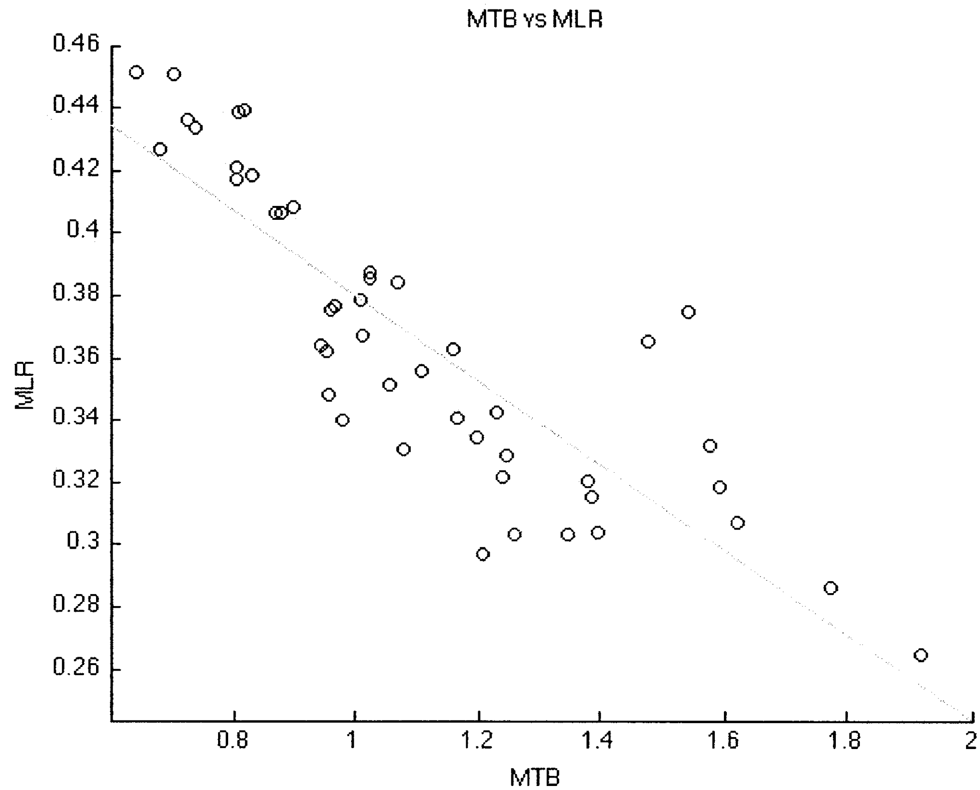

Figure 7.5: Removing upper and lower decile, mean market leverage ratio vs mean market to book by firm for years 81 to 84

7.2.1 Alternative Firm Removal Techniques

First, we remove all firms with at least one year in either the upper decile or lower decile of firm year market to book Ratios in the period 81-84. See Figures 7.5 - 7.8. All of the correlations remain in the same direction.

In Table 7.9, the coefficient on profitability becomes positive. However, the coefficient on market to book becomes significantly negative.

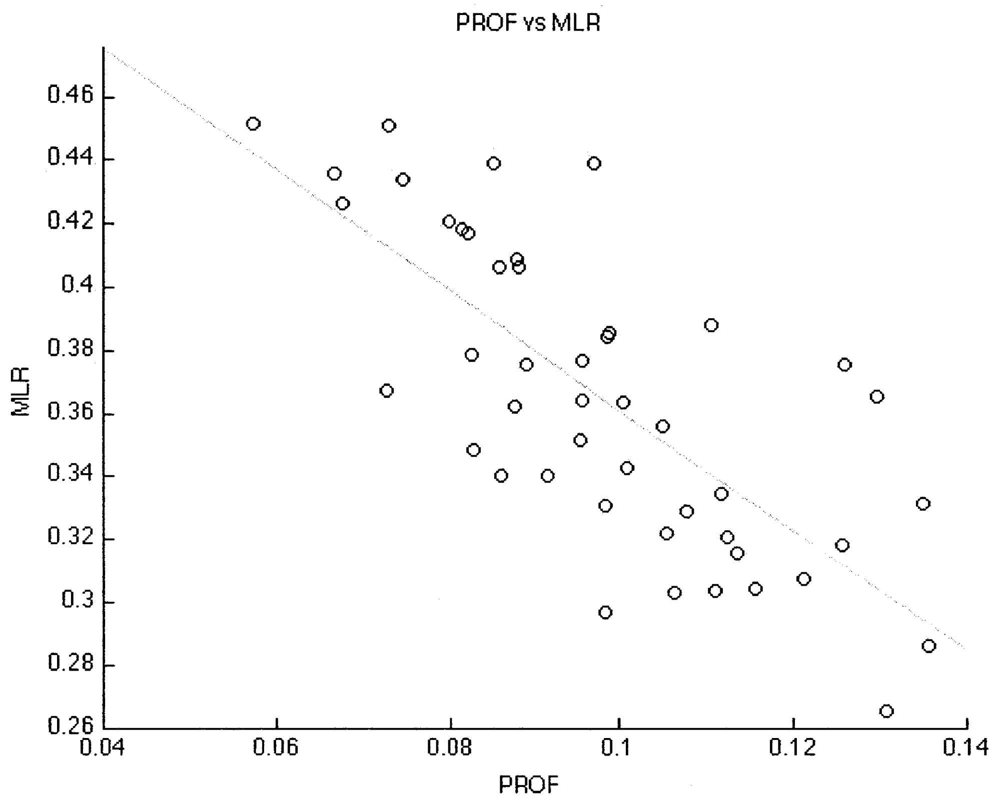

Figure 7.6: Removing upper and lower decile, mean market leverage ratio vs mean profitability by firm for years 81 to 84

MLR	Coefficient	Standard Error	T Statistic
MTB	-.177338	.0312135	-5.68
$PROF$	.7125128	.4995371	1.43
constant	.4919792	.022719	21.65

Table 7.9: Removing upper and lower decile, leverage regressions from Rajan and Zingales (1995)

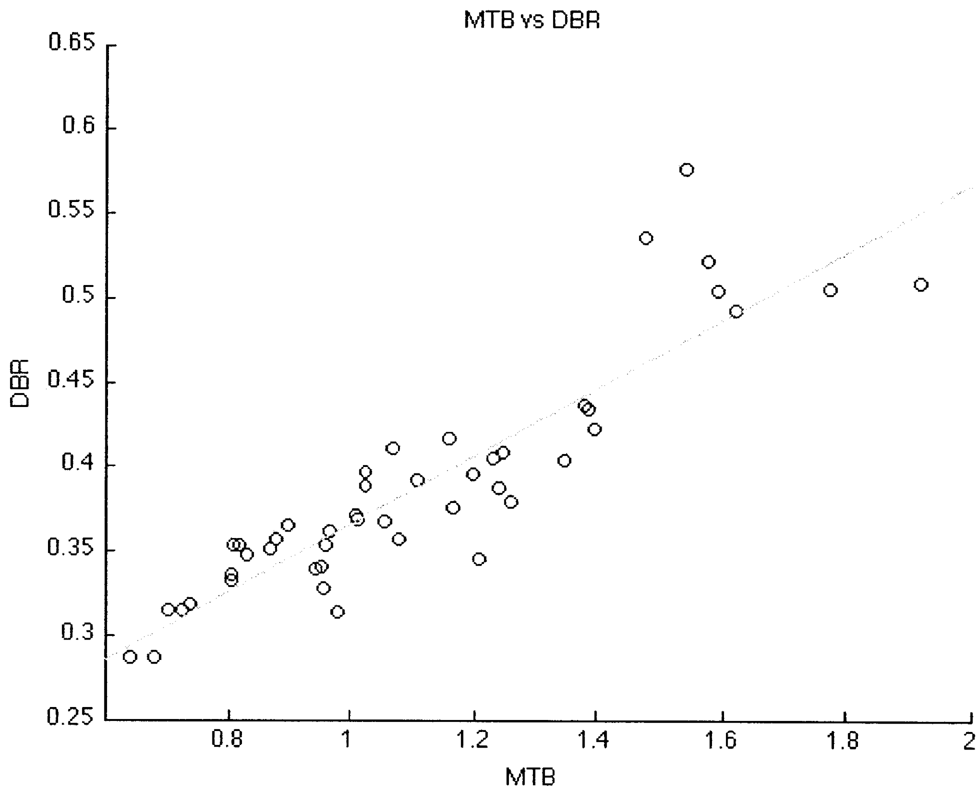

Figure 7.7: Removing upper and lower decile, mean book leverage ratio vs mean market to book by firm for years 81 to 84

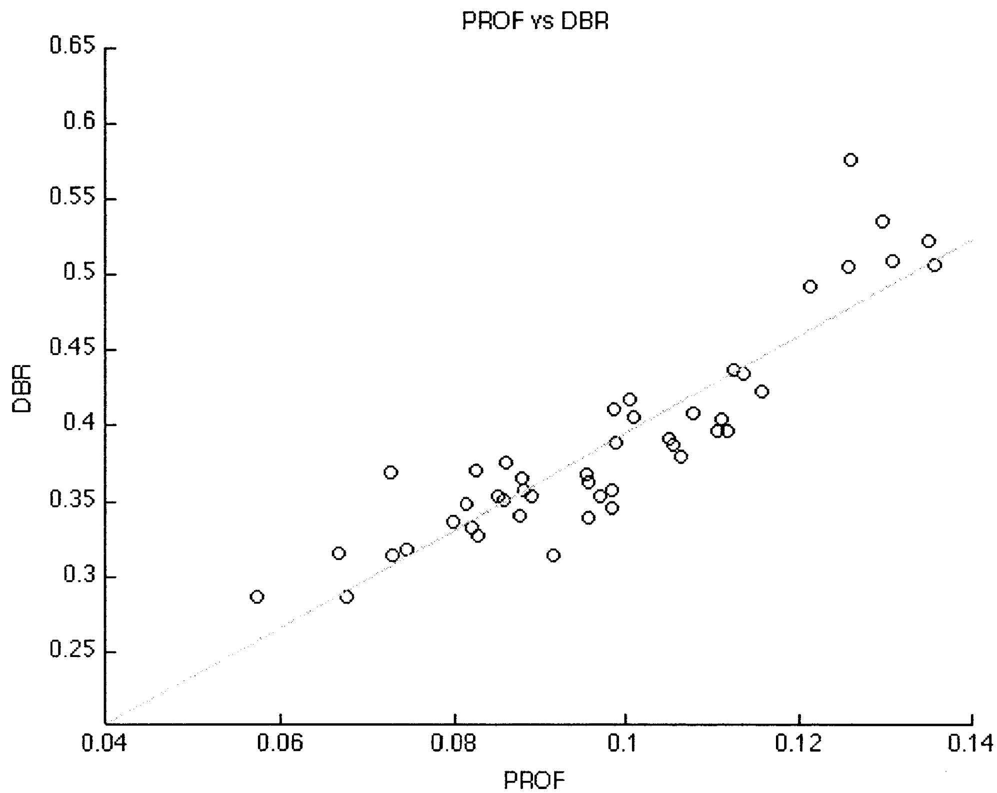

Figure 7.8: Removing upper and lower decile, mean book leverage ratio vs mean profitability by firm for years 81 to 84

BLR	Coefficient	Standard Error	T Statistic
MTB	.105737	.0341343	3.10
$PROF$	1.658287	.5462813	3.04
constant	.1087596	.0240192	4.53

Table 7.10: Removing upper and lower decile, leverage regressions from Rajan and Zingales (1995)

MLR	Coefficient	Standard Error	T Statistic
MTB	.0204384	.0349594	0.58
$PROF$	-.7805302	.5987	-1.30
constant	.4366357	.0224961	19.41

Table 7.11: Leverage regressions from Rajan and Zingales (1995) for entire sample

We get the same results for the book to debt ratio regression. See Table 7.10.

Next, we remove no firms in the period 81-84. The correlations remain mostly unchanged. See Figures 7.9 - 7.12 .

In Table 7.11, we get no significant coefficient on either market leverage ratio or profitability.

Table 7.12 gives the same positive coefficients of market to book and profitability on the book leverage ratio.

7.3 Welch (2004)

We run the regressions as in Welch (2004). Problems do not occur when we have large market to book ratios, as in these cases, the market to book ratio will be

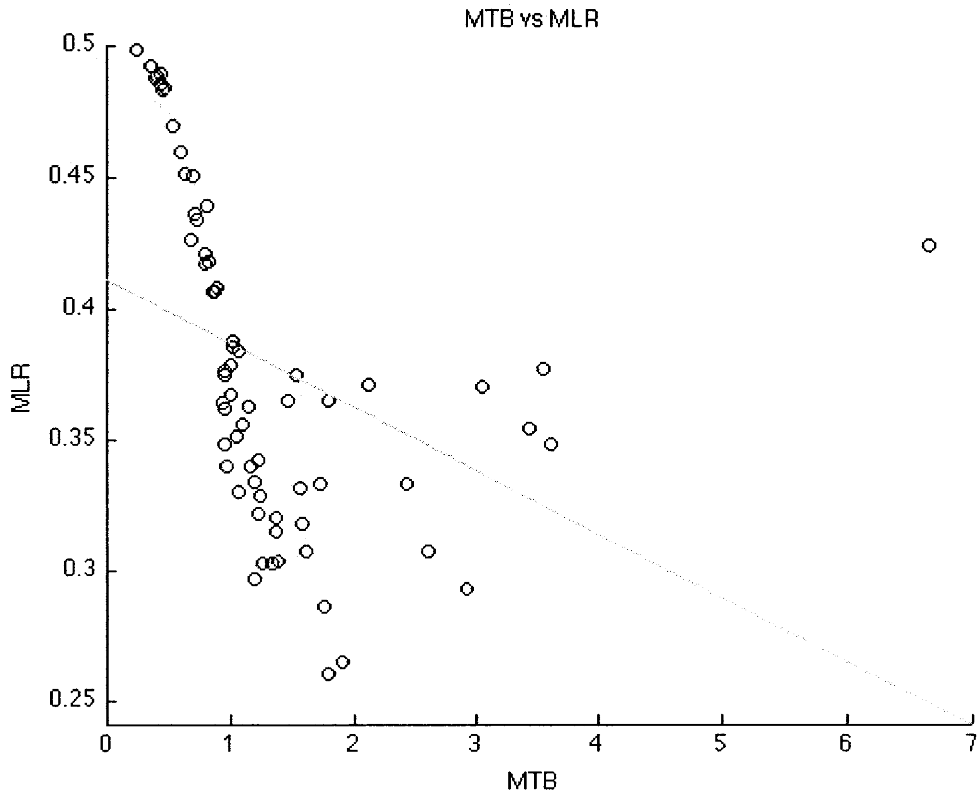

Figure 7.9: Mean market leverage ratio vs mean market to book by firm for years 81 to 84 for entire sample

