Essays on Dynamic Economies with Frictions

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Abstract

This dissertation consists of three essays. In the first essay, I develop and compare the implications of two closely related dynamic models of corporate capital structure to determine (i) whether costly capital adjustment is important for understanding the observed financial behavior of firms and, (ii) whether time-varying real investment opportunities or time-varying financial frictions are the key driving force behind corporate capital structure variation over time. In the first model, the firm always has real investment opportunities, capital adjustment is frictionless, and time-varying financial frictions in the debt market interact with the firm's choice of capital structure (capital market driven model). In the second model, the firm's real investment opportunities are time-varying, and capital adjustment is costly but there is no time-varying financial friction in the debt market (investment driven model). In the calibrated capital market driven model, the persistence of dividend, debt, and leverage is too low relative to the data. In the calibrated investment driven model, the persistence of dividend, debt, and leverage is reasonably close to the data. This result suggests that time-varying real investment opportunities, rather than time varying financial frictions, are the key driving force behind corporate capital structure variation over time. This finding holds in a model in which the firm faces both time-varying financial frictions, and time-varying real investment opportunities. The paper also shows that costly capital adjustment is important for understanding the observed persistence of dividend, debt, and leverage.

Existing dynamic general equilibrium models have not been fully successful at explaining the high volatility of asset prices that we observe in the data. In the second essay, we construct a general equilibrium model with heterogeneous firms and financial frictions that addresses this issue. In each period only a fraction of firms can start new

projects, which cannot be fully financed externally due to a financial constraint. We allow the tightness of the financial constraint to vary over time. Fluctuations in the tightness of the financial constraint result in fluctuations in the supply of equity and consequently in the price of equity. We calibrate the model to the U.S. data to assess the quantitative importance of fluctuations in the tightness of the financial constraint. The model generates a volatility in the price of equity comparable to the aggregate stock market while also fitting key aspects of the behavior of aggregate quantities.

In third essay, we compare counterfactual corporate bond issuing dates to actual issuing dates in order to test the ability of firms to time the credit market. The 50 most active bond issuing financial firms and the 50 most active industrial firms are studied using one week, one month, and one quarter windows. The ability to time firm-specific CDS prices is studied from January 2002 - October 2009. The ability to time the risk-free rate (10 year US government bond) is studied from January 1988 - October 2009. We find that: firms do not successfully time the risk-free rate or the credit spreads. There is no evidence of CDS timing ability over one week or one month, but there is some borderline evidence at one quarter. For a typical bond issue, the firm loses about 1% of the face value of the bond relative to a 1 month window, due to their inability to time the market. If the firms could improve their market timing, they could save many hundreds of millions of dollars. Since there is a degree of statistical predictability in the data, we find it surprising that these firms are not able to do a better job of timing the credit market.

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Driving Forces of Corporate Capital Structure Variation Over Time

Water is the driving force of all nature. -Leonardo da Vinci

1.1 Chapter Summary

This chapter develops and compares the implications of two closely related dynamic models of corporate capital structure to determine (i) whether costly capital adjustment is important for understanding the observed financial behavior of firms and, (ii) whether time-varying real investment opportunities or time-varying financial frictions are the key driving force behind corporate capital structure variation over time. In the first model, the firm always has real investment opportunities, capital adjustment is frictionless, and time-varying financial frictions in the debt market interact with the firm's choice of capital structure (capital market driven model). In the second model, the firm's real investment opportunities are time-varying, and capital adjustment is costly but there is no time-varying financial friction in the debt market (investment driven model). In the calibrated capital market driven model, the persistence of dividend, debt, and leverage is too low relative to the data. In the calibrated investment driven model, the persistence of dividend, debt, and leverage is reasonably close to the data. This result suggests that time-varying real investment opportunities, rather than time varying financial frictions, are the key driving force behind corporate capital structure variation over time. This finding holds in a model in which the firm faces both time-varying financial frictions, and time-varying real investment opportunities. The chapter also shows that costly capital adjustment is important for understanding the observed persistence of dividend, debt, and leverage.

1.2 Introduction

This chapter develops and compares the implications of two closely related dynamic models of corporate capital structure to determine whether time-varying real investment opportunities or time-varying financial frictions are the key driving force behind corporate capital structure variation over time. In the first model, the firm always has real investment opportunities, capital adjustment is frictionless, and time-varying financial frictions in the debt market interact with the firm's choice of capital structure (capital market driven model). In the second model, the firm's real investment opportunities are time-varying, and capital adjustment is costly but there is no time-varying financial friction in the debt market (investment driven model). An extended version of the investment driven model in which the firm faces time-varying financial frictions in the debt market is also considered. An important motivation for this comparison is the recent literature that advocates capital markets and financial frictions as major determinants of corporate behavior (see, e.g, Baker (2010), Bolton et al. (2010), Morellec (2010)). In the context of the presented models, this chapter also addresses some of the criticisms of dynamic capital structure models posed in Welch (2010).

The two models produce very different implications for the real and financial decisions of firms. The investment driven model performs better than the capital market driven model in explaining the time series of dividend, debt, and leverage of Compustat firms. Accordingly, the investment driven approach, which builds on time-varying real frictions, rather than the capital market driven approach, which builds on time-varying financial frictions, seems to be a better choice for further investigation of corporate capital structure. This finding holds even in the extended version of the investment driven model in which the firm faces time-varying financial frictions.

In both models, the firm's profitability is uncertain and the firm is solving a dynamic problem. The firm chooses dividends, investment, and capital structure. The firm pays taxes on its taxable income. It faces costly bankruptcy risk. There is no transaction cost for issuing debt, but issuing equity is costly. These are the common features of the two models, so similar questions can be asked of the two perspectives. They differ in whether the firm faces time-varying financial frictions in the debt market or time-varying real investment opportunities.

In the capital market driven model, the mechanism through which the capital market affects a firm's capital structure decisions is that creditors lend to the firm at rate $r = \tilde{r} + l$. The $\tilde{r}$ component of r is an endogenous break-even rate that depends on the firm's characteristics. The l component of r is a premium that creditors add to their break-even interest rate and is independent of the firm's characteristics. This premium is assumed to be stochastic. Therefore, the firm's cost of capital is stochastic. This is the time-varying financial friction that the firm faces in the debt market. The stochasticity of the cost of capital implies that the firm changes its capital structure in response not only to profit shocks but also to shocks to the cost of capital.

The debt market variation can be interpreted in several ways. It can be considered simply as a stochastic liquidity premium, or as non-fundamental, opinion-driven changes in investors' behavior. An appealing interpretation is as a "flight to quality". Such a flight introduces a mechanism through which the capital market affects a firm's capital structure decisions.

In the investment driven model, the firm faces no friction in the debt market. Instead there is variation in the availability of future investment projects. The idea is that apart from investment in the depreciated capital, the firm adjusts its capital stock by taking on new projects. However, new projects are not always available. This friction implies that investment responds to the firm's specific real opportunities rather than simply to the firm's profitability. Using data from the Longitudinal Research Database (LRD), covering 12,000 U.S. manufacturing plants over the period 1972-1989, Doms and Dunne (1998) document several aspects of "infrequent" and "large" capital adjustment.[1] Although this type of capital adjustment has typically been taken to be evidence of the existence of fixed costs of investment, it can also be thought of as evidence of infrequent project arrival.

After calibrating the two models, I find that in the capital market driven model, dividend time-series, debt time-series and leverage time-series of simulated firms lack the empirically important degree of persistence. The investment driven model is more successful in generating time-series properties of dividend, debt, and leverage that match those of Compustat firms. In particular, leverage time-series becomes highly persistent, which is due to mainly the nature of the firm's investment decisions. Calibrating an extended version of the investment driven model in which the firm faces debt market variation also shows that adjusting the firm's investment and capital structure in response to the debt market variation significantly reduces the persistence of dividend, debt, and leverage.

The chapter goes beyond the basic comparison of the two models. Although, structural models of capital structure, such as the ones in this chapter, have been popular

[1] For example, more than half of the establishments exhibit capital growth close to 50% in a single year, and more than 25% of an average plant's gross investment over the 17-year period is concentrated in a single year/project. One can expect that aggregation over plants to the company level smooths some of the discreteness observed for individual plants. However, using the Compustat database for the period 1974-1993, Abel and Eberly (2002) find that the distribution of investment rates is positively skewed in a large sample of publicly traded U.S. companies. In other words, investment is also lumpy at the firm level.

(e.g., Hennessy and Whited (2005), Strebulaev (2007), Morellec (2010)) they are not without critics (see, e.g., Welch (2010)). Welch (2010) suggests that structural models need to be tested against plausible alternatives. He suggests a number of alternatives, and I consider some of them.

To be specific, I define a *non-optimal capital structure decision experiment* as an experiment in which the firm uses a simple rule, rather than optimal choices, in selecting its capital structure. For instance, in one experiment the firm is indifferent to any choice of capital structure. In another experiment, the firm chooses its debt level as the 50th percentile of its debt capacity. The approach taken here is similar in spirit to the one used in Chang and Dasgupta (2009). Since the investment driven model performs better than the capital market driven model, the focus is on how the investment driven model performs relative to these non-optimal benchmarks. The evidence supports the importance of the optimality of the firm's decision making.

Welch (2010) also argues that there is little to be learned from dynamic models that could not be learned from a much simpler static model. To address this serious challenge, several experiments are conducted with the investment driven model. The intention is to highlight what we can learn from dynamic models that we could not learn from static models of capital structure. A few examples are as follows. The firms issue debt even when there is no corporate tax benefit to borrowing. The corporate tax benefit to borrowing significantly adds to the persistence of dividend. Investment decisions and sources of financing the investment interact with each other. In response to a drop in the corporate tax rate, there is no significant change in the book leverage.

The main findings of this chapter are as follows:

1. Simulations of the calibrated capital market driven model show that adjusting capital structure in response to variation in the debt market results in persistence of dividend, debt, and leverage that is lower than the observed persistence in the data. This finding holds in the extended version of the investment driven model in which the firm faces variation in the debt market. These results suggest that

time-varying financial frictions do not appear to be a key driving force behind corporate capital structure variation over time.

2. Simulations of the calibrated investment driven model show that one can successfully explain the observed persistence of dividend, debt, and leverage. This result suggests that time-varying real frictions do appear to be a key driving force behind corporate capital structure variation over time.

3. Simulations of the calibrated investment driven model also show that real-frictions-based explanation of the persistence of leverage is an alternative to the financial-frictions-based explanation put forth by Leary and Roberts (2005). Further, firms' production technologies along with the real frictions that they face can be an explanation for the persistence and the variation of leverage across firms documented in Lemmon et al. (2008).