BLR	Coefficient	Standard Error	T Statistic
MTB	.334929	.051594	6.49
$PROF$	.6540453	.8835773	0.74
constant	-.038717	.0332004	-1.17

Table 7.12: Leverage regressions from Rajan and Zingales (1995) for entire sample

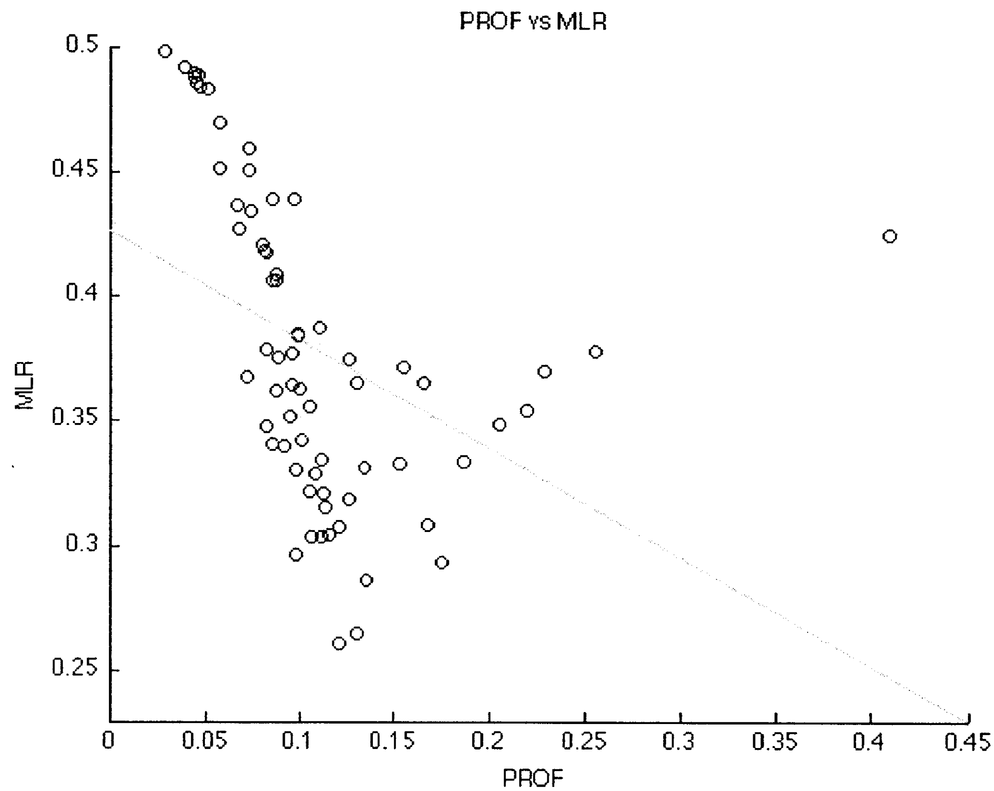

Figure 7.10: Mean market leverage ratio vs mean profitability by firm for years 81 to 84 for entire sample

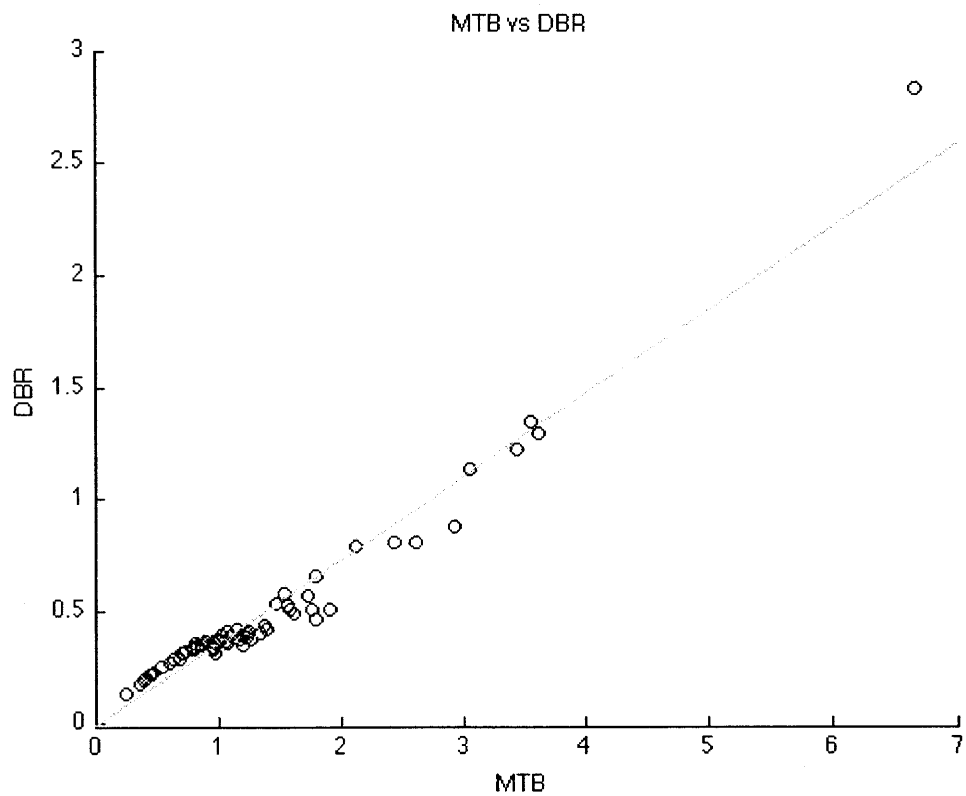

Figure 7.11: Mean book leverage ratio vs mean market to book by firm for years 81 to 84 for entire sample

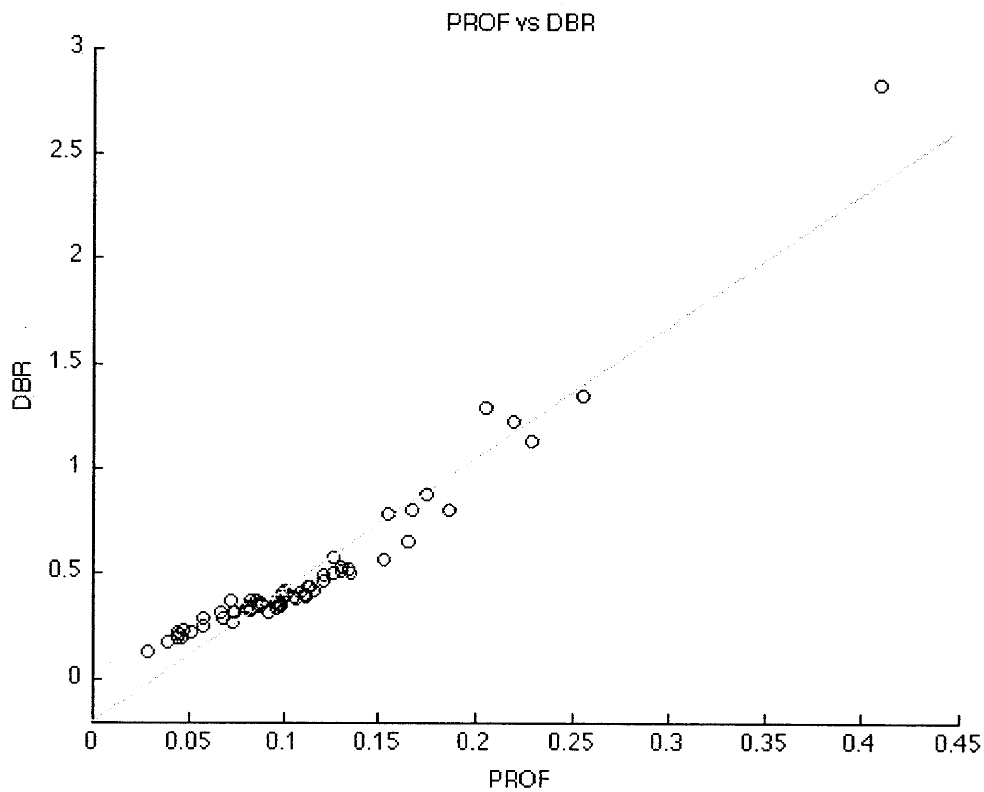

Figure 7.12: Mean book leverage ratio vs mean profitability by firm for years 81 to 84 for entire sample

$MLR - lagMLR$	Coefficient	Standard Error	T Statistic
$IDR - lagMLR$	.4765789	.0074348	64.10
constant	.0129243	.0005067	25.51

Table 7.13: Welch (2004), 1 year lag

MLR	Coefficient	Standard Error	T Statistic
IDR	.4801594	.0068923	69.67
lagMLR	.3809853	.009465	40.25
constant	.0637286	.0023617	26.98

Table 7.14: Welch (2004), 1 year lag

close to the target, λ. So we include these values. First, we consider a 1 period lag. There is a positive relation between Market leverage ratio and one year lagged market leverage ratio. (See Figure 7.13.) When $S(t)$ does not change much, the debt capacity of the options and assets in place is similar. The vertical line around 0.35 is because all new firms start at that leverage ratio initially.

Also, there is a positive relation between the market leverage ratio and the implied debt ratio(IDR). (See Figure 7.14). A larger $S(t+1)$ means a greater return on equity from t to $t+1$. It also means a larger negative debt capacity of the real options. The Market Leverage Ratio appears cut off at .5 because firms have debt capacity of $\frac{1}{2}$ on assets in place and the debt capacity of the options, no matter how far in the money, is at most $\frac{1}{2}$.

The results are given in Tables 7.13 and 7.14.

Next, we consider a 5 period lag. Figures 7.15, 7.16 give the distributions of market leverage ratio vs lagged market ratio and market leverage ratio vs implied

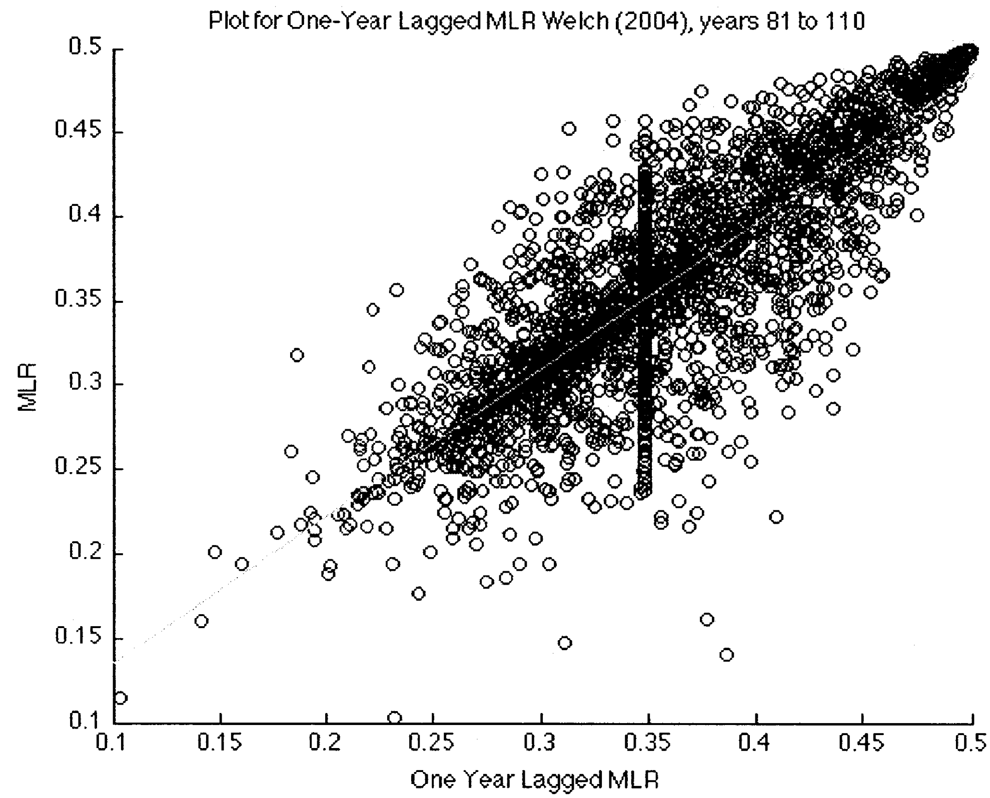

Figure 7.13: Market leverage ratio vs 1 year lagged market leverage ratio, one year lag

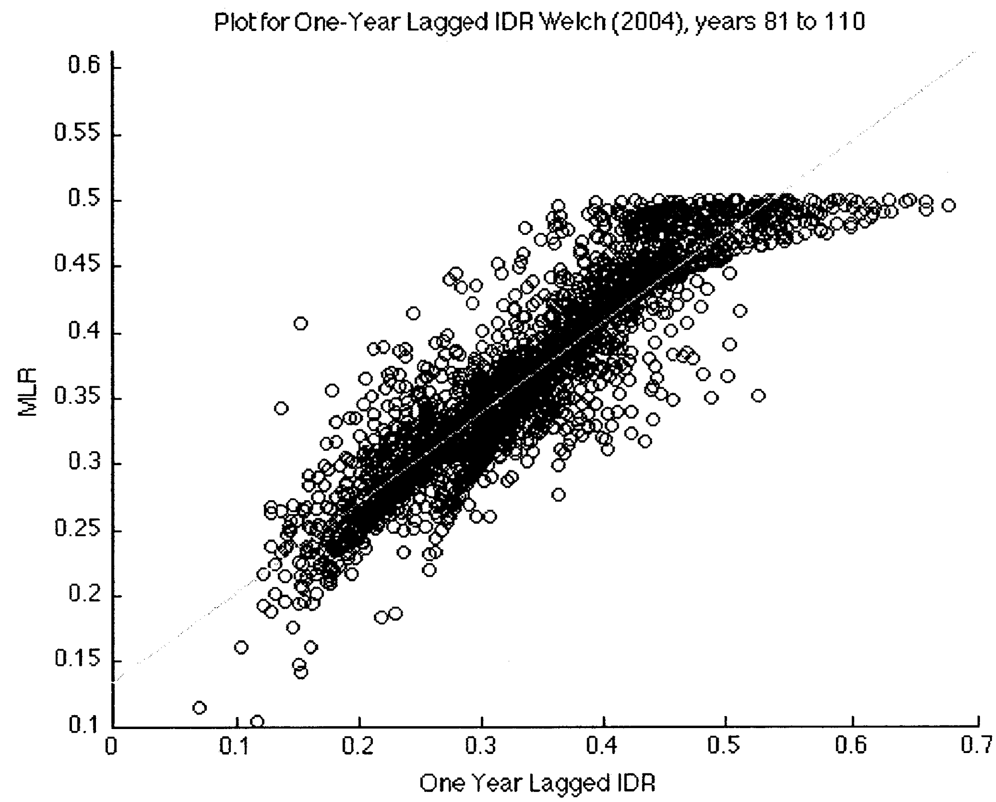

Figure 7.14: Market leverage ratio vs 1 year implied market leverage ratio, one year lag