The rest of the chapter is organized as follows. Section 1.3 reviews the current literature. The capital market driven model is presented in Section 1.4. The properties and implications of this model are studied in Section 1.5. The investment driven model is presented in Section 1.6. The properties and implications of this model are studied in Section 1.7. Section 1.8 compares the results of the two models with evidence from Compustat firms. Section 1.9 offers concluding remarks.

1.3 Related Literature

Traditionally the main focus of corporate finance has been on the demand side because of the implicit assumption that the equilibrium supply of capital is perfectly competitive and elastic at a price that reflects the fundamental value of future cash-flows. However, the demand driven theories of corporate capital structure that are built on firm's fundamentals, such as investment opportunities, taxes, financial distress, agency problems, and asymmetric information have recently been called into question (see, e.g., Baker (2010)).

Gan (2007) shows that following the negative shock to the real estate market in Japan in the early 1990s, which affected the financial health of banks, banks curtailed lending, which led to a significant drop in corporate investment. Focusing on the sharp decline of capital flows to the speculative-grade debt market that occurred in 1989, Lemmon and Roberts (2010) show that the supply shock had significant implications for the financing and investment behavior of below-investment-grade firms after 1989. Faulkender and Petersen (2006) show that firms that have access to the public bond markets, as measured by their having a debt rating, have significantly more leverage.

These studies, along with the survey results of Graham and Harvey (2001), have been interpreted as demonstrating that financing decisions are generally governed by the preference of the suppliers of capital rather than by the demand of the user of capital. Subsequently attempts have been made to introduce firm's independent time-varying financial frictions into dynamic models of capital structure to explain the observed behavior of firms (see, e.g., Bolton et al. (2010), and Morellec (2010)).

Bolton et al. (2010) present a continuous time model in which the firm only has access to the equity market. Issuing equity is costly, and there is uncertainty regarding this cost. They use the model to study how equity market timing, which is motivated by the stochastic equity issuance cost, interacts with a firm's cash reserves and investment. I show that when firms have access to the debt market, the issuing cost of equity plays a minor role in the real and financial decisions of the firms.

Morellec (2010) presents a continuous time model with exogenous cash flows in which the firm has one growth option and faces uncertainty regarding its access to the credit market to finance the growth option. He uses the model to explain the "conservative debt policy puzzle" and why firms may appear to time the equity market.

This chapter compares the implications of a capital market driven model and an investment driven model. This comparison, along with the models developed, is novel to the literature and sheds light on the recent departure in the literature relying on the supply side to explain firms' choice of capital structure. The investment driven model is chosen for comparison because firms do not find profitable projects instantly. Therefore, one expects that this friction affects a firm's choice of capital structure. Moreover, the empirical findings in Fama and French (2005) show that large capital structure changes are mainly associated with mergers and acquisitions, which can be thought of as project financing.

This chapter builds on the recent literature on dynamic capital structure. Hennessy and Whited (2005) present a discrete time dynamic model in which investment is frictionless and the firm can only issue default-free debt. They show that a rational dynamic model can be reconciled with the existing capital structure anomalies. Hennessy and Whited (2007) relax the assumption that the firm can only issue default-free debt and use the model to infer the magnitude of financing cost. DeAngelo et al. (2010) present a discrete time dynamic trade-off model, in which the firm can only issue default-free debt and faces an exogenous debt capacity. They show that firms have permanent leverage targets, and they typically forgo large tax benefits of debt to preserve debt capacity that can be tapped to fund their future investment opportunities.

In the capital market driven model, the firm faces variation in the debt market. This is the main feature distinguishing the credit market driven model from the current literature. The firm changes its dividend, investment and capital structure in response to profit shock and shock to the cost of capital driven by the uncertainty in the debt market. In this model, investment is assumed to be frictionless.[2] This assumption is made for two reasons. First, the assumption allows the firm to freely adjust its real activities in response to variation in the debt market, thus giving the capital market model its best chance. Second, it allows a comparison of the model with the investment driven model in which the firm faces friction in its real side. This comparison shows that the real frictions that firms face in practice are important not only for understanding firms' real activities but also for understanding firms' financial activities.

In the investment driven model, the firm faces no variation in the debt market.

[2] This assumption is not uncommon in the literature; see, e.g., Hennessy and Whited (2005) and Hennessy and Whited (2007).

Instead, there is uncertainty about the availability of future investment projects. This is the main feature distinguishing the investment driven model from the current literature. An interpretation of this uncertainty would be an investment technology with time-to-build. However, there is variation across time and across firms for the time that it takes to build projects. There is empirical evidence for this technology (see, e.g., Caballero and Engel (1999)) and to my best knowledge, its effects on the choice of capital structure have not been analyzed. This investment technology has different implications for the choice of capital structure in comparison to models that have a standard adjustment cost in the investment technology (e.g., Bazdresch (2007)), and models with time-to-build in the investment technology (e.g. Tsyplakov (2008)). In capital structure decisions of firms with the same assets and profitability, stochastic project arrival introduces heterogeneity, which does not exist in other models.

There is another strand of research in continuous time dynamic capital structure (e.g., Fischer et al. (1989), Leland (1994), Goldstein et al. (2001), and Strebulaev (2007)). These are dynamic trade-off models with exogenous investment and distribution policies. Firms do not continuously adjust their capital structure as they face a transaction cost to recapitalize. Although, these papers have offered important insights about capital structure decisions, this chapter is not built on them. This is because, empirically, firms rarely issue equity to buy back debt or issue debt to buy back equity, a common assumption in models with exogenous cash flows.

This chapter does not build on theories of capital structure that are based on agency problems and asymmetric information because taking such a model to data to study not only the choice of capital structure but also the dividend payments and investment of a firm is not straightforward. The chosen framework in this paper allows one to analyze the joint behavior of the real and the financial activities of firms. This joint analysis is important in the real world, where Modigliani-Miller assumptions do not hold.

1.4 Capital Market Driven Model

The fundamental object of interest in my work is the understanding of a firm's capital structure and its determinants. This section presents a model in which the interactions among financing frictions, corporate taxation, and costly bankruptcy are the determinants of the firm's capital structure.

The model is built on a micro-founded theory of a firm. The firm chooses its dividend, investment, and capital structure and faces variation in the debt market. Therefore, the firm changes its capital structure in response to profit shocks and to the variation in the debt market.

1.4.1 The Environment

Time is discrete and the horizon infinite. Throughout the chapter, it is assumed that the agents, i.e., the equity holders and the creditors of the firm are risk neutral. The firm enters into period t with capital k_t. The operating profit, denoted by π, depends on capital k_t and profit shock z_t. The operating profit function is

$$\pi(k_t, z_t) = z_t k_t^{\alpha},$$

where $\alpha < 1$ captures the decreasing returns to scale of profit. This occurs in conditions of imperfect competition where the firm faces a downward-sloping demand curve. This profit function should be thought of as that resulting from the determination of the optimal choices for all other static inputs such as labor.

The profit shock, z, follows an AR(1) process in logs

$$\log(z_{t+1}) = \rho \log(z_t) + \sigma\epsilon_{t+1},$$

where ϵ_{t+1} is a standard Gaussian random variable. The parameters ρ and σ are constant parameters that respectively determine the persistence and the volatility of the operating profit of the firm.

The law of motion for the firm's capital is

$$k_{t+1} = (1-\delta)k_t + i_t,$$

where k_{t+1} is the firm's capital in period $t+1$, δ is the depreciation rate of capital, and i_t is the firm's investment in period t. The firm adjusts its capital stock in response to profit shocks and to the cost of capital shocks. Capital stock adjustment is frictionless. Therefore, the firm can adjust its real side without any cost in response to its profitability and the conditions of the debt market. The firm is subject to corporate taxation at rate τ. However, the firm is allowed to use debt as a tax shield by subtracting the debt interest payments from its taxable earnings.

The firm can adjust its capital structure through issuing equity and through issuing one-period defaultable debt. A number of empirical studies have shown that issuing equity is costly (see, e.g., Smith (1977), Altinkilic and Hansen (2000), Hansen (2001), and Corwin (2003)). In the model, for each dollar of external equity paid into the firm, there is a flotation cost of $\lambda > 0$. The firm can borrow in the debt market by issuing one-period defaultable debt. The interest rate on the issued debt is endogenous and is determined by the creditors' problem. Details of the creditors' problem are discussed in the next subsection.

The firm goes bankrupt in states in which its realized net worth is negative, i.e., in states in which even after liquidating its capital, the firm does not have the resources to pay back the maturing debt. The firm enters into period t with debt contract (D_t, r_t). This contract was issued by the firm in period $t-1$. The variable D_t is the issued debt, and r_t is the interest rate on D_t. The net worth of the firm in period t is

$$z_t k_t^{\alpha} + (1-\delta)k_t - (1+r_t)D_t.$$

Therefore, given the firm's capital and its debt contract, the profit shock is the main determinant of the bankruptcy of the firm. If the firm's net-worth is positive, the firm can roll over its debt even in states in which the current realized operating profit is not enough to cover the maturing debt.

In states in which the realized net worth is negative the firm does not have the resources to pay back its matured debt. Therefore, creditors step in and verify the capital stock of the firm. Such verification is costly and leads to a deadweight bankruptcy cost.[3] This structure is inspired by the costly-state-verification paradigm of Townsend (1979) and is often used in the literature (see, e.g., Bernanke et al. (1999), Carlstrom and Fuerst (1997), and Gomes et al. (2003)). Suppose the firm enters into period t with capital k_t, the operating profit is $Q_t = z_t k_t^\alpha$, and the firm declares bankruptcy. Then the dividend paid to its current equity holders would be zero from period t onward. $(1-\kappa)Q_t$ of the operating profit Q_t and $(1-\kappa)(1-\delta)k_t$ of the depreciated capital of $(1-\delta)k_t$ are lost as a result of the firm going bankrupt. The variable κ is the parameter that determines the deadweight bankruptcy cost. The creditors get the post-bankruptcy operating profit of gQ_t and the post-bankruptcy capital of $\kappa(1-\delta)k_t$.

1.4.2 The Creditors' Problem

The creditors' problem determines the interest rate at which creditors lend to the firm. It also determines the debt capacity of the firm. The debt capacity of a firm is defined as the maximum amount of debt that the creditors lend to the firm.

Suppose the firm is solvent in period t with profit shock z_t, capital k_{t+1} in period $t+1$, and debt contract (D_{t+1}, r_{t+1}) issued by the firm in period t. Let z^* denote the solution to $z^* k_{t+1}^\alpha + (1-\delta)k_{t+1} = (1+r_{t+1})D_{t+1}$. For any z' such that $z' \leqslant z^*$, the firm goes bankrupt in period $t+1$.