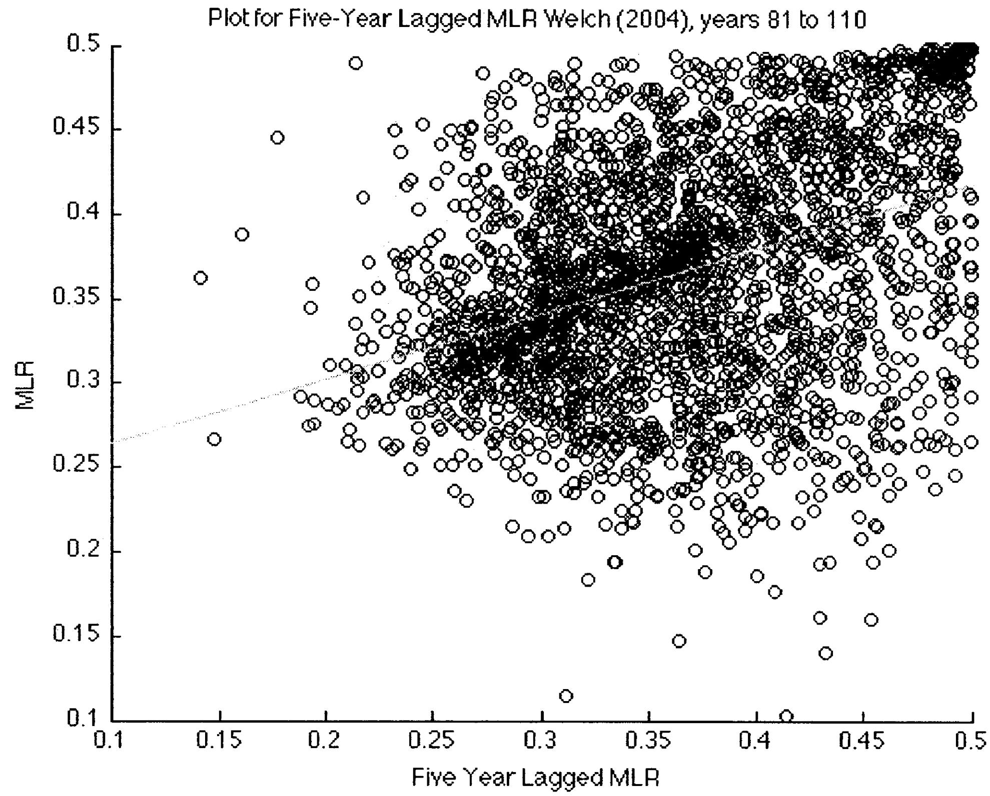

Figure 7.15: Market leverage ratio vs 5 year lagged market leverage ratio, one year lag

debt ratio. The correlations are less strong, as the path of S in five periods is much more volatile than in one.

The results are given in Tables 7.15 and 7.16,. Again, the coefficients are smaller, as $S(t)$ can change more over time. However, the coefficients are still significant.

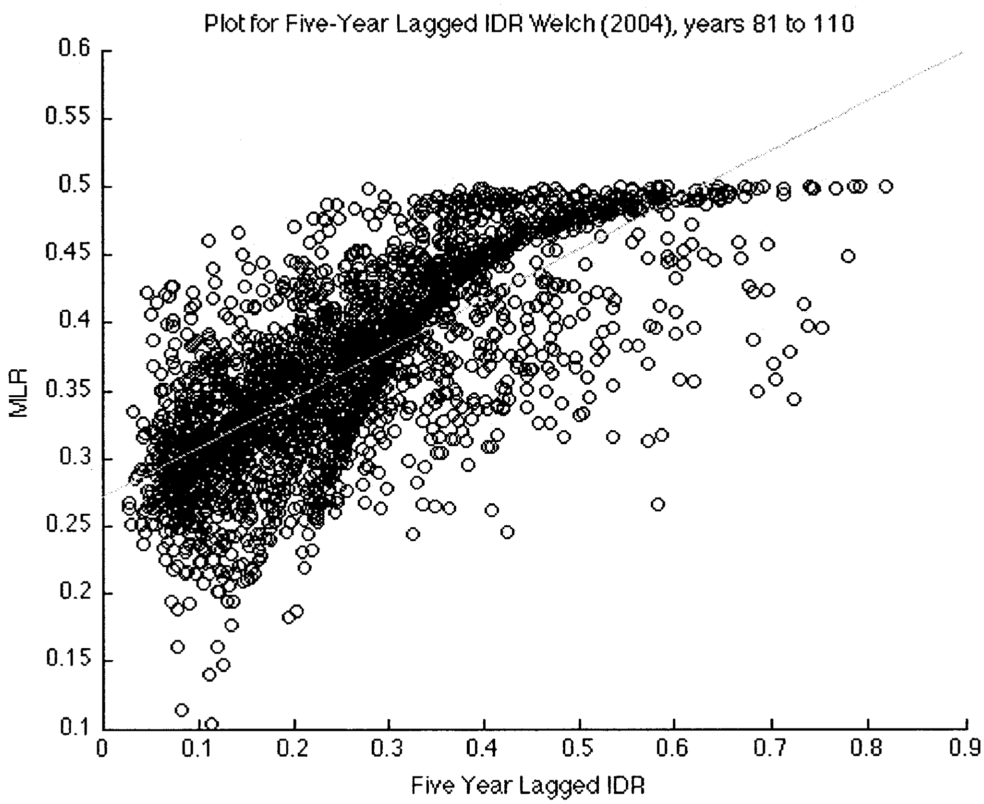

Figure 7.16: Market leverage ratio vs 5 year implied market leverage ratio, one year lag

$MLR - lagMLR$	Coefficient	Standard Error	T Statistic
$IDR - lagMLR$	.3564871	.0100338	35.53
constant	.0368426	.0016368	22.51

Table 7.15: Welch (2004), 5 year lag

MLR	Coefficient	Standard Error	T Statistic
IDR	.362008	.0073753	49.08
lagMLR	.0153742	.0150174	1.02
constant	.2663567	.0049291	54.04

Table 7.16: Welch (2004), 5 year lag

7.3.1 Welch (2004) using Mature vs Non-Mature Companies

One can imagine that mature firms act differently than growth companies in terms of market leverage's reaction to stock returns. Mature value companies will try more intently to stay on target. To proxy for growing vs mature companies, we use profitability. We will still use the period 81-110. Firms in the top half of profitability in the lagged period of the regression in Welch (2004) are considered mature companies and firms in the bottom half of profitability are considered not mature. To determine EBITDA, we need firms to exist one period before the lagged date. So not all firms enter the sample.

The results for the mature firms are given in Figures 7.17 and 7.18. The same directions of correlations are present. However, in Tables 7.17 and 7.18, we find a lower coefficient on implied debt ratio than for the entire sample. Additionally, the coefficient on the lagged market debt ratio increases. This is due to the firms being closer to the target of $\lambda = 0.50$. Thus, the market leverage ratio does not move as much. So the coefficient on of the implied debt ratio should be lesser, as it has a less intense impact.

The results for the non-mature firms are given in Figures 7.19 and 7.20. The

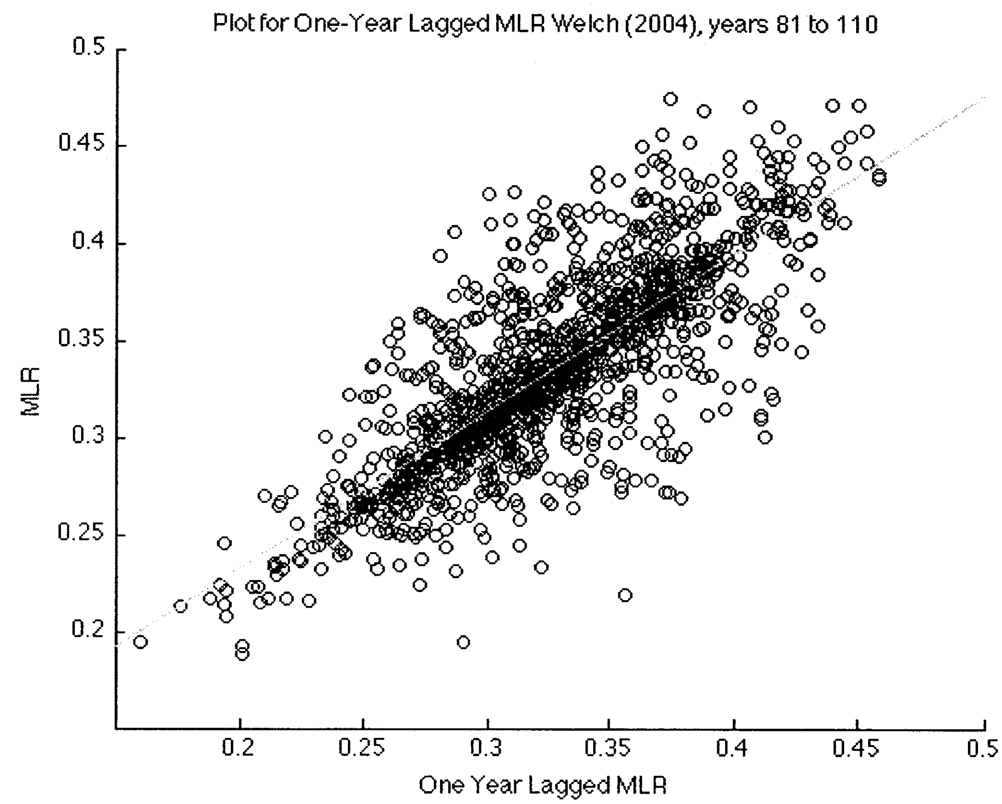

Figure 7.17: Mature firms, market leverage ratio vs 1 year lagged market leverage ratio, one year lag

$MLR - lagMLR$	Coefficient	Standard Error	T Statistic
$IDR - lagMLR$	.3797132	.0105135	36.12
constant	.0185617	.0006675	27.81

Table 7.17: Mature firms, Welch (2004), 1 year lag

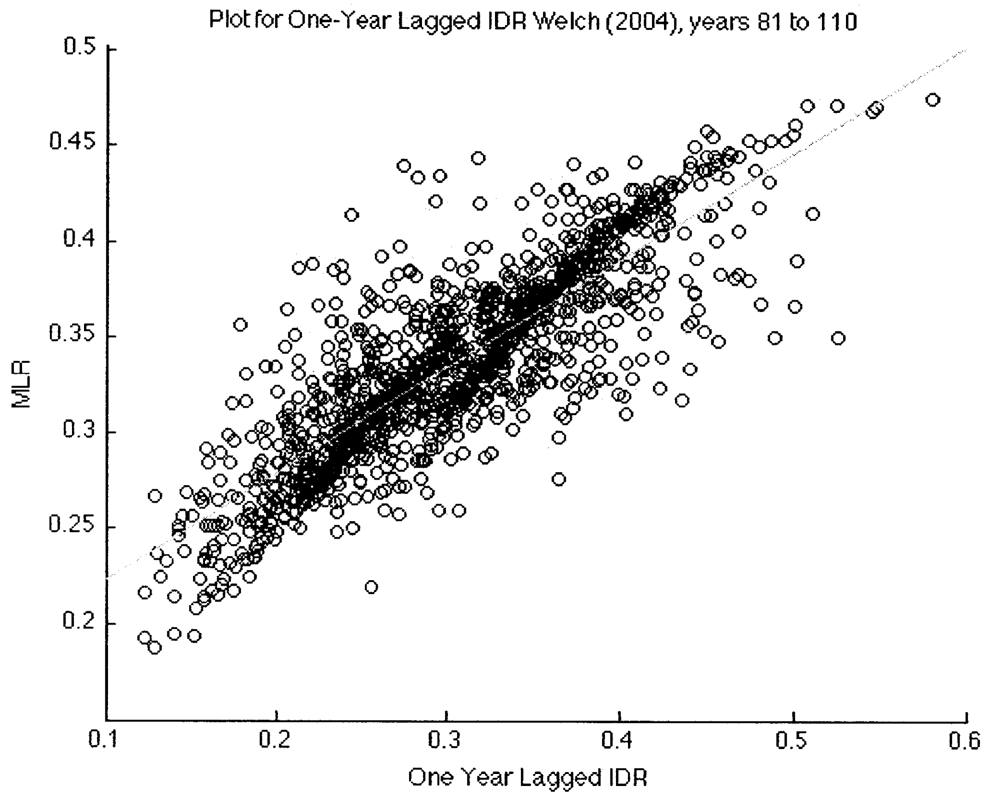

Figure 7.18: Mature firms, market leverage ratio vs 1 year implied market leverage ratio, one year lag

MLR	Coefficient	Standard Error	T Statistic
IDR	.3794034	.0096631	39.26
lagMLR	.4357315	.0150402	28.97
constant	.0789068	.0038181	20.67

Table 7.18: Mature firms, Welch (2004), 1 year lag

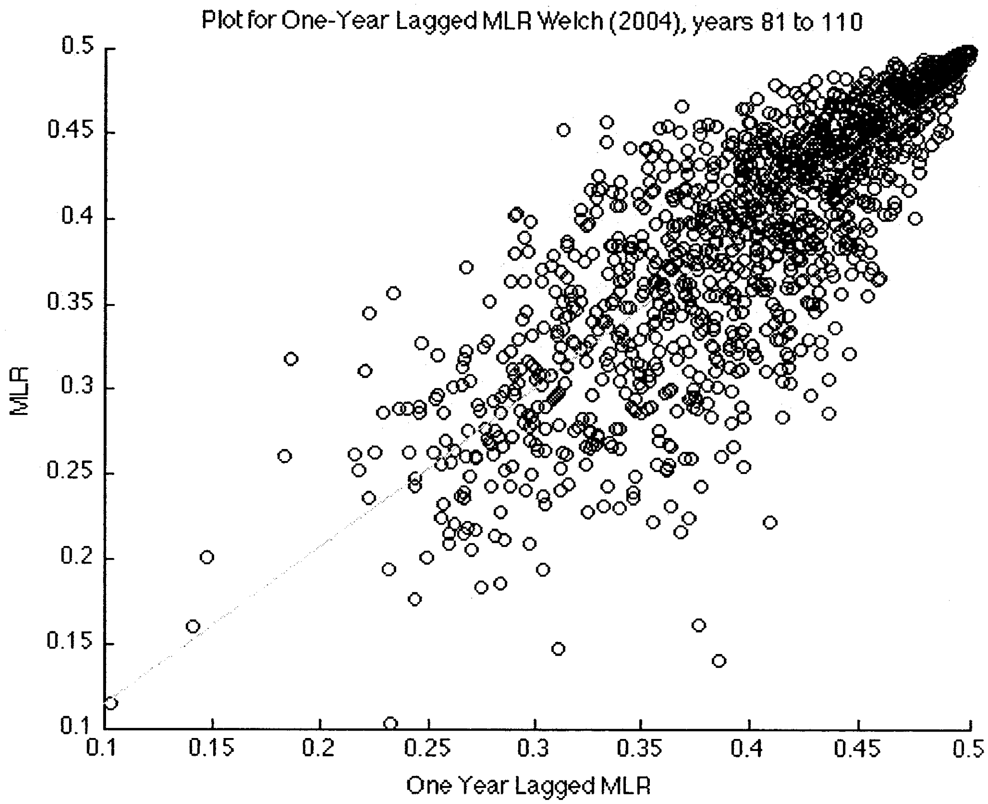

Figure 7.19: Non-mature firms, market leverage ratio vs 1 year lagged market leverage ratio, one year lag

same directions of correlations are present. However, in Tables 7.19 and 7.20, we have a higher coefficient on implied debt ratio than for the entire sample. The optimal leverage does change more with these firms' options being closer to the money or even out of the money.