The ex ante probability of bankruptcy, denoted by ξ, for a firm entering into period $t+1$ with capital k_{t+1} and debt contract (D_{t+1}, r_{t+1}) is

$$\xi(k_{t+1}, D_{t+1}, r_{t+1}) \quad := \quad \int_{-\infty}^{s^*} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(s'-\rho s_t)^2}{2\sigma^2}} ds',$$

where s^* and s are defined as $s^* := \log(z^*)$ and $s_t := \log(z_t)$.

[3] See Carlstrom and Fuerst (1997), and Bernanke et al. (1999) for a similar approach.

The break-even interest rate, denoted by $\tilde{r}_{t+1}$, for the creditors that lend D_{t+1} to the firm satisfies the following equation:

$$\begin{aligned}(1+r_f)D_{t+1} &= (1-\xi)(1+\tilde{r}_{t+1})D_{t+1} \\ &+ \int_{-\infty}^{s^*} \frac{1}{\sqrt{2\pi\sigma^2}}\kappa[e^{s'}k_{t+1}^{\alpha}+(1-\delta)k_{t+1}]e^{-\frac{(s'-\rho s_t)^2}{2\sigma^2}}ds',\end{aligned} \tag{1.4.1}$$

where r_f is the risk-free rate in the economy. The model is one of partial equilibrium. Therefore, r_f is assumed to be exogenous. Term $(1-\xi)(1+\tilde{r}_{t+1})D_{t+1}$ is the expected pay off to the creditors if the firm does not declare bankruptcy in period $t+1$. Term $\int_{-\infty}^{s^*} \frac{1}{\sqrt{2\pi\sigma^2}}\kappa[e^{s'}k_{t+1}^{\alpha}+(1-\delta)k_{t+1}]e^{-\frac{(s'-\rho s_t)^2}{2\sigma^2}}ds'$ is the expected pay off to the creditors if the firm declares bankruptcy in period $t+1$. The creditors do not lend D_{t+1} to the firm if there is no $\tilde{r}_{t+1}$ that satisfies equation (1.4.1).

It is assumed that if the firm goes bankrupt, the managers of the firm walk away. Therefore, the creditors get the capital of the firm priced at the market price of capital, which is assumed to be 1. If one assumes that the creditors get the market value of the firm in the case of bankruptcy, then the creditors can get more than what they loaned to the firm. In practice, however, this rarely happens.

The main question of this chapter is whether capital structure decisions are mainly driven by the capital market or by the firm's investment. To introduce a mechanism through which the capital market affects a firm's capital structure decisions, it is assumed that the creditors add a liquidity premium to their break-even interest rate. The liquidity premium is assumed to be stochastic. Therefore, the firm's cost of capital is uncertain. This uncertainty is independent of the firm's characteristics. The stochasticity of the cost of capital implies that the firm changes its capital structure in response not only to profit shocks but also to shocks to the cost of capital.

"Flight to quality" is the main motivation for the approach taken here to introduce a mechanism through which the capital market affects a firm's capital structure decisions. During expansion periods in the economy, borrowing conditions are loose and the credit market is more competitive. Therefore, creditors lend at a break-even rate. However, during contraction periods in the economy, borrowing conditions become tight and creditors lend at a rate that is above their break-even rate.

It is assumed that the liquidity premium follows a two-state Markov chain.[4] In the "expansion" state of the economy the liquidity premium is assumed to be 0; in the "contraction" state, it is $\bar{l}$. The transition probability matrix for the liquidity premium is

$$Q_l = \begin{bmatrix} q_{11} & 1 - q_{11} \\ 1 - q_{22} & q_{22} \end{bmatrix}$$

The state of the liquidity premium and its transition matrix are known by both the firm and its creditors.

The creditors interact with the firm's choice of capital structure through two channels: 1) the interest rate at which they lend to the firm, and 2) the debt capacity that they impose on the firm. The current literature mainly ignores the debt capacity imposed on the firm by the creditors. However, in the model, the debt capacity of a firm plays a significant role in the firm's choice of capital structure. This is consistent with the survey evidence of Graham and Harvey (2001) in which CFOs cite credit ratings and financial flexibility as very important determinants of their debt policy.

The debt capacity of the firm is an endogenous variable that is determined by the break-even condition for the creditors. The creditors are not going to lend D_{t+1} to the firm if there is no interest rate $\tilde{r}_{t+1}$ that satisfies the break-even condition for them. Note that the expected pay off of the creditors is not an increasing function of the interest rate at which they lend to the firm. This is because the increase of the debt interest rate leads to a concurrent increase in the probability of the firm declaring bankruptcy. The debt capacity of a firm is a function of the firm's capital and its current profit shock. In the case of two firms with the same profit shock, a large firm can borrow more than a

[4] It is straightforward to extend the model to allow for more states, but such an extension does not change the main insight of the chapter.

small firm. In the case of two firms of the same size, a profitable firm can borrow more than a not-profitable firm.

The stochastic liquidity premium approach that is taken here is closely related to an alternative approach in which one assumes that the creditors' opportunity cost of capital is stochastic. In the current setup, the debt capacity of the firm only depends on the firm's characteristics. However, if one works with the alternative approach, the debt capacity of the firm would have a component that is independent of the firm's characteristics. The model has a better chance of success with the first approach, although the second approach is of interest too.

1.4.3 The Firm's Problem

The firm enters into period t with capital k_t and debt contract (D_t, r_t). This contract was issued by the firm in period $t-1$. The variable D_t is the issued debt, and r_t is the interest rate on D_t. The operating profit shock, i.e. z_t is realized. If the net worth, i.e., $z_t, k_t^\alpha + (1-\delta)k_t - (1+r_t)D_t$ is positive, the firm remains solvent. If the firm remains solvent, it pays its taxes and decides how much dividend to pay (or equivalently, how much equity to issue), how much debt to issue, and how much to invest.

The budget constraint for the firm in period t is

$$d_t = z_t k_t^\alpha + D_{t+1} - (1+r_t)D_t - i_t - \tau(z_t k_t^\alpha - \delta k_t - r_t D_t)1_{z_t k_t^\alpha - \delta k_t \geqslant r_t D_t}$$

where d_t is the dividend paid to the equity holders. If $d_t < 0$, the firm issues equity in period t. $z_t k_t^\alpha$ is the operating profit. D_{t+1} is the issued debt in period t, which matures in period $t+1$. i_t is the firm's investment. τ is the corporate tax rate, and $(z_t k_t^\alpha - \delta k_t - r_t D_t)1_{z_t k_t^\alpha - \delta k_t \geqslant r_t D_t}$ is the taxable income of the firm, which is equal to the operating profit less economic depreciation less interest expense. The firm enters into period $t+1$ with capital $k_{t+1} = (1-\delta)k_t + i_t$ and debt contract (D_{t+1}, r_{t+1}).

The objective of the managers of the firm is to maximize the value of the firm. The value of the firm is the discounted value of the dividend paid to its equity holders. Let variables with primes denote future values. The Bellman equation that determines the value of the firm and its real and financial decisions is

$$
\begin{aligned}
& V(s,l,k,D,r) = \max_{D',i} \{(1+\lambda 1_{d<0})d \\
& \qquad +\beta \left(\sum_{l'} Q_l(l,l') \int_{s^*}^{\infty} \frac{1}{\sqrt{2\pi\sigma^2}} V(s',l',k',D',\tilde{r}'+l) e^{\frac{(s'-\rho s)^2}{2\sigma^2}} ds' \right) \} \\
& s.t. \\
& d = e^s k^\alpha + D' - (1+r)D - i - \tau(e^s k^\alpha - \delta k - rD) 1_{e^s k^\alpha - \delta k \geqslant rD} \\
& (1+r_f)D' = (1-\xi)(1+\tilde{r}')D' + \\
& \qquad \int_{-\infty}^{s_b^*} \frac{1}{\sqrt{2\pi\sigma^2}} \kappa [e^{s'} k'^\alpha + (1-\delta)k'] e^{-\frac{(s'-\rho s)^2}{2\sigma^2}} ds' \\
& s^* = \log((1+\tilde{r}'+l)D' - (1-\delta)k') - \alpha \log k' \\
& s_b^* = \log((1+\tilde{r}')D' - (1-\delta)k') - \alpha \log k' \\
& \xi = \int_{-\infty}^{s_b^*} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(s'-\rho s)^2}{2\sigma^2}} ds' \\
& k' = (1-\delta)k + i \\
& k' \geqslant 0, D' \geqslant 0
\end{aligned}
\tag{1.4.2}
$$

V is the value of a solvent firm. This is the value of the firm after the profit shock and shock to the cost of capital are realized. $s = \log(z)$, and z is the realized profit shock in period t. l is the realized liquidity premium in period t. k is the firm's capital in period t. D is the debt maturing in period t, and r is the interest rate on D. d is the dividend paid to equity holders in period t. In Problem (1.4.2): 1) equation $d = e^s k^\alpha + D' - (1+r)D - i - \tau(e^s k^\alpha - \delta k - rD) 1_{e^s k^\alpha - \delta k \geqslant rD}$ is the budget constraint for the firm in period t, 2) equation $(1+r_f)D' = (1-\xi)(1+\tilde{r}')D' + \int_{-\infty}^{s_b^*} \frac{1}{\sqrt{2\pi\sigma^2}} [\kappa(e^s k'^\alpha + (1-\delta)k')] e^{\frac{(s'-\rho s)^2}{2\sigma^2}} ds'$ determines the break-even rate for the creditors, 3) equation $s^* = \log((1+\tilde{r}'+l)D' - (1-\delta)k') - \alpha \log k'$ determines the threshold for the profit shock such that for any shock s' such that $s' < s^*$ the firm goes bankrupt, 4) equation $s_b^* = \log((1+\tilde{r}')D' - (1-\delta)k') - \alpha \log k'$ is the threshold shock for the creditors' break-even rate, 5) equation $\xi_b = \int_{-\infty}^{s^*} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(s'-\rho s)^2}{2\sigma^2}} ds'$ determines the bankruptcy probability for the creditors' break-even rate, 6) equation $k' = (1-\delta)k + i$ is the law of motion for the firm's capital, 7) inequality $k' \geqslant 0$ implies that the firm can disinvest but should have positive capital in each period, and 8) inequality $D' \geqslant 0$ implies that the firm is not allowed to save.

1.5 Quantitative Discussion of the Capital Market Driven Model

This section discusses the choice of parameters of the model and the method used to solve the model. It then proceeds with the results of the baseline capital market driven model, in which the creditors lend to the firm at a break-even rate. Following this subsection, the results of the capital market driven model are presented. The intention in discussing the results in such a way is to highlight the role played by each building block of the model.

1.5.1 The Choice of Parameters and Model Solution

The degree of returns to scale of the operating profit function is set to be $\alpha = 0.689$, the same as that in Cooper and Ejarque (2003). The annual depreciation rate is set to be $\delta = 0.12$, the empirical estimate in Cooper and Haltiwanger (2006). The subjective discount factor is set to be $\beta = 0.98$, which corresponds to a real annual risk-free rate of $r_f = 0.02$. The equity flotation cost is set to be $\lambda = 0.07$, the empirical estimate in Lee et al. (1996), in which they find that the average firm pays around 7% of the total proceeds to raise capital through a seasoned equity offering (SEO). The parameter that determines the deadweight bankruptcy cost is set to be $\kappa = 0.78$, which is in line with recent empirical estimates in Hennessy and Whited (2007). The persistence of profit shock to is set to be $\rho = 0.65$ and the volatility of the profit shock to $\sigma = 0.15$, similar to those in Gomes (2001). The corporate tax rate is set to be $\tau = 35\%$, the statutory corporate tax rate over 1993-2010. Whenever there is no general consensus in the empirical literature regarding the value of parameters, comprehensive sensitivity analyses are conducted.[5]

The model is solved numerically on grids of profit shock, capital, and debt using the value function iteration method. The profit shock process is transformed into a discrete-state Markov chain using the method in Adda and Cooper (2003). The capital grid and the debt grid are determined as follows.

For any chosen set of parameters of the model, the steady state level of capital of an all-equity-financed firm with an equity flotation cost of 0 is determined. A capital grid is chosen around the steady state level of capital. The problem of the all-equity-financed firm on the chosen capital grid is solved. If the solution of the problem is such that the boundaries of the capital grid are binding, then the capital grid is expanded.

The debt capacity of the firm is determined next. The debt capacity of a firm depends on its capital and its profitability. An iterative method is used to find the debt capacity for capital and profit shock on the grids of capital and profit shock, respectively. Let $D_{Max}(k, z)$ denote the debt capacity of a firm with capital k and profit shock z. The iterative method starts with $D_{Max} = (1 - \delta)k$. Equation (1.4.1) is solved as a function of $\tilde{r}$. If there is a $\tilde{r}$ such that equation (1.4.1) is satisfied, D_{Max} is increased. Equation (1.4.1) is solved with the new D_{Max}. This iteration is done until there is no interest rate that satisfies equation (1.4.1). The last D_{Max} that satisfied equation (1.4.1) is chosen as the debt capacity of the firm with capital k and profit shock z. In each step, D_{Max} is increased by small steps to ensure that the numerical procedure gets close to the debt

[5] In this chapter, I do not estimate the parameters of a model by matching moments of the simulated model to those of the data. Although parameter estimation using moment matching can be informative, it also has shortcomings. For instance, estimating the parameters of the profit shock process using moments of investment in a model with no investment friction results in a profit volatility that is much smaller than that estimated using firm-level data. Another example is a capital structure model in which corporate tax code is parameterized and the moment-matching approach is used to estimate the parameters of the tax code. The tax code, although complicated, is known. Attempts to match moments of the model to those in data while treating the tax parameters as free parameters can hide the main forces in the model. This is especially problematic in models in which one cannot evaluate the estimated parameters with empirical data.

capacity. For each (k, z) on the grids of capital and profit shock, the debt capacity is determined using the iterative method just discussed. A debt grid is chosen for every (k, z), over $[0, D_{Max}(k, z)]$. For each $D \in [0, D_{Max}(k, z)]$, the break-even rate for the creditors is determined.

1.5.2 Baseline Capital Market Driven Model Results

This section presents the results of simulating the baseline capital market driven model, in which the creditors lend to the firm at a break-even rate.

Properties of the Investment and Financing Policies in the Baseline Capital Market Driven Model

Consider two firms named A_L and A_H that enter into period t with capital k. In period t, firm A_H has a high profit shock and firm A_L has a low profit shock. Figure 1.5.2 shows 1) the optimal leverage ratios of these firms and 2) the optimal investment of these firms. It can be seen that 1) the higher the profitability, the higher the leverage, and 2) the higher the profitability, the larger the investment.

Figure 1.5.2 also shows that in contrast to the data, as the firm's capital stock increases, its leverage decreases. In other words, undercapitalized firms with growth opportunity have high leverage, and overcapitalized firms with negative growth opportunity have low leverage.[6] Why does leverage decrease as capital stock increases? In the absence of an equity flotation cost, since there is no friction in the firms' real side, the undercapitalized firm and the overcapitalized firm invest such that they have the same capital in the next period. Therefore, the debt capacity of both firms is the same, because debt capacity is only a function of capital and profit shock. However, the market value of the overcapitalized firm is larger than the market value of the undercapitalized firm. Therefore, the leverage decreases as the capital stock of the firm

[6] A firm is defined to be undercapitalized if the firm finds it optimal to invest. A firm is defined to be overcapitalized if the firm finds it optimal to disinvest.

increases. Due to the flotation cost of issuing equity, the optimal level of capital would not be the same for firms with different levels of capital even when they have the same profit shock. However, Figure 1.5.2 shows that in the calibrated model, as the firm's capital stock increases, its leverage decreases.

These results imply that one cannot ignore the frictions that a firm faces in its real side since such frictions affect not only the firm's real side but also its financial side.

Benchmark Results

This subsection shows the results of simulated panels of firms in the baseline capital market driven model. Simulated panels of One thousand firms are constructed as follows. For each firm, a sequence of profit shocks is generated using the transition matrix governing the profit shock process. Each firm is initialized with some level of capital and debt. Using the sequence of profit shock, the value of the firm, optimal investment, and capital structure are determined in each period. The sequence of profit shocks is 200, and the first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point.

Table 1.1 shows the results of simulated panels of firms with benchmark parameters. The table also shows the results of 1) a simulated panel of all-equity-financed firms, and 2) a simulated panel of firms for which there is no corporate tax benefit to borrowing. In this table, 1) Tobin's Q is defined as the firm's market value of equity plus the firm's debt divided by the firm's capital plus the firm's debt. 2) Book leverage is defined as the firm's debt divided by the firm's debt plus the firm's capital. 3) Market leverage is defined as the firm's debt divided by the firm's debt plus the firm's market value of equity.

The variations of the model presented in Table 1.1 highlight that 1) investment and available financing sources significantly interact with each other, 2) the firm borrows even in the absence of corporate tax benefit to borrowing, and 3) capital structure models with exogenous cash flows are not appropriate to analyze the capital structure decisions of firms. Table 1.1 also shows that having access to the debt market when debt interest payments are tax deductible significantly increases the persistence of dividend payments.

Why does the firm borrow even when there is no tax benefit to doing so? It borrows because issuing equity is costly. Therefore, the firm invests less than the "optimal"[7] amount when it does not have access to the debt market. Having access to the debt market even in the absence of tax benefits to borrowing allows the firm to move closer to the "optimal"[7] level of investment.

Why aren't capital structure models with exogenous cash flows appropriate to analyze the capital structure decisions of firms? The reason is because the value of a levered firm is not equal to the value of an all-equity-financed firm plus the tax benefits of debt. The investment choices of an all-equity-financed firm and a levered firm with the same profit shocks are different. So are their cash flows, as well as their values.

1.5.3 Capital Market Driven Model Results

This subsection discusses the results of simulating the capital market driven model, in which the cost of capital for the firm's creditors is not constant. The liquidity premium is assumed to be driven by business cycle fluctuations. Therefore, the transition matrix for the liquidity premium is calibrated using the EM algorithm of Hamilton (1989). Quarterly real GDP for the time period 1950-2009 is used. The average duration of the expansion state is 16.4 quarters and 3.3 quarters for the recession state. The probability of transition from expansion state to expansion state is 0.94. The probability of transition from contraction state to contraction state is 0.7. Therefore, for the annual data, the transition matrix for the liquidity premium is

$$Q_l = \begin{bmatrix} 0.8613 & 0.1387 \\ 0.3065 & 0.6935 \end{bmatrix}.$$

[7] "Optimal" here refers to the optimal level of investment in the absence of an equity flotation cost.

Table 1.1: Baseline Capital Market Driven Model Results with Benchmark Parameters
Panel data are generated using the baseline capital market driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. The AEF column represents an economy in which firms are all-equity-financed. The NTB column represents an economy in which there is no tax benefit to borrowing. The BM column represents an economy with benchmark parameters.

	AEF	NTB	BM
Average investment to total assets	0.12	0.17	0.17
Volatility of investment to total assets	0.09	0.35	0.34
Average size	132.9	148.2	185.9
Average dividend to total assets	0.08	0.05	0.04
Frequency of equity issuance	0.18	0.00	0.00
Average equity issuance to total assets	0.03	0.00	0.00
Average Tobin's Q	3.43	2.19	1.63
Average book leverage	-	0.38	0.50
Average market leverage	-	0.20	0.32
Persistence of dividend/assets	0.04	-0.01	0.06
Persistence of debt/assets	-	0.52	0.55
Persistence of leverage	-	0.53	0.57

Table 1.2: The Capital Market Driven Model: Low Profit Volatility Firms
Panel data are generated using the capital market driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. The volatility of profit shock is set to be $\sigma = 0.15$.

$\lambda \rightarrow$	7%			2%		
$\bar{l} \rightarrow$	0.5%	1%	2%	0.5%	1%	2%
Average investment to total assets	0.17	0.17	0.20	0.17	0.17	0.19
Volatility of investment to total assets	0.33	0.35	0.45	0.33	0.35	0.41
Average size	173.8	171.41	171.9	173.2	171.4	166.3
Average dividend to total assets	0.04	0.04	0.04	0.05	0.04	0.05
Frequency of equity issuance	0.00	0.00	0.02	0.08	0.01	0.10
Average equity issuance to total assets	0.00	0.00	0.00	0.04	0.00	0.01
Average Tobin's Q	1.73	1.74	1.79	1.72	1.74	1.80
Average book leverage	0.49	0.49	0.49	0.49	0.49	0.48
Average market leverage	0.30	0.30	0.29	0.30	0.30	0.29
Persistence of dividend/assets	-0.02	-0.08	-0.16	-0.16	-0.09	-0.19
Persistence of debt/assets	0.46	0.38	0.29	0.46	0.44	0.28
Persistence of leverage	0.58	0.57	0.461	0.59	0.57	0.46

Table 1.2 shows the results of the simulated panel of firms in economies in which the liquidity premium is $\bar{l} = 0.005$, $\bar{l} = 0.01$, and $\bar{l} = 0.02$. (give some reference for this range.) Table 1.2 shows that as the liquidity premium increases, 1) the volatility of investment increases significantly, 2) the persistence of dividend drops significantly, and 3) the persistence of debt and leverage drop.