The results are given in Tables 7.19 and 7.20.

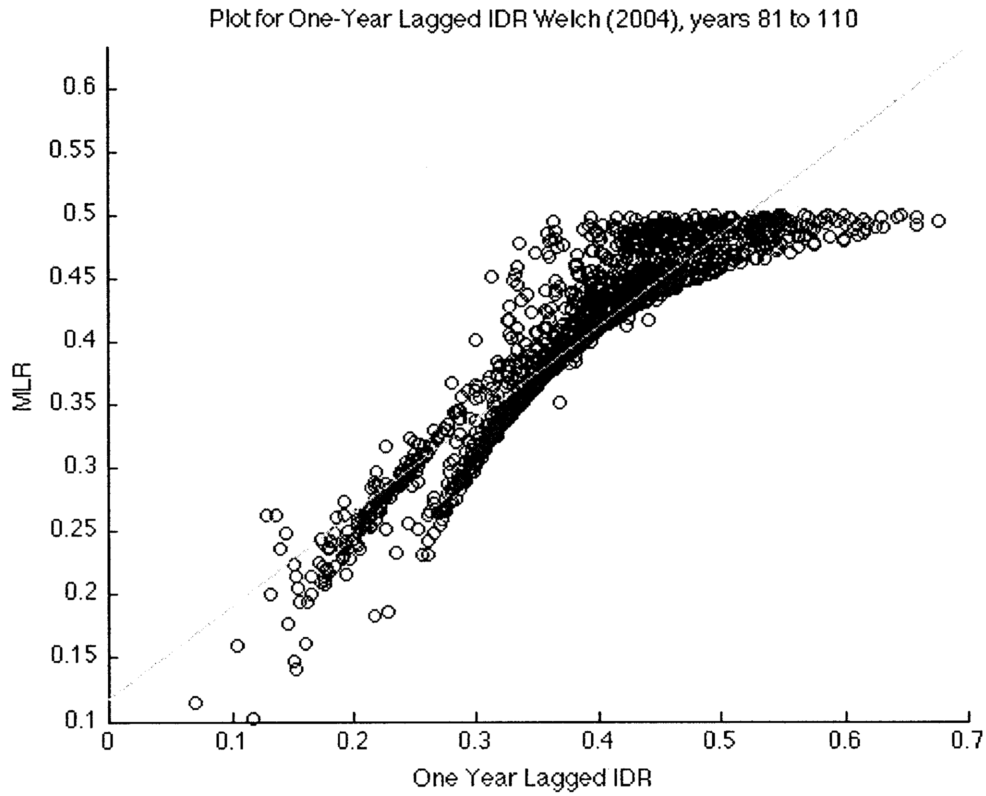

Figure 7.20: Non-mature firms, market leverage ratio vs 1 year implied market leverage ratio, one year lag

$MLR - lagMLR$	Coefficient	Standard Error	T Statistic
$IDR - lagMLR$	.5367752	.0096762	
constant	55.47	.000674	9.10

Table 7.19: Non-mature firms, Welch (2004), 1 year lag

MLR	Coefficient	Standard Error	T Statistic
IDR	.5382209	.0094708	56.83
lagMLR	.3887695	.0133593	29.10
constant	.0359198	.0038273	9.39

Table 7.20: Non-mature firms, Welch (2004), 1 year lag

7.4 Flannery and Rangan (2006)

Finally, we consider the Flannery and Rangan (2006) test. We remove firm n at year t if the market to book ratio of firm n at time $t-1$ is above 4. We use the period 81-110. There is a negative relation between the market leverage ratio and lagged market to book ratio. (See Figure 7.21.) A higher $S(t-1)$ means a larger lagged market to book, and also is correlated with a higher $S(t)$. A higher $S(t)$ means more negative debt from the real options, and thus a lower debt to market ratio.

Also, we find a negative relation between market leverage and lagged book value of assets. (See Figure 7.22.) A higher $S(t-1)$ means that the firm has exercised more options and thus has a larger book value. Additionally, a higher $S(t-1)$ is correlated with a higher $S(t)$. The higher $S(t)$ causes the firm to tend to have a lower market leverage ratio.

Furthermore, there is negative relation between the market leverage ratio and profitability. (See Figure 7.23. Again, a higher S(t-1) tends to mean a higher lagged profitability. It also tends to mean a higher $S(t)$, which tends to mean a lower debt to market ratio.

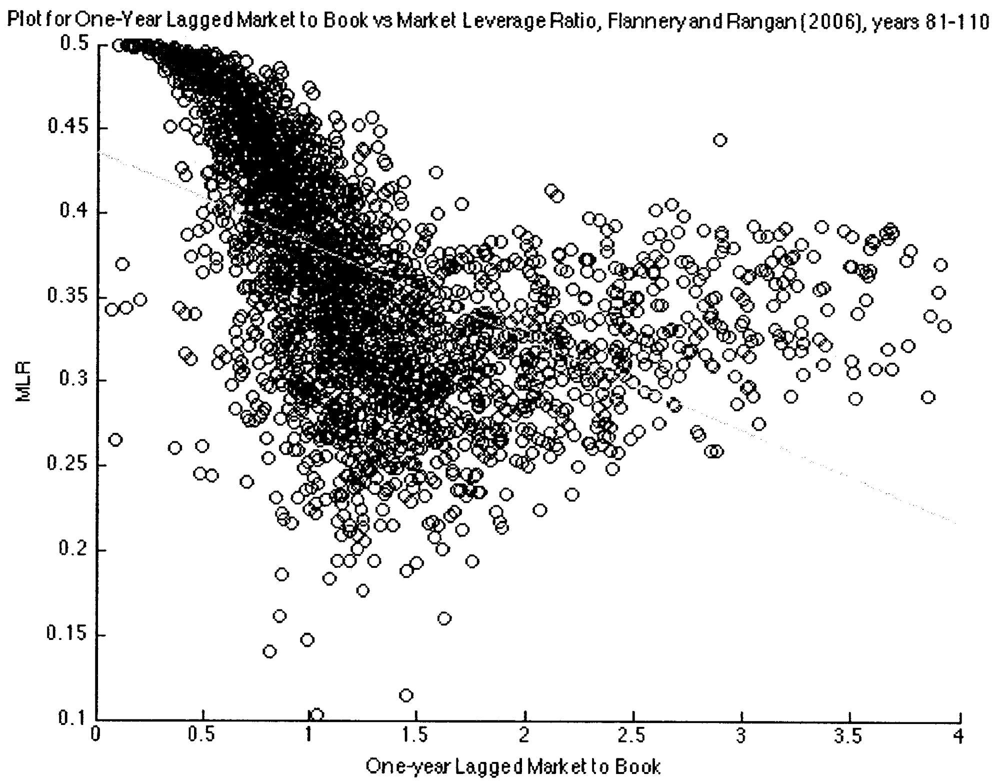

Figure 7.21: Market leverage ratio vs lagged market to book, years 81-110

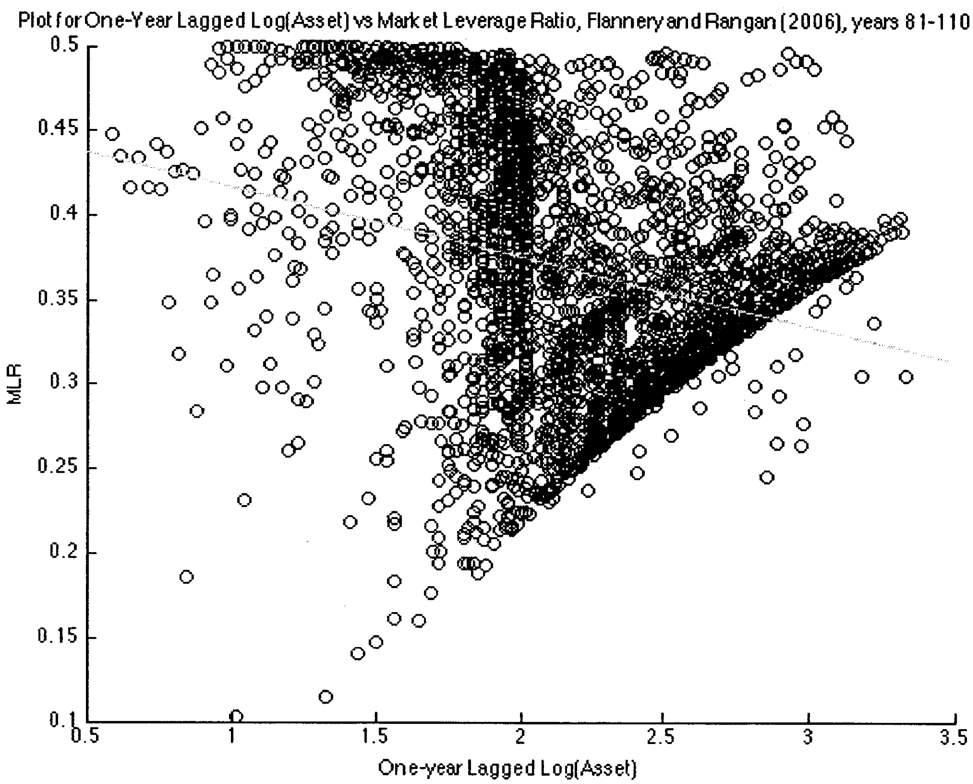

Figure 7.22: Market leverage ratio vs total assets (book value), years 81-110

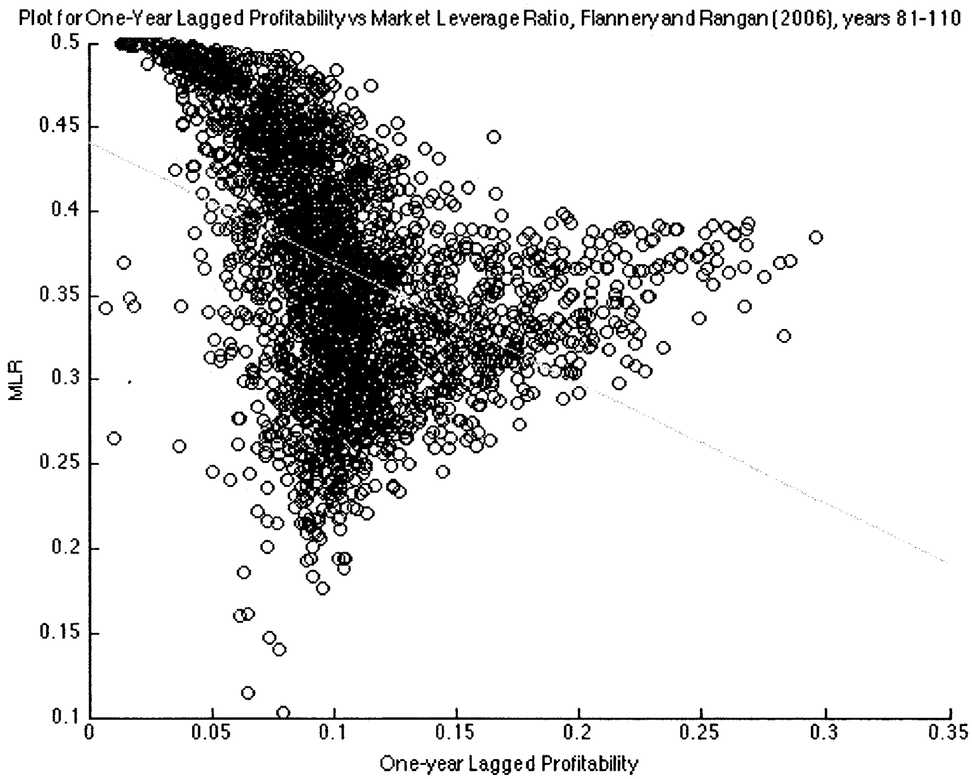

Figure 7.23: Market leverage ratio vs lagged profitability, years 81-110

MLR_t	Coefficient	Standard Error	T Statistic
MLR_{t-1}	.8199852	.0145716	56.27
MTB_{t-1}	.0039871	.0029742	1.34
$LNTA_{t-1}$	.0077399	.0026308	2.94
$PROF_{t-1}$	-.1054055	.0476155	-2.21
constant	.0549434	.0074134	7.41

Table 7.21: Flannery and Rangan (2006), 1 year lag

The results are given in Tables 7.21 and Equation 7.1. The lagged market leverage ratio is a very important factor on current leverage. Also the logarithm of book value and profitability are important. When letting the target vary, we get nearly twice the level of reversion to the target as in the Shyam-Sunder and Myers (1999) target adjustment regression.

$$MLR^i_{t+1} - MLR^i_t = 5.49\% + 19.00\%(\beta^* X^i_t - MLR) \tag{7.1}$$

$$\beta^* X^i_t = 2\%MTB + 4\%LOGASSET - 28.89\%PROFITABILITY \tag{7.2}$$

7.4.1 Alternate Firm Removal Techniques

We first remove the firms with the highest and lowest decile of lagged market to book ratio. The relations go similarly. See Figures 7.24, 7.25, and 7.26.

In Table 7.22, we do no gain or lose significance on any of the variables. Equation 7.3 points out that the speed of adjustment rises slightly.

Figure 7.24: Upper and lower decile removed, market leverage ratio vs lagged market to book, years 81-110

MLR_t	Coefficient	Standard Error	T Statistic
MLR_{t-1}	.7834251	.028127	27.85
MTB_{t-1}	.0013117	.0062512	0.21
$LNTA_{t-1}$	.0091407	.0036532	2.50
$PROF_{t-1}$	-.0119717	.0629754	-0.19
constant	.0572824	.0123445	4.64

Table 7.22: Upper and lower decile removed, Flannery and Rangan (2006), 1 year lag

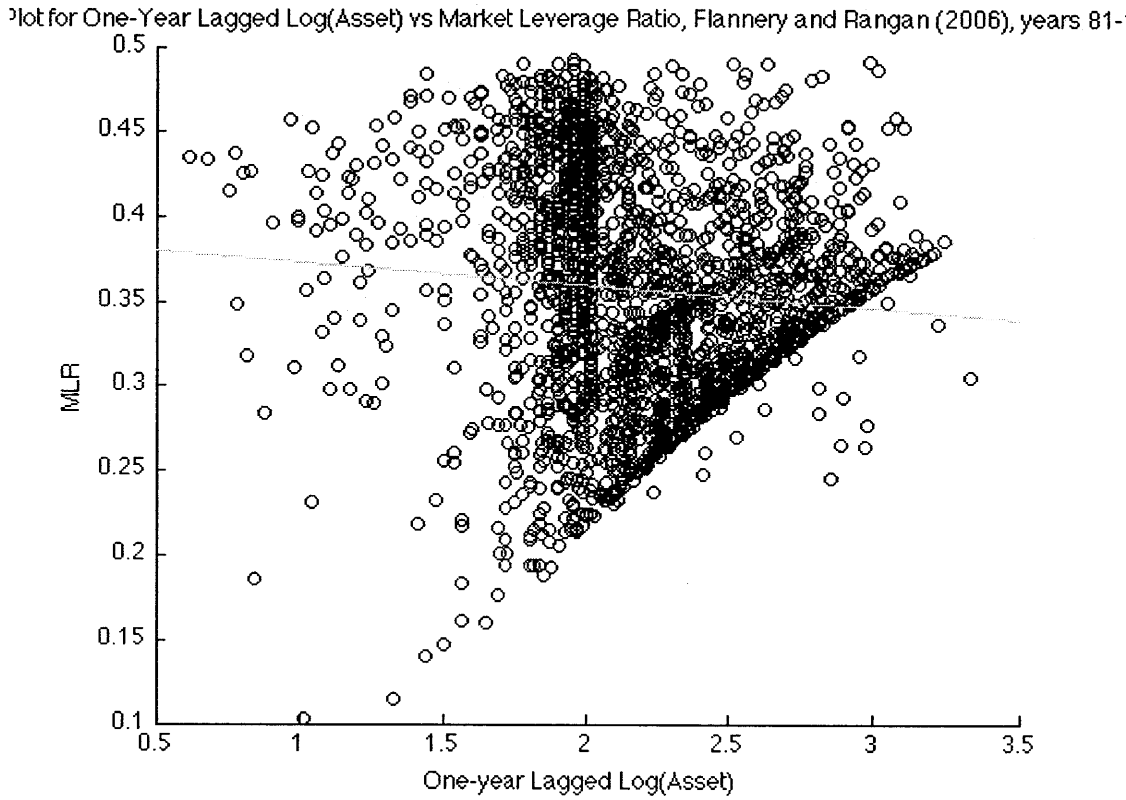

Figure 7.25: Upper and lower decile removed, market leverage ratio vs total assets (book value), years 81-110

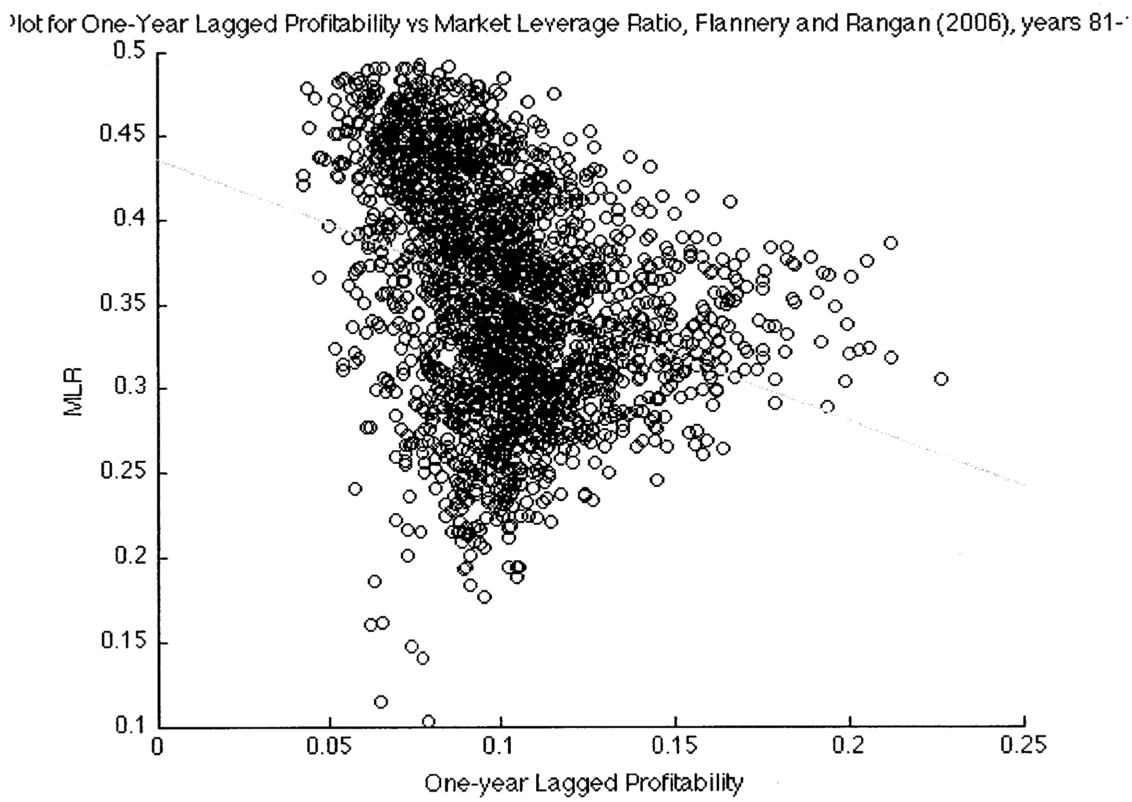

Figure 7.26: Upper and lower decile removed, market leverage ratio vs lagged profitability, years 81-110

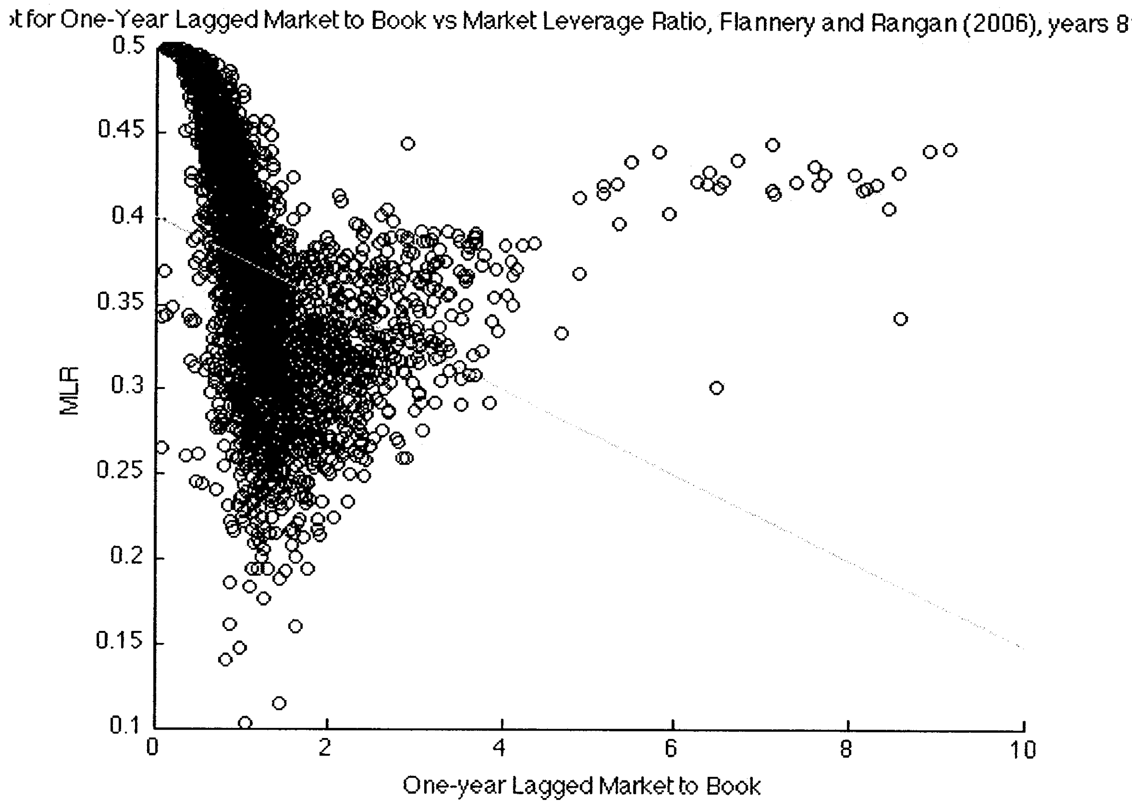

Figure 7.27: Market leverage ratio vs lagged market to book, years 81-110 for entire sample

$$MLR^i_{t+1} - MLR^i_t = 5.73\% + 21.66\%(\beta^* X^i_t - MLR) \tag{7.3}$$

$$\beta^* X^i_t = 0.60\% MTB + 4.22\% LOGASSET - 0.05\% PROFITABILITY \tag{7.4}$$

Next, we consider the results when we do not remove any firms. Figures 7.27, 7.28, and 7.29 point to similar conclusions.

Notice that in Table 7.23, profitability becomes statistically significant and

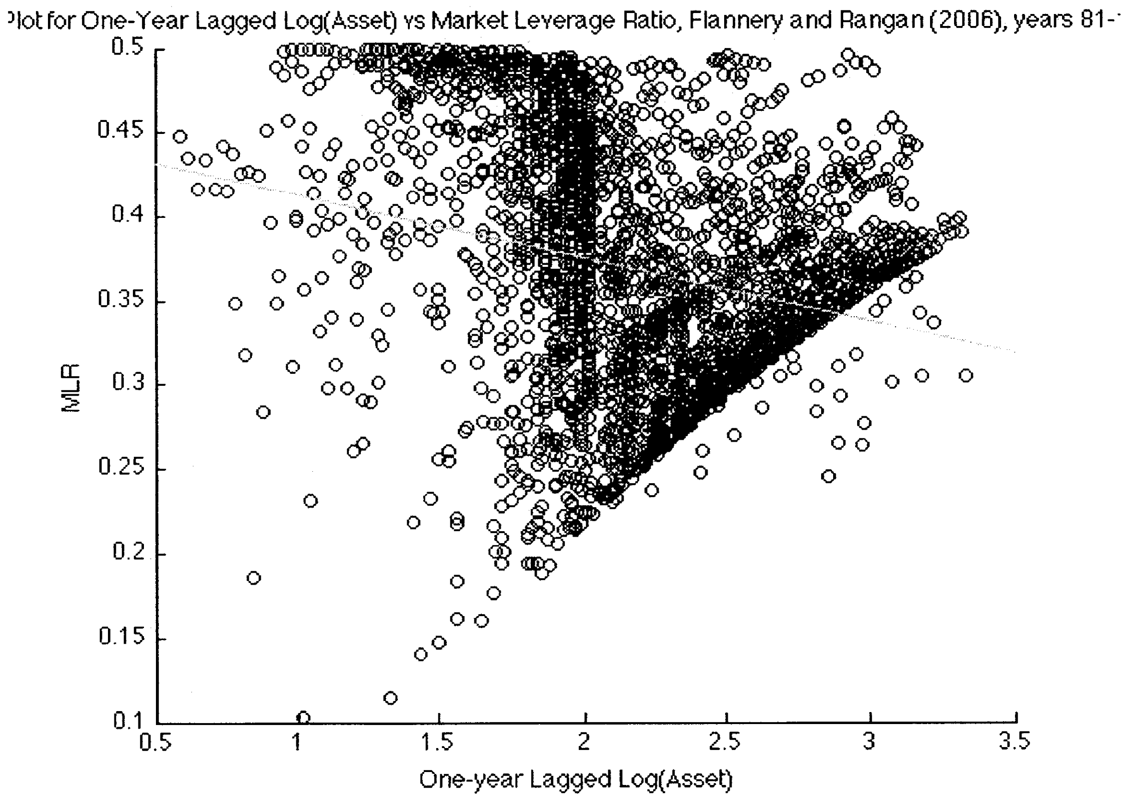

Figure 7.28: Market leverage ratio vs total assets (book value), years 81-110 for entire sample

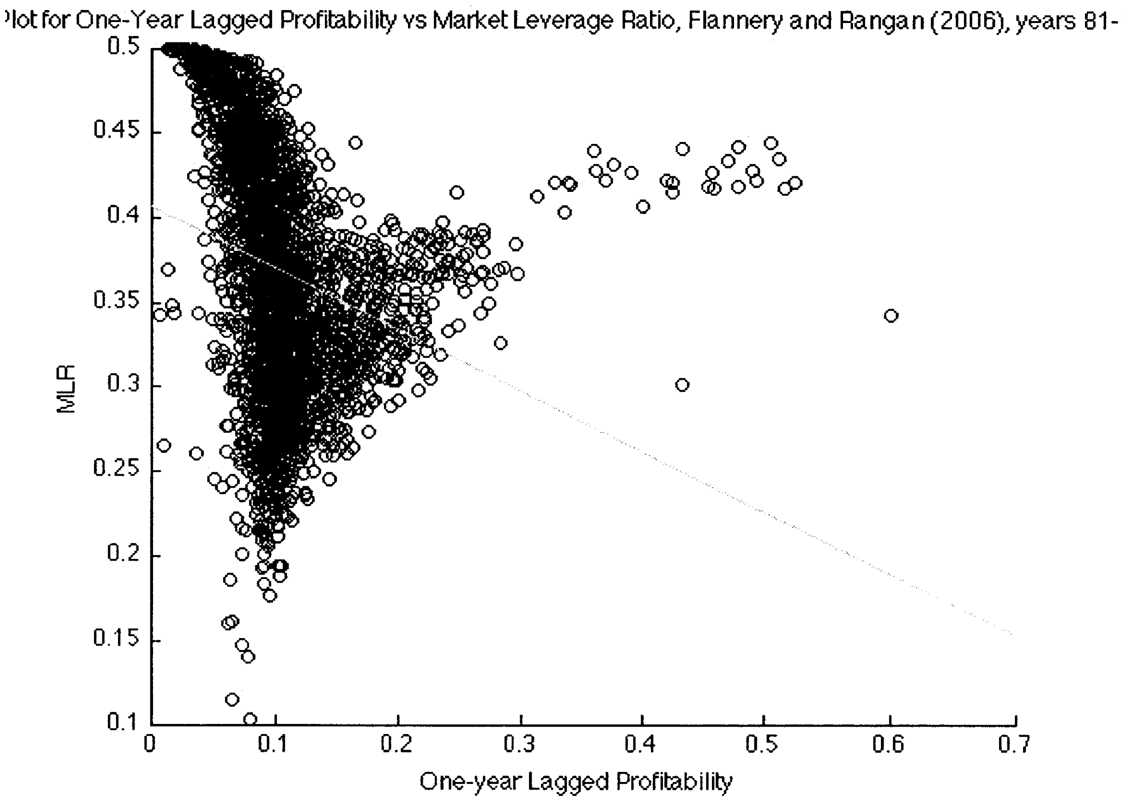

Figure 7.29: Market leverage ratio vs lagged profitability, years 81-110 for entire sample

MLR_t	Coefficient	Standard Error	T Statistic
MLR_{t-1}	.8238807	.0122399	67.31
MTB_{t-1}	.0044758	.002418	1.85
$LNTA_{t-1}$	.0070812	.0023878	2.97
$PROF_{t-1}$	-.0982585	.0436497	-2.25
constant	.0536237	.006843	7.84

Table 7.23: Flannery and Rangan (2006), 1 year lag for entire sample

in Equation 7.5 that the speed of adjustment is decreased slightly from 19% to 17.61%.

$$MLR^i_{t+1} - MLR^i_t = 5.36\% + 17.61\%(\beta^* X^i_t - MLR) \tag{7.5}$$

$$\beta^* X^i_t = 2.54\% MTB + 4.02\% LOGASSET - 55.80\% PROFITABILITY \tag{7.6}$$

8 Target Adjustment Effect on Tests

We see what will happen if a firm does not adjust fully to a target, but rather only adjusts part of the way. Concretely,

$$\hat{D}ebt(t) = \rho \hat{D}ebt(t-1) + (1-\rho) TargetDebt(t). \tag{8.1}$$

We choose $\rho = 50\%$. So a firm will adjust half way to its target each period. Note that the firm's market value and market to book ratios will not be affected by the change in capital structure in this framework.