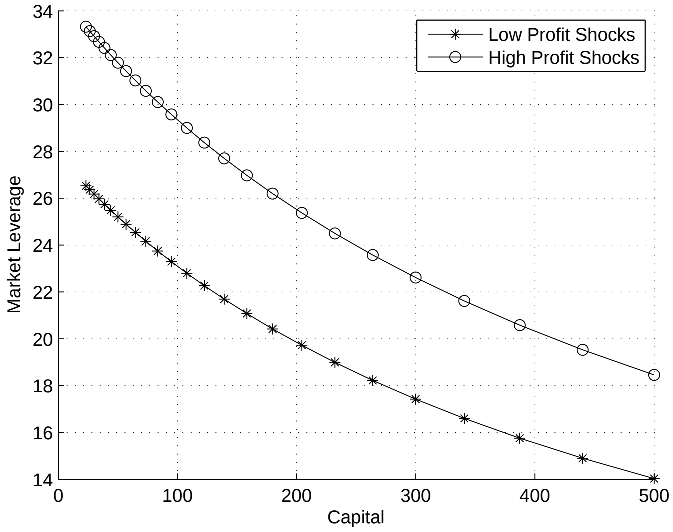
Table 1.2 shows the results of simulated panels of firms in economies in which the volatility of profit shock is $\sigma = 15\%$. It can be seen that for both low and high issuing cost of equity, 1) the higher the liquidity premium, the higher the volatility investment, and 2) the higher the liquidity premium, the lower the persistence of the dividend. Table 1.3 shows the results of a simulated panel of firms in economies in which the volatility of profit shock is $\sigma = 35\%$. It can be seen that for both low and high issuing cost of equity, the higher the liquidity premium the lower the persistence of the dividend.

Table 1.3: The Capital Market Driven Model: High Profit Volatility Firms
Panel data are generated using the capital market driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. The volatility of profit shock is set to be $\sigma = 0.35$.

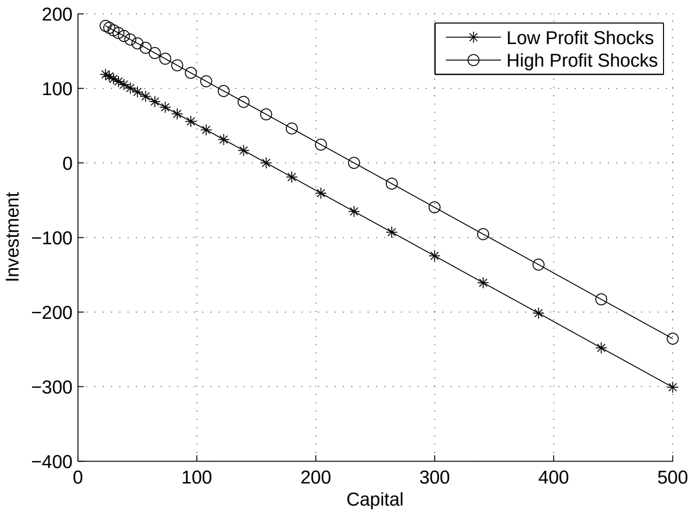
$\lambda \rightarrow$	7%			2%		
$\bar{l} \rightarrow$	0.5%	1%	2%	0.5%	1%	2%
Average investment to total assets	0.38	0.39	0.38	0.40	0.41	0.41
Volatility of investment to total assets	0.92	0.95	0.94	1.05	1.04	1.03
Average size	236.3	231.9	224.6	236.3	233.0	223.7
Average dividend to total assets	0.04	0.04	0.05	0.04	0.04	0.06
Frequency of equity issuance	0.08	0.08	0.11	0.13	0.17	0.27
Average equity issuance to total assets	0.02	0.02	0.03	0.10	0.05	0.06
Average Tobin's Q	2.65	2.71	2.84	2.60	2.66	2.79
Average book leverage	0.47	0.47	0.44	0.48	0.48	0.46
Average market leverage	0.25	0.24	0.22	0.25	0.24	0.23
Persistence of dividend/assets	0.17	0.06	-0.05	-0.01	-0.02	-0.05
Persistence of debt/assets	0.38	0.30	0.27	0.54	0.25	0.26
Persistence of leverage	0.58	0.57	0.499	0.57	0.56	0.52

Figure 1.1: Leverage, Investment, and Profit Shock in the Baseline Capital Market Driven Model

Leverage and Profit Shock



Investment and Profit Shock



Description: The baseline capital market driven model is solved with benchmark parameters. The upper figure shows 1) the optimal leverage of a firm with a low profit shock in period t and 2) the optimal leverage of a firm with a high profit shock in period t. The lower figure shows 1) the optimal investment of a firm with a low profit shock in period t, and 2) the optimal investment of a firm with a high profit shock in period t.

1.6 Investment Driven Model

Section 1.4 began with the statement that the fundamental object of interest in my work is the understanding of the capital structure of a firm and its determinants. Toward this goal, a model was presented in which the firm was not facing any friction in its real side. The interactions among time-varying financial frictions, corporate taxation, and costly bankruptcy were the determinants of capital structure.

Section 1.8 compares the results of the credit market driven model with the data and shows that it fails to describe the observed behavior of firms along a few dimensions. In particular, the model fails to reconcile the moments of investment and the persistence of dividend, debt, and leverage with the data.

This section presents a model in which a firm's capital structure is determined through interactions among the firm's collection of projects, financing frictions, corporate taxation, and costly bankruptcy. In contrast to the capital market driven model, there is no firm's independent variation in the debt market. However, there is uncertainty about the availability of future investment projects. To avoid repetition, only the features of the model that are different from those of capital market driven model are described. The exclusion of the common features of the two models also highlights the driving forces of the results.

1.6.1 The Environment

The law of motion for the firm's capital is different from the capital market driven model. The firm enters into period t with capital k_t. The firm's capital depreciates at rate δ. In each period, the firm can do maintenance on its depreciated capital to maintain its capital at k_t. However, the firm may not be able to increase its capital stock beyond k_t in period t if a new project does not become available.

In each period, a project becomes available with probability p. When a project becomes available, undertaking the project requires an immediate investment. Projects cannot be delayed. Suppose in period t the firm has capital k_t and a project becomes available. The investment required to undertake the project is $f(k_t)$, which is indivisible.[8] Therefore, projects are all or nothing, i.e., the firm cannot take only part of a project. This way of modeling investment is motivated by the evidence that plant-level and firm-level investment is lumpy and infrequent. (See, e.g., Doms and Dunne (1998), Caballero, Engel and Haltiwanger (1995), Caballero and Engel (1999), Cooper and Haltiwanger (2006), Favilukis and Lin (2010)). See also Berk et al. (1999) for a similar structure.

The firm can disinvest in every period. The firm can at most disinvest $g(k_t)$.[8] This way of modeling disinvestment is motivated by the evidence that asset sales occur in discrete amounts and the transactions typically involve a significant fraction of firms' assets. As a starting point for this research agenda, it is assumed that $f(.)$ and $g(.)$ are linear functions of the firm's capital. In other words, the firm cannot optimize the size of the investment project, nor the size of disinvestment. This assumption has been made solely for the purpose of simplification. (See Berk et al. (1999) for a similar assumption.)

1.6.2 The creditors' Problem

The creditors' problem is the same as in the capital market driven model, except that the creditors do not add any liquidity premium to their break-even rate.

1.6.3 The Firm's Problem

The firm enters into period t with capital k_t and debt contract (D_t, r_t). This contract was issued by the firm in period $t-1$. The variable D_t is the issued debt, and r_t is the interest rate on D_t. The operating profit shock, i.e., z_t, is realized. If the net worth, i.e. $z_t k_t^\alpha + (1-\delta)k_t - (1+r_t)D_t$ is positive, the firm remains solvent. If the firm remains solvent, it pays its taxes and decides how much dividend to pay (or equivalently how much equity to issue), how much debt to issue, whether to take or reject a project if it

[8] Functions f(.) and g(.) are known and deterministic. It is straightforward to extend the model to allow for projects with stochastic size, but such an extension does not change the main insight of the chapter.

has one, make maintenance on the depreciated capital or disinvest.

Suppose a project does not become available in period t. Then the budget constraint for the firm in period t is

$$d_t = z_t k_t^\alpha + D_{t+1} + \Phi_l g(k_t) - (1+r_t)D_t - i_t - \tau(z_t k_t^\alpha - \delta k_t - r_t D_t)1_{z_t k_t^\alpha - \delta k_t \geqslant r_t D_t}$$

where d_t is the dividend paid to the equity holders. $z_t k_t^\alpha$ is the operating profit and D_{t+1} is the issued debt in period t, which matures in period $t+1$, and $\Phi_l \in \{0,1\}$ is a choice variable. If the firm disinvests in period t then $\Phi_l = 1$, otherwise $\Phi_l = 0$. i_t is the firm's "maintenance" investment, which is constrained by $0 \leqslant i_t \leqslant \delta k_t$. τ is the corporate tax rate, and $(z_t k_t^\alpha - \delta k_t - r_t D_t)1_{z_t k_t^\alpha - \delta k_t \geqslant r_t D_t}$ is the taxable income of the firm, which is equal to the operating profit less economic depreciation less interest expense. The firm enters into period $t+1$ with capital $k_{t+1} = (1-\delta)k_t - \Phi_l g(k_t) + i_t$ and debt contract (D_{t+1}, r_{t+1}).

Suppose a project becomes available in period t. Then the budget constraint for the firm in period t is

$$d_t = z_t k_t^\alpha + D_{t+1} + \Phi_l g(k_t) - (1+r_t)D_t - i_t - \Phi_p f(k_t) - \tau(z_t k_t^\alpha - \delta k_t - r_t D_t)1_{z_t k_t^\alpha - \delta k_t \geqslant r_t D_t}$$

where $\Phi_p \in \{0,1\}$ is a choice variable. If the firm takes the project then $\Phi_p = 1$, otherwise $\Phi_p = 0$. The firm enters into period $t+1$ with capital $k_{t+1} = (1-\delta)k_t - \Phi_l g(k_t) + i_t + \Phi_p f(k_t)$ and debt contract (D_{t+1}, r_{t+1}).