Figures 8.1 gives the distribution of the debt to book ratio. The distribution is

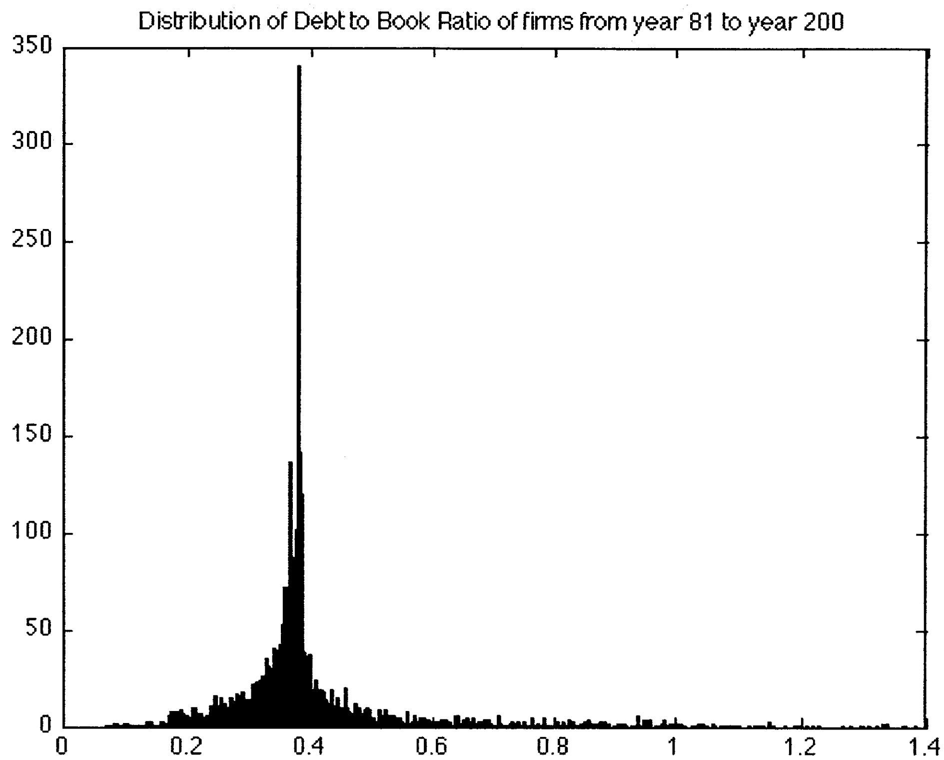

Figure 8.1: Debt to book ratio for years 81 to 110

positively skewed, as when S increases, the debt tends to first increase. The spike is caused by all firms starting identically.

Figure 8.2 gives the distribution of the debt to market ratio. There is only one spike. There is no spike around 0.5 since firms do not adjust completely to their target, and thus can have a debt to market ratio greater than 0.5. The lower spike is because all firms start identically there. The debt to market being very low is caused by the firms which have done well enough to have a substantial synthetic

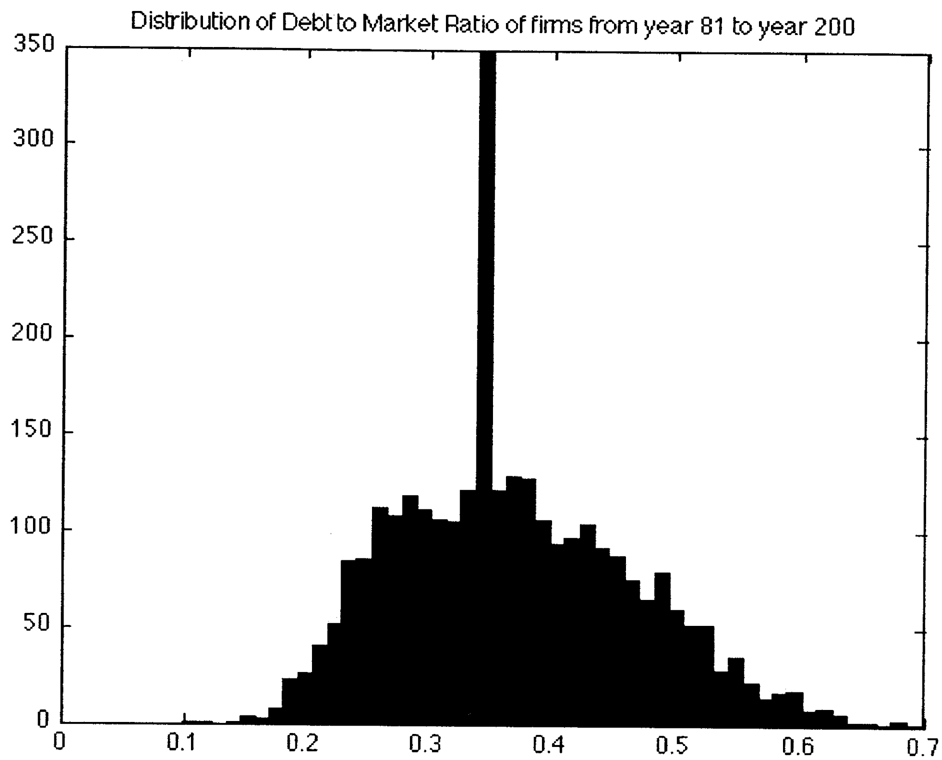

Figure 8.2: Debt to market ratio for years 81 to 110

debt from the growth options.

Table 8.1 gives the various summary statistics of these distributions.

8.1 Shyam-Sunder and Myers (1999)

First, we perform the regressions in Shyam-Sunders and Myers (1999). We exclude a sample point from our regression if the firm has a market to book ratio greater than 4 in our sample period. The results of the target adjustment model are

	Market to Book	Debt to Book	Debt to Market
mean	1.2239	0.4109	0.3693
median	1.0948	0.3794	0.3531
std. dev.	0.6333	0.1675	0.0948

Table 8.1: Summary statistics of the distributions of market to book ratio, debt to book ratio, and debt to market ratio for the years 81-110.

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
$D^* - D_{t-1}$	.0561329	0.0077075	7.28
constant	.0114749	.0010613	10.81

Table 8.2: Target adjustment regression from Shyam-Sunder and Myers (1999) for the years 81-110. Target adjustment model

presented in Table 8.2. While the coefficient is significantly different from 0, it is also quite small. One would expect the estimated target adjustment coefficient to be greater, but the method of estimating the mean Debt to Lagged Book Ratio could be at fault.

The results of the Pecking Order Regression are presented in Table 8.3. The results are quite similar to the perfect adjustment case. The pecking order is soundly rejected.

$D_t - D_{t-1}$	Coefficient	Standard Error	T Statistic
Def	-.3016341	.0154416	-19.53
constant	-.0212953	.0019839	-10.73

Table 8.3: Pecking order regression from Shyam-Sunder and Myers (1999) for the years 81-110. Target adjustment model

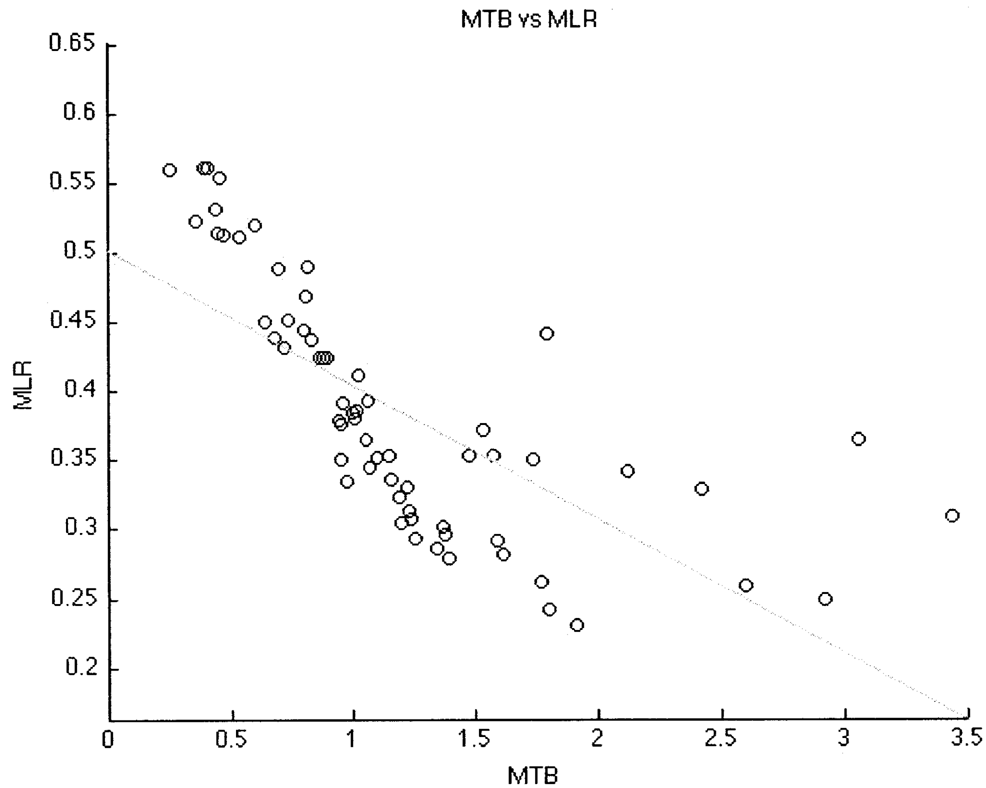

Figure 8.3: Target adjustment mean market leverage ratio vs mean market to book by firm for years 80 to 83

8.2 Rajan and Zingales (1995)

Next, we present the results from the Rajan and Zingales (1995) for our simulated data. We use the same firms as for the perfect adjustment case. The negative relation between market leverage and market to book as well as the negative relation between market leverage and profitability from Rajan and Zingales (1995) is still present .(See Figures 8.3 and 8.4, respectively) . The correlation is not as strong.

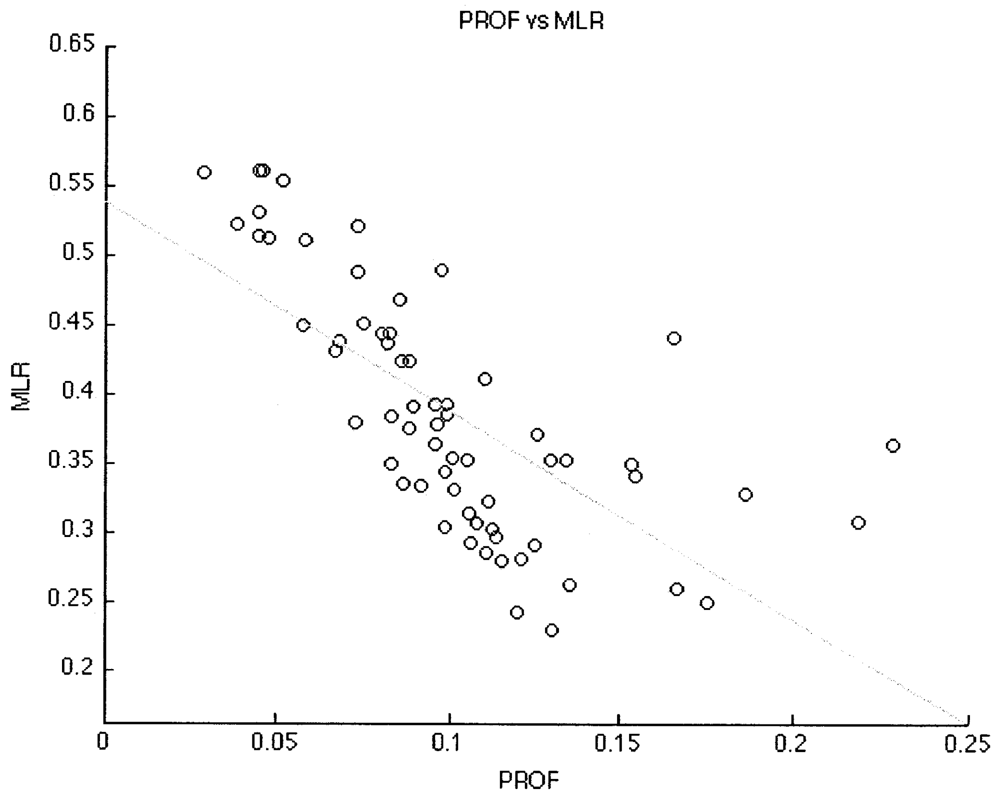

Figure 8.4: Target adjustment mean market leverage ratio vs mean profitability by firm for years 80 to 83