The objective of the managers of the firm is to maximize the value of the firm. The value of the firm is the discounted value of the dividend paid to its equity holders. Let variables with primes denote future values. The Bellman equations that determine the value of the firm and its optimal real and financial decisions are as follows:

$$
\begin{aligned}
V_0(s,k,D,r) \quad = \quad & \max_{i,D',\Phi_l} \{(1+\lambda 1_{d<0})d \\
& \quad +\beta\left((1-p)\int_{s^*}^{\infty}\frac{1}{\sqrt{2\pi\sigma^2}}V_0(s',k',D',r')e^{\frac{(s'-\rho s)^2}{2\sigma^2}}ds' \right.\\
& \quad \left. +p\int_{s^*}^{\infty}\frac{1}{\sqrt{2\pi\sigma^2}}V_1(s',k',D',r')e^{\frac{(s'-\rho s)^2}{2\sigma^2}}ds'\right)\Big\}
\end{aligned}
$$

s.t.

$$
\begin{aligned}
& d = e^s k^\alpha + D' + g(k)\Phi_l - (1+r)D \\
& -i - \tau(e^s k^\alpha - \delta k - rD)1_{e^s k^\alpha - \delta k \geqslant rD} \\
& (1+r_f)D' = (1-\xi)(1+r')D' \\
& \quad + \int_{-\infty}^{s^*}\frac{1}{\sqrt{2\pi\sigma^2}}[\kappa(e^{s'}k'^\alpha + (1-\delta)k')]e^{\frac{(s'-\rho s)^2}{2\sigma^2}}ds' \\
& s^* = \log((1+r')D' - (1-\delta)k') - \alpha\log k' \\
& \xi = \int_{-\infty}^{s^*}\frac{1}{\sqrt{2\pi\sigma^2}}e^{-\frac{(s'-\rho s)^2}{2\sigma^2}}ds' \\
& k' = (1-\delta)k - g(k)\Phi_l + i \\
& \delta k \geqslant i \geqslant 0 \\
& D' \geqslant 0 \qquad (1.6.1)
\end{aligned}
$$

$$
\begin{aligned}
V_1(s,k,D,r) &= \max_{i,D',\Phi_l,\Phi_p} \{(1+\lambda 1_{d<0})d \\
&\quad +\beta\left((1-p)\int_{s^*}^{\infty}\frac{1}{\sqrt{2\pi\sigma}}V_0(s',k',D',r')e^{\frac{(s'-\rho s^2}{2\sigma}}ds'\right. \\
&\quad \left.+p\int_{s^*}^{\infty}\frac{1}{\sqrt{2\pi\sigma^2}}V_1(s',k',D',r')e^{\frac{(s'-\rho s)^2}{2\sigma}}ds'\right)\Big\}
\end{aligned}
$$

s.t.

$$
\begin{aligned}
& d = e^s k^\alpha + D' + g(k)\Phi_l - (1+r)D \\
& -i - \Phi_p f(k) - \tau(e^s k^\alpha - \delta k - rD)1_{e^s k^\alpha - \delta k \geqslant rD} \\
& (1+r_f)D' = (1-\xi)(1+r')D' \\
& \quad + \int_{-\infty}^{s^*}\frac{1}{\sqrt{2\pi\sigma^2}}[\kappa(e^{s'}k'^\alpha + (1-\delta)k')]e^{\frac{(s'-\rho s)^2}{2\sigma^2}}ds' \\
& s^* = \log((1+r')D' - (1-\delta)k') - \alpha\log k' \\
& \xi = \int_{-\infty}^{s^*}\frac{1}{\sqrt{2\pi\sigma^2}}e^{-\frac{(s'-\rho s)^2}{2\sigma^2}}ds' \\
& k' = (1-\delta)k - g(k)\Phi_l + i + f(k)\Phi_p \\
& \delta k \geqslant i \geqslant 0 \\
& D' \geqslant 0
\end{aligned}
\tag{1.6.2}
$$

V_0 is the value of a solvent firm if it does not have a new project in period t. V_1 is the value of the firm if a new project becomes available in period t. $s = \log(z)$ and z is the realized profit shock in period t. k is the firm's capital in period t. D is the debt maturing in period t and r is the interest rate on D. d is the dividend paid to equity holders in period t. Term $(1-p)\int_{s*}^{\infty}\frac{1}{\sqrt{2\pi\sigma^2}}V_0(s',k',D',r')e^{\frac{(s'-\rho s)^2}{2\sigma^2}}ds'$ represents the expected value of a solvent firm in period $t+1$ if no project becomes available in period $t+1$. Term $p\int_{s^*}^{\infty}\frac{1}{\sqrt{2\pi\sigma^2}}V_1(s',k',D',r')e^{\frac{(s'-\rho s)^2}{2\sigma^2}}ds'$ represents the expected value of a solvent firm in period $t+1$ if a project becomes available in period $t+1$. In Problem (1.6.1): 1) equation $d = e^s k^\alpha + D' + g(k)\Phi_l - (1+r)D - i - \tau(e^s k^\alpha - \delta k - rD)1_{e^s k^\alpha - \delta k \geqslant rD}$ is the budget constraint for the firm if no new project becomes available in period t, 2) equation $(1+r_f)D' = (1-\xi)(1+r')D' + \int_{-\infty}^{s^*}\frac{1}{\sqrt{2\pi\sigma^2}}[\kappa(e^s k'^\alpha + (1-\delta)k')]e^{\frac{(s'-\rho s)^2}{2\sigma^2}}ds'$

determines the interest rate on issued debt in period t, 3) equation $s^* = \log((1+r')D' - (1-\delta)k') - \alpha \log k'$ defines the threshold for the profit shock such that for any shock $s' < s^*$ the firm goes bankrupt, 4) equation $\xi = \int_{-\infty}^{s^*} \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(s'-\rho s)^2}{2\sigma^2}} ds'$ determines the bankruptcy probability, 5) equation $k' = (1-\delta)k - g(k)\Phi_l + i + f(k)\Phi_p$ is the law of motion for the firm's capital, 6) inequalities $\delta k \geqslant i \geqslant 0$ implies that the firm's maintenance investment is constraint by the capital depreciated, and 7) inequality $D' \geqslant 0$ implies that the firm is not allowed to save. Problems (1.6.1) and (1.6.2) are solved together to obtain the firm's value and its optimal real and financial policies.

1.7 Quantitative Discussion of the Investment Driven Model

1.7.1 Model Solution

The model is solved numerically on grids of profit shock, capital, and debt using the value function iteration method. Methods similar to those used in the capital market driven model are used to determine the capital and debt grids.

1.7.2 Investment Driven Model Benchmark Results

This section presents the results of the simulations of the model. The benchmark parameters of the capital market driven model are used. Investment technology is the distinguishing feature of the investment driven model and the baseline credit driven model. The parameters of the investment technology are estimated as follows. The size of the investment project is set to be $f(k) = ((1-\delta)^{-1} - 1)k = 0.13k$, where k is the firm's capital. Sensitivity analysis for this choice is reported in the Appendix. Figure 1.2 shows 1) the annual rate of investment for Compustat firms over 1993-2003 and 2) the dollar value involved in each annual rate bin. This choice of the size of the project implies that the firms in the third bin and above have an investment projects, whereas the firms in the first and second bins do not have an investment project. I determine the percentage of firms that increase their PPENTs in a year by more than

$((1-\delta)^{-1} - (1-\delta) + g) = 28\%$, where $g = 3\%$ is the average increase in PPENT due to growth in the economy. I find that, on average 40% of firms increase their assets by 28% in a given year. Therefore, I set the probability of a new project becoming available in each period to $p = 0.4$. The size of disinvestment is set to be constrained by $g(k) = \delta(1-\delta)k = 0.10k$. Sensitivity analysis for this choice is reported in the Appendix. There is an endogeneity problem with such a direct estimate of the size of projects and the probability of receiving new projects. This problem is addressed by conducting sensitivity analyses on these choices.[9]

Properties of the Investment and Financing Policies in the Investment Driven Model

Consider two firms that enter into period t with the same capital stock of k. The two firms are identical except that one firm, firm A, has a new project in period t and the other firm, firm B, does not have a new project. Neither firm has debt.[10] The realized profit shocks are the same for these firms. Therefore, they have the same profitability in period t.

Figure 1.3 shows 1) the ratio of optimal debt issued by firm A to the optimal debt issued by firm B as function of the firm's capital, and 2) the optimal investment by these firms as a function of the firm's capital. It can be seen that in the region in which firm A finds it optimal to take on the project, its debt policy is very different from that of firm B. When firm A takes on the project, the creditors increase the debt capacity of the firm. Moreover, the firm finds it optimal to take advantage of the increase in its debt capacity to shield its future profit from taxation. Therefore, in a dynamic model in which investment is endogenous and the firm faces frictions in its real side, even two firms with the same profitability may optimally choose very different capital structures.

This result hinges on the importance of investment in capital structure decisions.

[9] An alternative approach would be to estimate these parameters of the model by matching some moments of the model with those of data.

[10] I observe the same behavior when the firms enter into the period levered.

In most of the capital structure literature (e.g. Leland (1994), Goldstein et al. (2001), and Strebulaev (2007)), the authors abstract from the firm's real side and only analyze capital structure decisions in which the firm issues debt to buy back equity or issues equity to buy back debt, which are decisions rarely seen in practice. This result is also in contrast to those in Hennessy and Whited (2005), and Hennessy and Whited (2007). In their models there is no friction in the real side of the firm. Therefore, for instance, two firms of the same size and the same profitability, one in an industry with high growth opportunity and one in an industry without growth opportunity, choose the same capital structure.

Consider four firms that enter into period t with the same capital stock of k. Let A_L and A_H denote the firms that have new projects, and let B_L and B_H denote the firms that do not have new projects in period t. A_L and B_L have low profit shocks. A_H and B_H have high profit shocks.

Figure 1.4 shows 1) the optimal leverage ratios of these firms and 2) the optimal investment of these firms. It can be seen that depending on the level of capital, the firm's real and financial activities differ vastly in response to profit shock. Overcapitalized and undercapitalized firms change their leverage very conservatively. Firms that have new projects and are close to their optimal level of capital are the most responsive to profit shocks. The firms without new projects are explained. The case of firms with new projects follows the same logic.

Consider the region in which the leverage ratios of firms B_L and B_H are very close to each other and both firms are undercapitalized. This is the region in which the firm's response to profit shock is insignificant. In this region both firms B_L and B_H find it optimal to invest to maintain their capital level. Therefore, the increase in the debt capacity of firm B_H relative to firm B_L is due to the higher profit shock of firm B_H. However, this increase is small relative to the debt capacity of firm B_L. Therefore in this region, firms change their leverage very conservatively in response to profit shock. Further, in this region the leverage decreases as profitability increases. This is because of the non-linear relationship between the debt-capacity and the value of a firm. The increase in the debt capacity due to the change in profitability does not grow as fast as the market value of the firm. Therefore, as the profitability increases the market leverage ratio decreases. A similar argument holds for overcapitalized firms that respond conservatively to profit shocks.

Consider the region in which there is a large gap between the leverage ratios of firms B_L and B_H. This is the region in which a firm's response to the profit shock is significant and more profitable firms take higher leverage. Firm B_H finds it optimal to invest in the maintenance capital, whereas firm B_L finds it optimal to disinvest. Therefore, the increase in the debt capacity of firm B_H relative to that of firm B_L is due to the higher profit shock of firm B_H and the optimal (dis)investment decision of firm B_L. The disinvestment of firm B_L lowers its debt capacity, and the gap between the leverage ratios of firms B_H and B_L becomes more prominent.