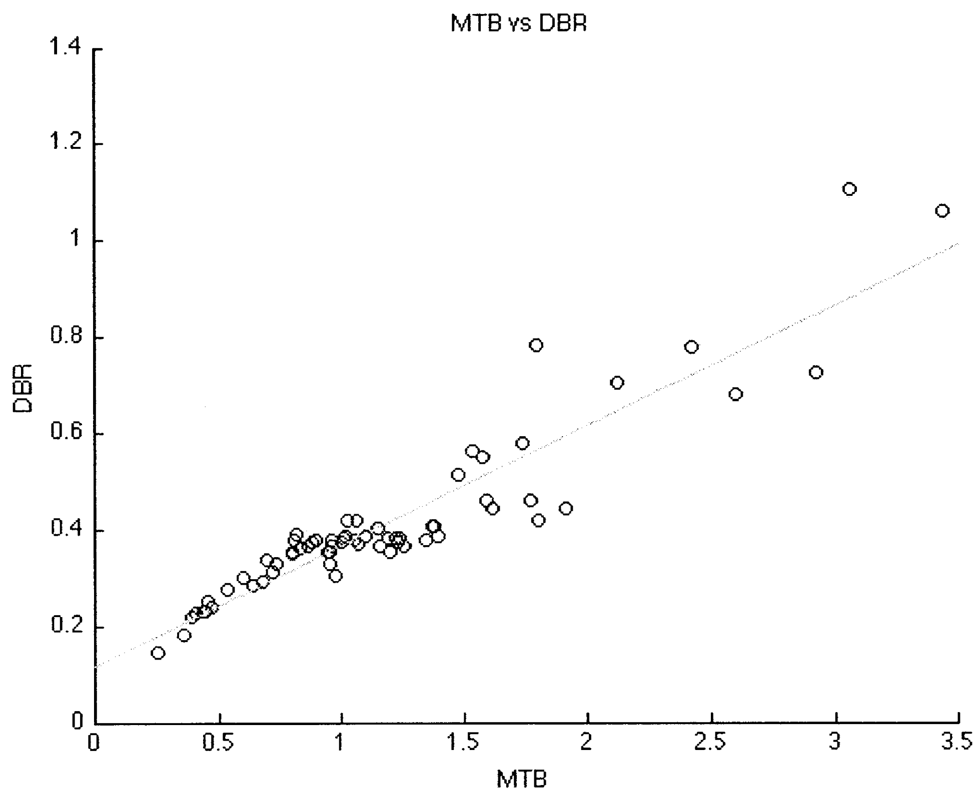

Figure 8.5: Target adjustment mean book leverage ratio vs mean market to book by firm for years 80 to 83

When find that the positive relation between book leverage and market to book, as well as the positive relation between book leverage and profitability, remains. (See Figures 8.5, and 8.6, respectively.)

When we run the full regression in Table 8.4 as in Rajan and Zingales (1995), we again get insignificant coefficients.

Running the regression on the book debt ratio in Table 8.5 yields an insignificantly positive coefficient on market to book and an significantly positive coeffi-

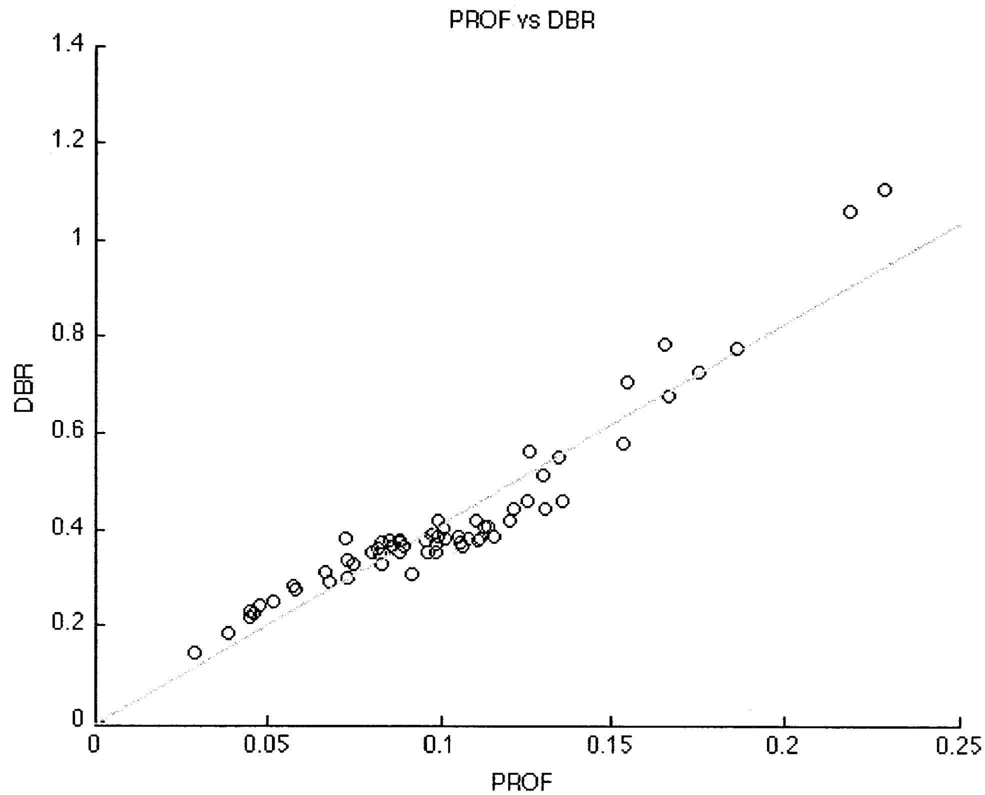

Figure 8.6: Target adjustment mean book leverage ratio vs mean profitability by firm for years 80 to 83

MLR	Coefficient	Standard Error	T Statistic
MTB	-.1051017	.044731	-2.35
$PROF$	.1378856	.7237781	0.19
constant	.498194	.026707	18.65

Table 8.4: Leverage regressions from Rajan and Zingales (1995). Target adjustment model

BLR	Coefficient	Standard Error	T Statistic
MTB	.0424712	.0404722	1.05
$PROF$	3.499786	.6548679	5.34
constant	.0106814	.0241643	0.44

Table 8.5: Leverage Regressions from Rajan and Zingales (1995). Target adjustment model

cient on profitability.

One should not expect much of a difference to the Rajan and Zingales (1995) tests, as the relevant variables are time series averages, and do not react as much to target adjustment.

8.3 Welch (2004)

First, we consider a 1 period lag. The relations between market leverage and lagged Market leverage, and well as market leverage and implied debt ratio remain positive and the correlations are stronger than the perfect adjustment case. (See Figures 8.7and 8.8.) The reasoning is that the inertia Welch was discussing is really in the model. Managers only adjust debt partially to their target, and so the market leverage ratio is more affected by lagged market leverage and the implied debt ratio.

The results are given in Tables 8.6 and 8.7. In Table 8.7, the coefficient for the implied debt ratio increases substantially from 0.48 to 0.68, as the effect Welch (2004) proposes is indeed in the data. The coefficient on lagged market leverage ratio decreases from 0.38 to 0.26, because its effect is being captured by the im-

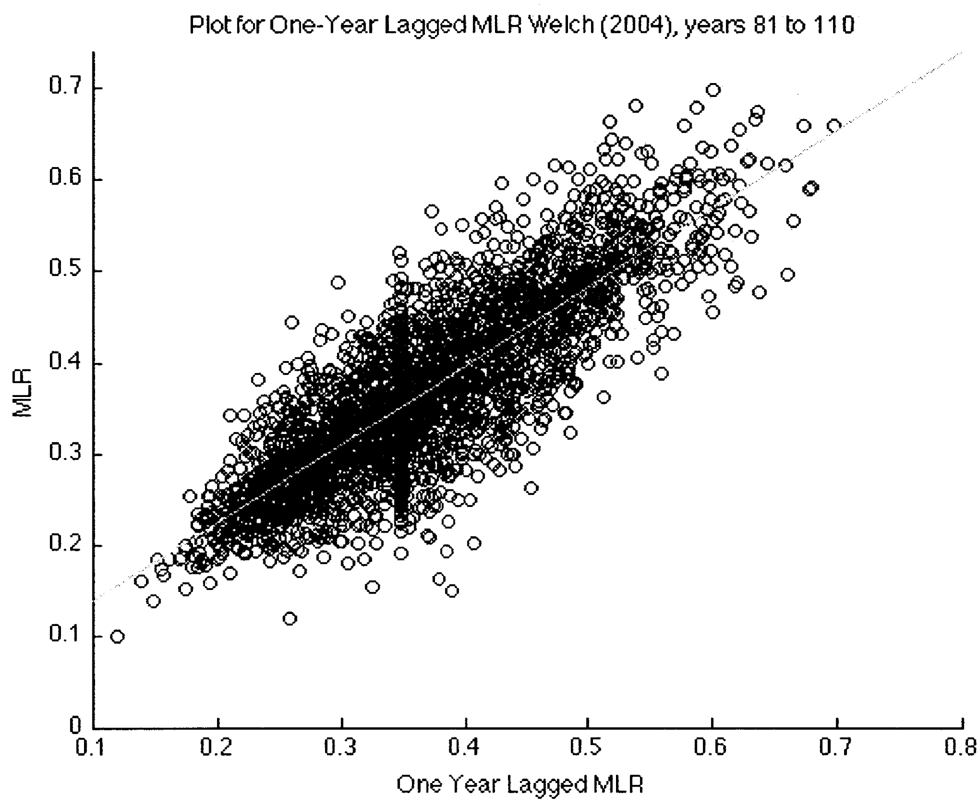

Figure 8.7: Market leverage ratio vs 1 year lagged market leverage ratio, one year lag

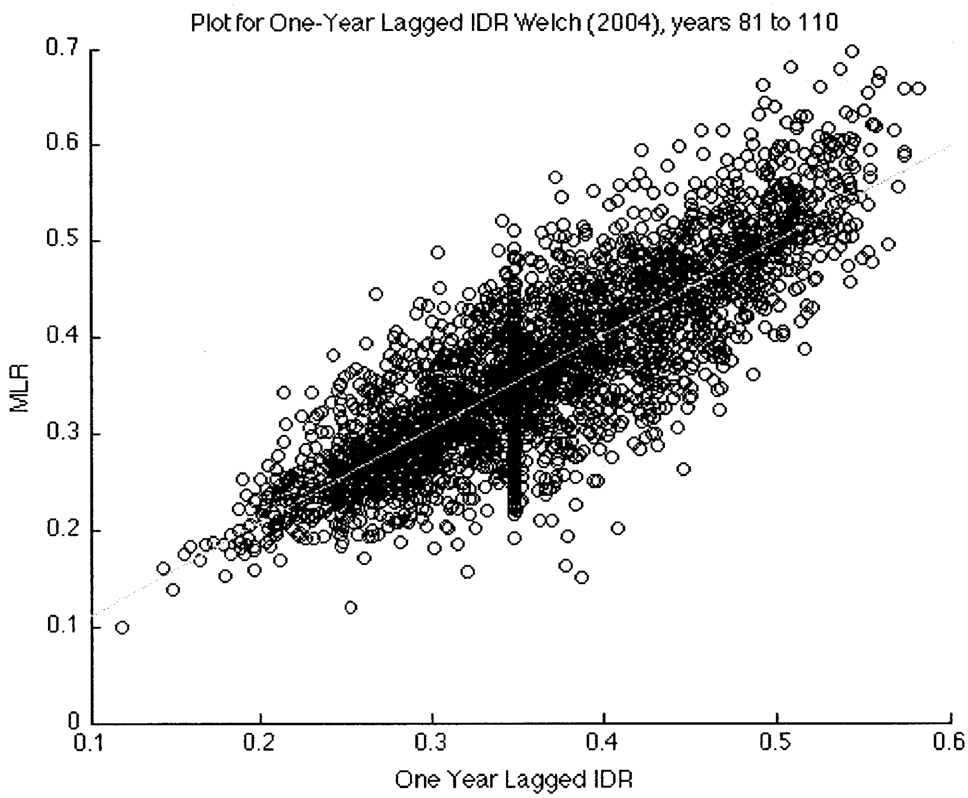

Figure 8.8: Market leverage ratio vs 1 year implied debt ratio, one year lag

$MLR - lagMLR$	Coefficient	Standard Error	T Statistic
$IDR - lagMLR$	.9779109	.0685042	14.28
constant	.0048914	.0010381	4.71

Table 8.6: Welch (2004), 1 year lag

MLR	Coefficient	Standard Error	T Statistic
IDR	.6801697	.1161349	5.86
lagMLR	.2627226	.1021382	2.57
constant	.0248976	.0063911	3.90

Table 8.7: Welch (2004), 1 year lag

plied debt ratio term. In Table 8.7, we see a coefficient very similar to that of Welch (2004) on the real data.

Next, we consider a 5 period lag. The results and comparisons with the perfect adjustment to target are similar to that of the 1 year lag. Since we are dealing with five years out, and so S can change a good deal, results in Table 8.8 do not make that much sense.

$MLR - lagMLR$	Coefficient	Standard Error	T Statistic
$IDR - lagMLR$	3.388216	.1217928	27.82
constant	.0128005	.0019248	6.65

Table 8.8: Welch (2004), 5 year lag, target adjustment

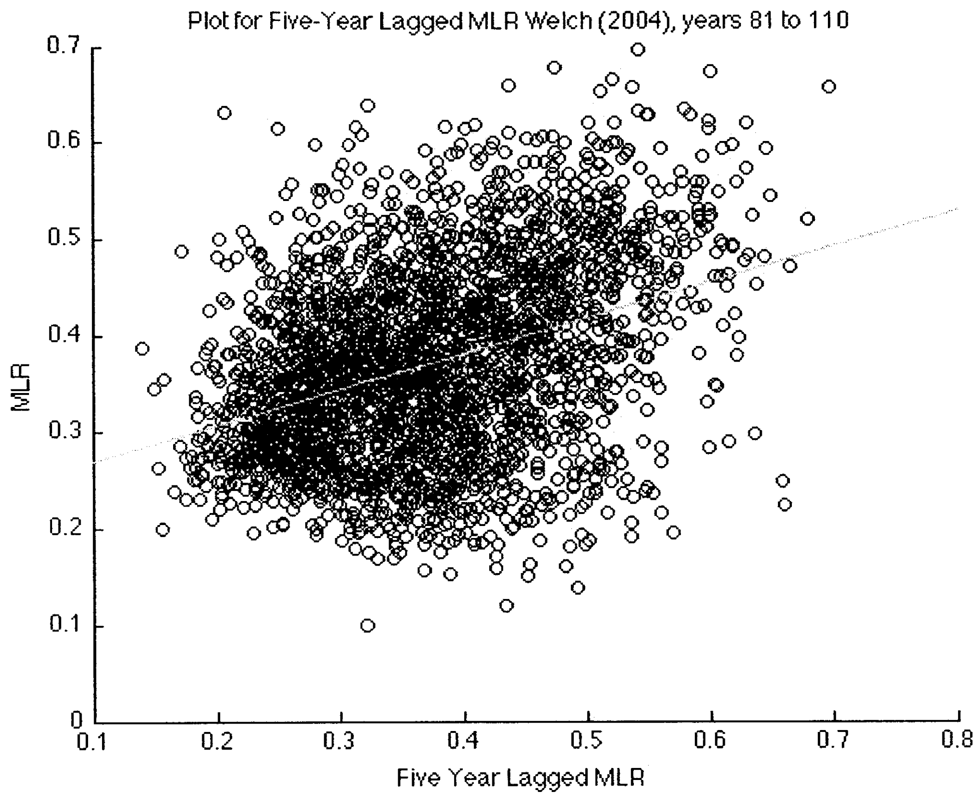

Figure 8.9: Market leverage ratio vs 5 year lagged market leverage ratio, one year lag

MLR	Coefficient	Standard Error	T Statistic
IDR	.3720042	.1945405	1.91
lagMLR	.0483466	.1709881	0.28
constant	.2165157	.0107843	20.08

Table 8.9: Welch (2004), 5 year lag, target adjustment

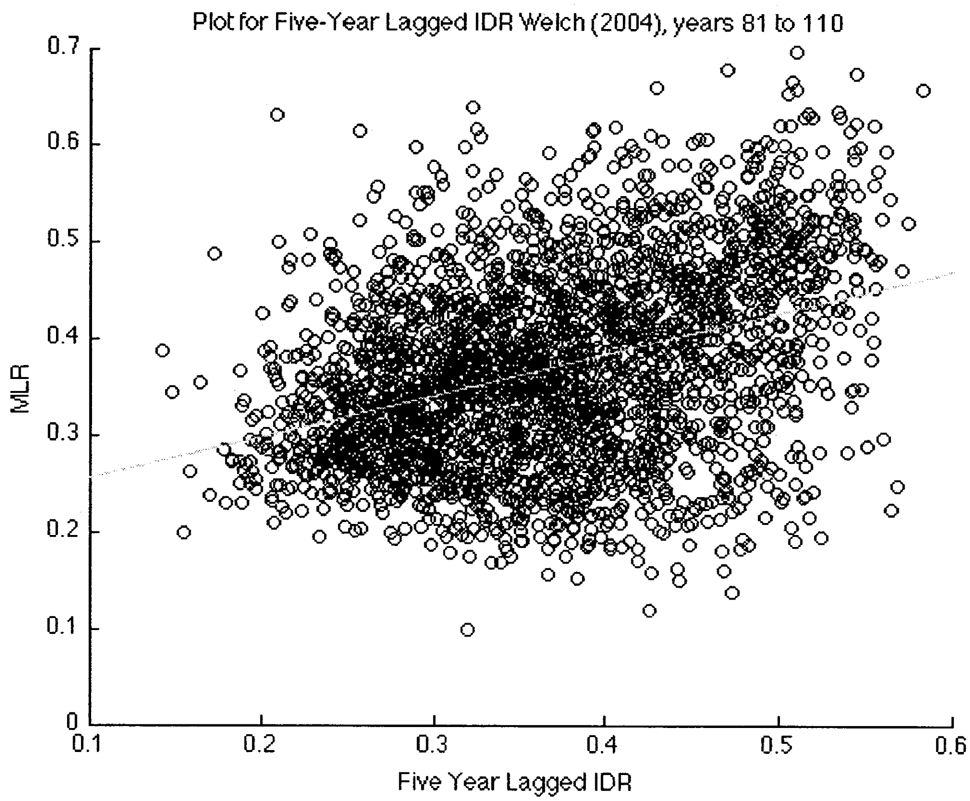

Figure 8.10: Market leverage ratio vs 5 year implied debt ratio, one year lag

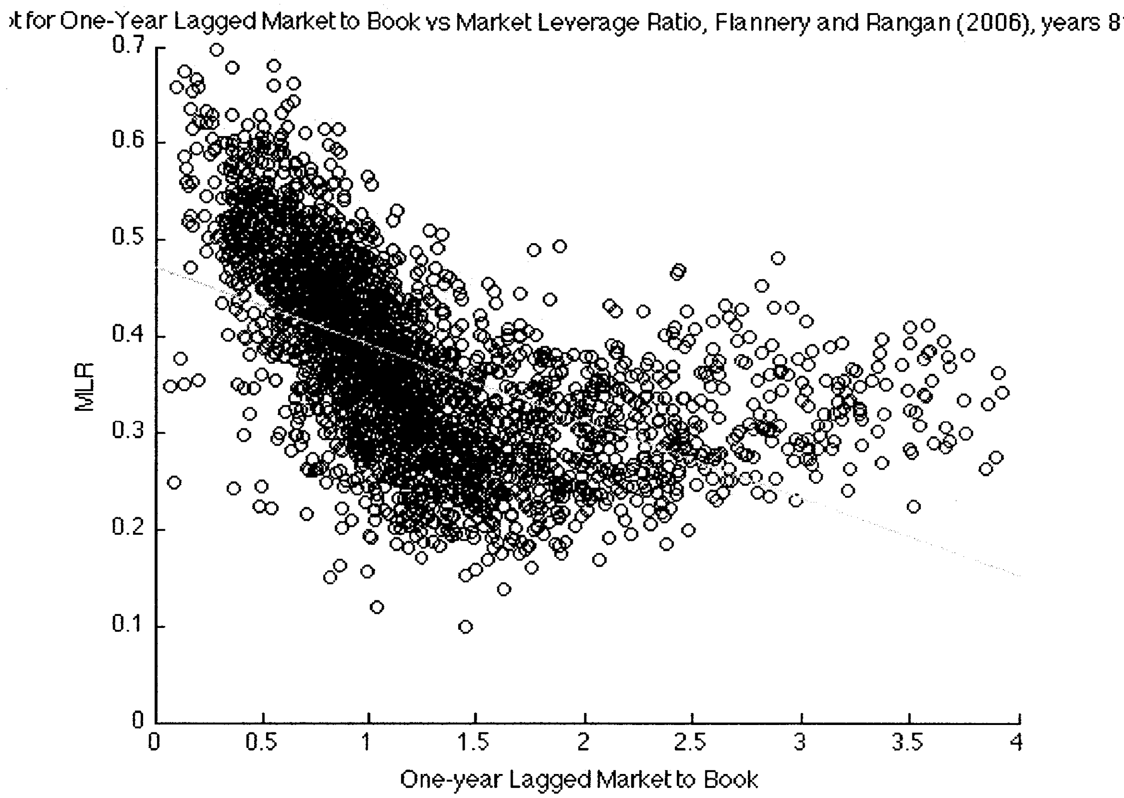

Figure 8.11: Market leverage ratio vs lagged market to book, years 81-110

8.4 Flannery and Rangan (2006)

Finally, we consider the Flannery and Rangan (2006) tests. We use the same sample as in the perfect adjustment case. Figures 8.11, 8.12, and 8.13 give similar results to the case of no target adjustment.

The results are given in Table 8.10 and Equation 8.2. The market to book ratio becomes significant, but the logarithm of book value becomes insignificant. The speed of convergence drops from 19% to 17.51 % per year. The speed of

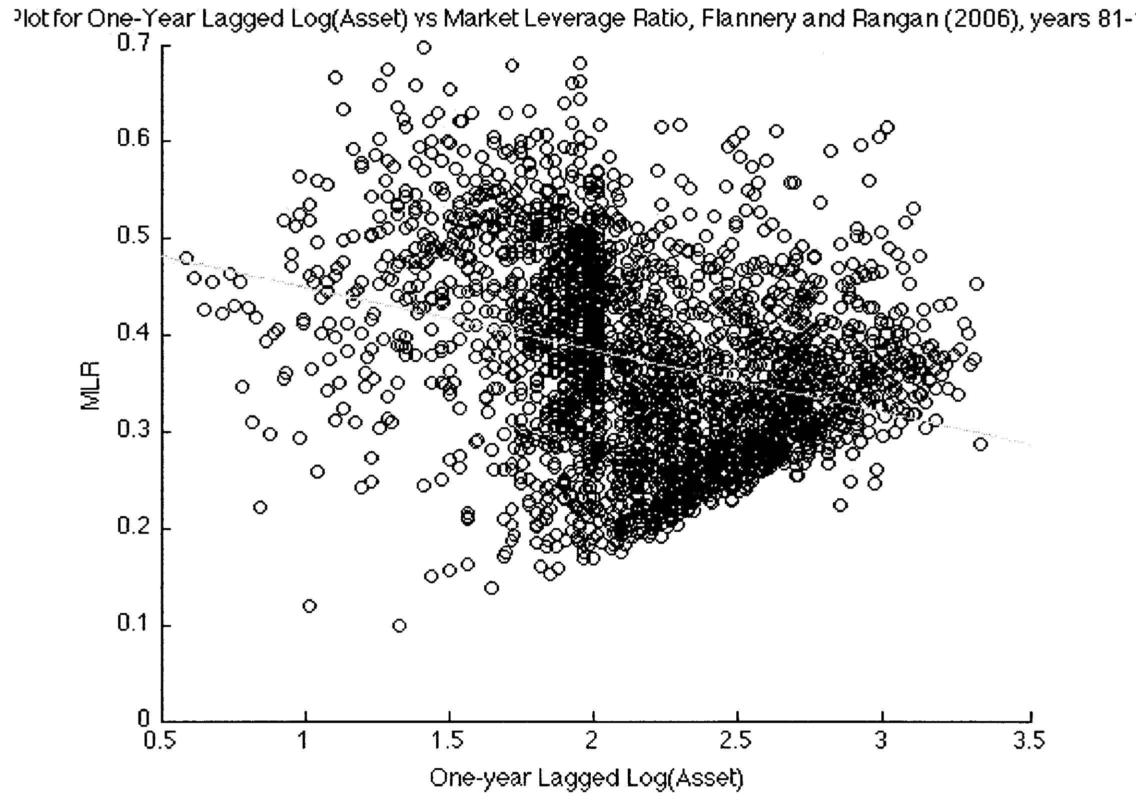

Figure 8.12: Market leverage ratio vs total assets (book value), years 81-110

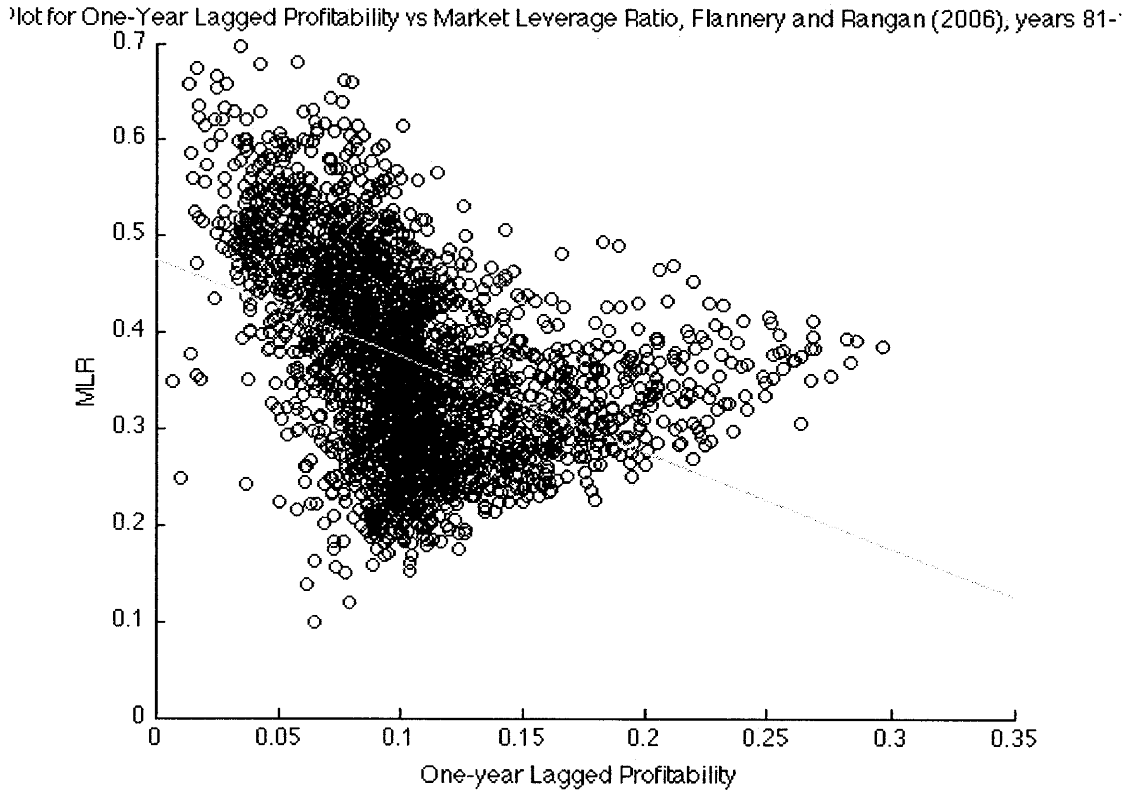

Figure 8.13: Market leverage ratio vs lagged profitability, years 81-110

MLR_t	Coefficient	Standard Error	T Statistic
MLR_{t-1}	.8248721	.0163855	50.34
MTB_{t-1}	.0144428	.0045592	3.17
$LNTA_{t-1}$	.0041249	.003715	1.11
$PROF_{t-1}$	-.2000327	.0689183	-2.90
constant	.0582352	.0095065	6.13

Table 8.10: Flannery and Rangan (2006), 1 year lag

convergence should drop as we introduced target adjustment into the model. It is however surprising that the speed drops by such a small amount.

$$MLR^i_{t+1} - MLR^i_t = 5.82\% + 17.51\%(\beta^* X^i_t - MLR) \tag{8.2}$$

$$\beta^* X^i_t = 8\% MTB + 2.36\% LOGASSET - 114.22\% PROFITABILITY \tag{8.3}$$

9 Conclusion

We introduced a tradeoff model of capital structure which accounts for the presence of real options. In reality, options are very important for firms when they decide their capital structure. We simulate such firms with reasonable parameters and let them leave the sample some probability so that we can get a stationary distribution. Then we evaluate what four of the main capital structure tests tell us the underlying process is when it is really driven by this process.

The pecking order test of Shyam-Sunder and Myers (1999) soundly rejects the pecking order theory, as it should because the pecking order is not present in the data.

Their target adjustment test tells us that firms adjust slowly 10% per year towards a target, whereas in the data they perfectly adjust to a moving target.

The empirical facts of Rajan and Zingales (1995) are confirmed in the simulated data, even though their interpretations do not apply to this data.

Welch (2004) tells us that firms have a great deal of inertia and the main driver for the market leverage is the implied debt ratio, followed to a much lesser extent by lagged market leverage ratio. The behavior of sluggish adjustment does not hold in this data.

Flannery and Rangan (2006) show us that firms move a bit faster than Shyam-Sunder and Myers (1999), at 19% per year toward a target, and also that profitability is very negatively related to the target. This last point is true in the simulated data, but firms are really on target each period.

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