Comparing the leverage ratios of firm A_L and firm B_H is also of interest. Firm A_L has low profit shock but has a new project. Firm B_H has high profit shock but does not have a project. Consider the region in which A_L finds it optimal to take on the new project. The creditors impose a debt capacity on each firm to make sure that they break even in the case of a firm's default. Two forces interact with each other to determine the debt capacity of each firm. The increase in the debt capacity of A_L due to an increase in its level of assets as a consequence of taking the project, and the decrease in the debt capacity due to the low profitability of A_L. It turns out that the increase in the debt capacity due to an investment opportunity dominates the decrease in the debt capacity due to lower profitability. More importantly the debt capacity of A_L increases more than the debt capacity of B_H. Moreover, A_L finds it optimal to take on more debt than B_H.

Figure 1.4 also shows that as the firm's capital increases, its leverage increases. In other words, undercapitalized firms have a low leverage ratio, and overcapitalized firms have a high leverage ratio.

Table 1.4: Investment Driven Model Results with Benchmark Parameters
Panel data are generated using the investment driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. The AEF column represents an economy in which firms are all-equity-financed. The NTB column represents an economy in which there is no tax benefit to borrowing. The BM column represents an economy with benchmark parameters.

	AEF	NTB	BM
Average investment to total assets	0.12	0.12	0.13
Volatility of investment to total assets	0.06	0.10	0.10
Average size	136.1	136.9	176.3
Average dividend to total assets	0.07	0.06	0.04
Frequency of equity issuance	0.10	0.00	0.00
Average equity issuance to total assets	0.04	0.00	0.00
Average Tobin's Q	3.32	3.11	1.57
Average book leverage	-	0.08	0.50
Average market leverage	-	0.03	0.32
Persistence of dividend/assets	0.03	0.06	0.36
Persistence of debt/assets	-	0.72	0.60
Persistence of leverage	-	0.71	0.82

Benchmark Results

Table 1.4 shows the results of the simulated panels of firms with benchmark parameters. Table 1.4 also shows the results of 1) a simulated panel of all-equity-financed firms and 2) a simulated panel of firms for which there is no corporate tax benefit to borrowing.

Similar to Table 1.1, Table 1.4 shows that 1) investment and available financing sources significantly interact with each other, 2) the firm borrows even in the absence of corporate tax benefit to borrowing, and 3) capital structure models with exogenous cash flows are not appropriate to analyze the capital structure decisions of firms.

Table 1.5: How Does the Frequency of Arrival of New Projects Affect Firms' Behavior in the Investment Driven Model?
Panel data are generated using the investment driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. σ is the volatility of profit shock and p is the probability of a new project becoming available in each period.

$\sigma \rightarrow$	15%			35%		
$p \rightarrow$	0.2	0.4	0.6	0.2	0.4	0.6
Average investment to total assets	0.12	0.12	0.13	0.12	0.13	0.13
Volatility of investment to total assets	0.07	0.10	0.11	0.08	0.10	0.12
Average size	177.8	176.2	175.2	187.8	194.9	189.9
Average dividend to total assets	0.04	0.04	0.04	0.06	0.06	0.06
Frequency of equity issuance	0.00	0.00	0.00	0.19	0.16	0.18
Average equity issuance to total assets	0.00	0.00	0.00	0.02	0.02	0.02
Average Tobin's Q	1.54	1.58	1.59	1.77	1.79	1.87
Average book leverage	0.50	0.50	0.50	0.48	0.49	0.49
Average market leverage	0.33	0.32	0.32	0.28	0.28	0.27
Persistence of dividend/assets	0.43	0.36	0.30	0.43	0.41	0.41
Persistence of debt/assets	0.46	0.59	0.56	0.58	0.59	0.58
Persistence of leverage	0.79	0.83	0.79	0.84	0.88	0.88

1.7.3 Frequency of New Project's Arrival and Firms' Behavior

How does the frequency of new project arrival affect a firm's behavior? Should firms in industries with a high probability of receiving investment projects take on less debt than firms in an industry with a low probability of receiving new investment projects?

Table 1.5 shows the results of simulated panels of firms in economies in which the probability of receiving new projects is $p = 0.2, 0.4$, and 0.6. The first three columns in Table 1.5 represent economies in which the volatility of profit shock is $\sigma = 15\%$. The second three columns represent economies in which the volatility of profit shock is $\sigma = 35\%$. It can be seen that as the probability of receiving a new project increases, the volatility of investment and the persistence of the market leverage also increases, but there is not a significant variation in the book leverage and the market leverage of the firms across these economies.

Table 1.6: How Does the Corporate Tax Rate Affect Firms' Behavior in the Investment Driven Model?

Panel data are generated using the investment driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. τ is corporate tax rate.

$\tau \rightarrow$	46%	40%	35%	34%
Average investment to total assets	0.13	0.13	0.13	0.13
Volatility of investment to total assets	0.11	0.10	0.10	0.10
Average size	173.3	182.6	194.5	194.4
Average dividend to total assets	0.05	0.06	0.06	0.06
Frequency of equity issuance	0.19	0.16	0.16	0.16
Average equity issuance to total assets	0.02	0.02	0.02	0.02
Average Tobin's Q	1.66	1.74	1.79	1.82
Average book leverage	0.49	0.49	0.49	0.48
Average market leverage	0.30	0.29	0.28	0.27
Persistence of dividend/assets	0.49	0.47	0.42	0.42
Persistence of debt/assets	0.64	0.55	0.59	0.63
Persistence of leverage	0.88	0.85	0.88	0.88

1.7.4 Corporate Tax Rate and the Firm's Behavior

How does the tax rate affect a firm's behavior? The statutory corporate tax rate was 48% in the period 1971-1978, 46% in the period 1979-1986, 40% in 1987, 34% in the period 1988-1992, and 35% in the period 1993-2001. Table 1.6 represents economies in which the corporate tax rates are $\tau = 46\%, 40\%, 35\%$, and 34%. It can be seen that as the tax rate decreases, 1) the firm become bigger and issues more debt, 2) there is not a significant change in the book leverage, and 3) the market leverage decreases.

1.8 Capital Market Driven Model, Investment Driven Model, and Compustat Firms

1.8.1 How Well Do the Models Describe the Data?

This subsection compares the results of simulated panels of firms in the credit market driven model and in the investment driven model with data.

The degree of returns to scale of the operating profit function is set to be $\alpha = 0.689$, which is the same as that in Cooper and Ejarque (2003). The annual depreciation rate is set to be $\delta = 0.12$, the empirical estimate in Cooper and Haltiwanger (2006). The subjective discount factor is set to be $\beta = 0.98$, which corresponds to a real annual risk-free rate of $r_f = 0.02$. The equity flotation cost is set to be $\lambda = 0.02$, lower than Ritter's 7% rule and more in line with Gomes (2001). The parameter that determines the deadweight bankruptcy cost is set to be $\kappa = 0.78$, which is in line with recent empirical estimates in Hennessy and Whited (2007). The persistence of profit shock is set to be $\rho = 0.65$, the same as in Gomes (2001), which is also in line with recent empirical estimates in Hennessy and Whited (2007). The volatility of profit shock is set to $\sigma = 35\%$, similar to that in Zhang (2005). This profit volatility is higher than that in Gomes (2001). But the volatility of profit shock of $\sigma = 0.35$ seems in line with Pastor and Veronesi (2003) who show that the average volatility of firm-level profitability has risen from 10% per year in the early 1960s to about 45% in the late 1990s. The corporate tax rate is set to be $\tau = 35\%$, the statutory corporate tax rate over 1993-2010. The size of new projects in the investment driven model is set to be $0.13k$ and the probability of receiving a new project is set to be $p = 0.4$. The size of disinvestment is set to be constrained by $g(k) = \delta(1 - \delta)k = 0.10k$.

To compare the results of the simulated panel of firms with data, the conventional data source of Compustat is used. The time period for the data is 1993-2009. Years prior to 1993 are not considered, since the tax parameter is relevant only for this period. Regulated companies (SIC 4900-4999) and financial companies (SIC 6000-6999) are also excluded, because my model is inappropriate for regulated and financial companies.

The variables of interest in the model are defined as follows in the data. Average investment to assets is the ratio of CAPXV (item #30) to PPENT (item #141).[11] The model is stationary while there is growth in the economy. Over 1962-2009, real PPENT has grown 4% per year on average, and real total assets (item #6) have grown 7% per year on average. Over 1993-2009, real PPENT has grown 3% per year on average, and real total assets (item #6) have grown 7% per year on average. Therefore, I subtract 3% from the average investment to assets ratio in the data to make it comparable to the model. Equivalently, one can detrend the time series for investment and assets in the data. Average Tobin's Q is the ratio of debt (long-term debt (#9) plus short-term debt (#34)), plus the market value of equity (item #199 times item #25), plus the purchase of common and preferred stocks to debt, plus total assets (item #6). Average book leverage is the ratio of debt (long-term debt (#9) plus short-term debt (#34)) to debt plus PPENT (item #141). Average market leverage is the ratio of debt (long-term debt (#9) plus short-term debt (#34)) to debt plus the market value of equity. All variables are winsorized at 0.1% and weight the variables with total assets to compute averages. This is done to avoid biasing the estimates due to outliers or small firms.

Table 1.7 shows that the investment driven model does a better job in matching moments of data. Accordingly, the investment driven approach seems to be a better basis for further investigation of the corporate capital structure.

Limiting the evaluation of models to only a few moments is not a comprehensive evaluation. Watson (1993) proposes a procedure for evaluating the fit of calibrated dynamic structural economic models. The procedure begins by augmenting the variables in the model with just enough stochastic error so that the model can exactly match the second moments of the actual data. A measure of fit for the model is constructed on the basis of this error.

Watson (1993)'s methodology is used to evaluate the fit of the two models to the

[11] Total assets (item #6) is not an appropriate match of assets in the model and in the data, because, for instance, there are no inventories or receivables in the model.

aggregate Flow of Funds data. The procedure begins by augmenting the variables in the model with just enough stochastic error, u, so that the model can exactly match the second moments of the actual data. A measure of fit for the model is constructed on the basis of this error. For instance, suppose the variables of interest in the model are $x = [d, K, D]$. d is the dividend, K is the firm's capital, and D is the firm's debt. The variable y is the counterpart of x in the data. Watson's measure of fit is based on the size of the stochastic error required to reconcile the autocovariances of the model, x, with those of the data, y. If the covariance matrix of the required error is "small", then the economic model might be deemed a good approximation to the data, and conversely if the covariance matrix of u is "large". I find that in comparison to the credit market driven model, the investment driven model does a better job in matching the power spectra of aggregate dividend, capital, and debt.

1.8.2 Counterfactual Experiments in the Investment Driven Model

This subsection shows that the *optimal* choice of capital structure is important for reconciling the investment driven model with the data. I define a *non-optimal capital structure decision experiment* as an experiment in which the firm uses simple rules, rather than optimal choices, in selecting its capital structure.

Welch (2010) say that "Could managers readjust their capital structures non-optimally by following rules, in which they pay little consideration to bankruptcy costs, tax benefits, transaction costs, and project funding needs, but enact random changes? Could they just be "asleep at the switch", and readjust whenever they wake up?". In the first experiment, it is assumed that in each period the firm chooses its deb level randomly with a uniform distribution over $[0, D_{Max}(k, z)]$, where $D_{Max}(k, z)$ is the debt capacity of a firm with capital k and profit shock z.

Modigliani and Miller (1963) say that "The existence of a tax advantage of debt financing ... does not necessarily mean that corporations should at all times seek the use of the maximum possible amount of debt in their capital structure. There are, as

Table 1.7: How Well Do the Models Describe the Data?

One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. Column M1-0 represents the capital market driven model with no liquidity premium. Column M1-05 represents the capital market driven model with a liquidity premium of 0.5%. Column M1-1 represents the capital market driven model with a liquidity premium of 1%. Column M1-2 represents the capital market driven model with a liquidity premium of 2%. Column M2 represents the investment driven model. Column D represents the data. The average equity issuance to total assets in column D is from Hennessy and Whited (2005). The frequency of equity issuance in column D is from Hennessy and Whited (2007).

	M1-0	M1-05	M1-1	M1-2	M2	D
Average investment to total assets	0.40	0.40	0.41	0.41	0.13	0.15
Volatility of investment to total assets	1.03	1.05	1.04	1.03	0.10	0.11
Average dividend to total assets	0.04	0.04	0.04	0.06	0.06	0.02
Frequency of equity issuance	0.13	0.13	0.17	0.27	0.20	0.18
Average equity issuance to total assets	0.07	0.10	0.05	0.06	0.02	0.04
Average Tobin's Q	2.52	2.60	2.66	2.79	1.78	1.63
Average book leverage	0.49	0.48	0.48	0.46	0.49	0.46
Average market leverage	0.26	0.25	0.24	0.23	0.28	0.31
Persistence of dividend/assets	0.05	-0.01	-0.02	-0.05	0.52	0.41
Persistence of debt/assets	0.56	0.54	0.25	0.26	0.52	0.49
Persistence of leverage	0.58	0.57	0.56	0.52	0.88	0.91

we pointed out, limitations imposed by lenders as well as many other dimensions in real world problems of financial strategy which are not fully comprehended within the framework of static equilibrium models ... These additional considerations, which are typically grouped under the rubric of the need for preserving flexibility, will normally imply the maintenance by the corporation of a substantial reserve of untapped borrowing power." In the second experiment, it is assumed that in each period the firm chooses its debt level as the 50th percentile of its debt capacity. In the third experiment, it is assumed that in each period the firm chooses its debt level as the 90th percentile of its debt capacity.

The choice of debt at the 50th or 90th percentile of debt capacity does not mean that the firm keeps the same level of debt all the time. The debt capacity of the firm is determined by the break-even condition for the creditors. The debt capacity is a function of the firm's capital and its profitability. Therefore, as the capital and profitability of the firm change, so does its debt capacity. It should be emphasized that these experiments represent one-period deviations from the optimal decisions. Moreover, it is assumed that 1) the firm does not change its optimal investment policy, and 2) the non-optimal debt issuance decision affects the dividend policy.

Table 1.8 shows the results of simulated panels of firms in these experiments. Not surprisingly, the average investment and the volatility of investment in firms that follow non-optimal decisions are close to those of the firms that follow the optimal decisions. This is because the non-optimal capital structure decisions considered here mainly affect the financial side of the firms and not the real side.

If we compare the results of a panel of firms that follow the optimal real and financial decisions with a panel of firms that follow the random rule, we can see that relative to the firms optimizing their capital structure decisions, the non-optimizing firms 1) issue equity much more often, 2) have a much higher average equity issuance, 3) have a higher average Tobin's Q, 4) have a much lower book leverage and market leverage, 5) have negatively correlated current and lagged dividends, 6) have current and lagged debt that "are" uncorrelated, and 7) have current and lagged leverage that "are" uncorrelated.

If we compare the results of a panel of firms that follow the optimal real and financial decisions with a panel of firms that follow the 50th percentile rule, we can see that relative to the firms optimizing their capital structure decisions, the non-optimizing firms 1) issue equity much more often, 2) have a higher average Tobin's Q, 3) have a much lower book leverage and market leverage, and 4) have current and lagged dividends that are less correlated.

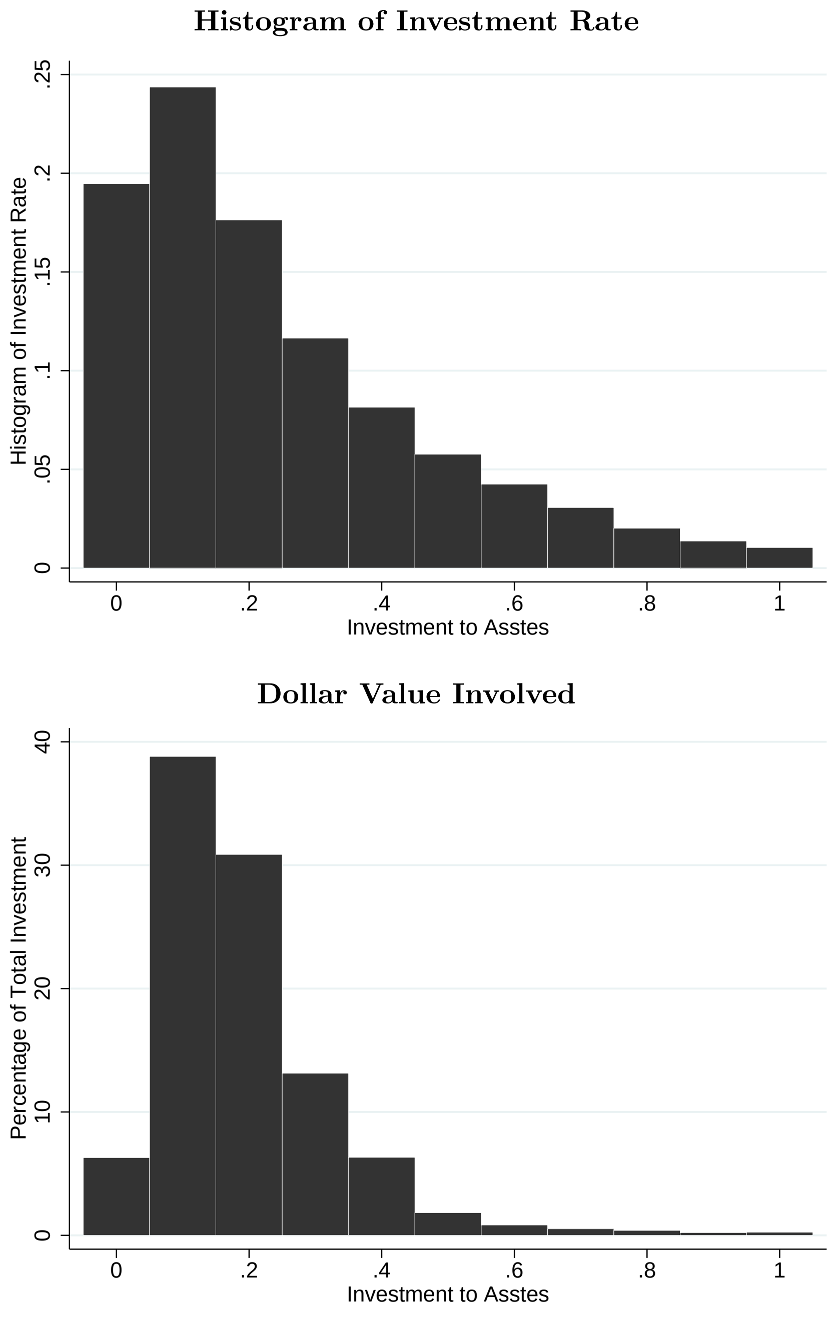
If we compare the results of a panel of firms that follow the optimal real and financial decisions with a panel of firms that follow the 90th percentile rule, we can see that relative to the firms optimizing their capital structure decisions, the non-optimizing firms 1) issue equity much more often, and 2) have current and lagged dividends that are less correlated.

The results in Table 1.8 show that the *optimal* choice of capital structure is important for reconciling the investment driven model with the data. In other words, the observed behavior of firms is more consistent with a model in which firms optimize their capital structure than with a model in which firms do not.

Table 1.8: Do Optimal Capital Structure Decisions Matter in the Investment Driven Model?
Panel data are generated using the investment driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point.

	Optimal	Uniform	50th	90th
Average investment to total assets	0.13	0.13	0.13	0.13
Volatility of investment to total assets	0.10	0.10	0.11	0.10
Average size	194.8	195.0	194.2	194.6
Average dividend to total assets	0.06	0.40	0.07	0.07
Frequency of equity issuance	0.20	0.45	0.24	0.22
Average equity issuance to total assets	0.02	0.38	0.03	0.02
Average Tobin's Q	1.79	2.51	2.34	1.94
Average book leverage	0.49	0.28	0.33	0.45
Average market leverage	0.28	0.14	0.14	0.24
Persistence of dividend/assets	0.52	-0.35	0.14	0.26
Persistence of debt/assets	0.52	0.00	0.46	0.46
Persistence of leverage	0.88	0.03	0.89	0.89

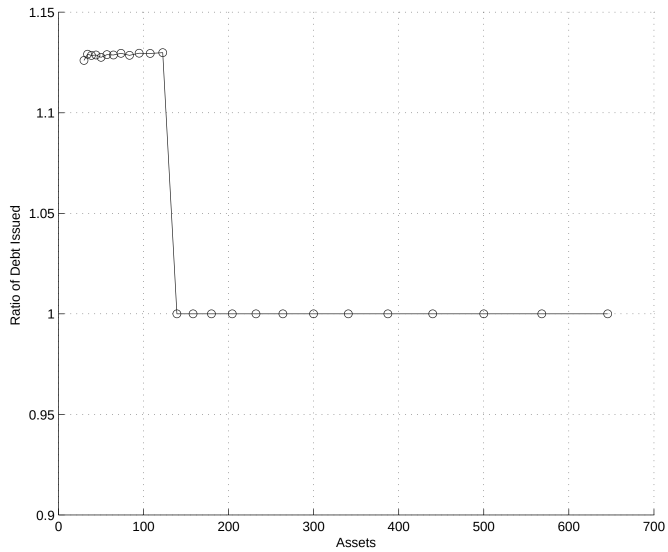
Figure 1.2: Investment in Compustat Firms



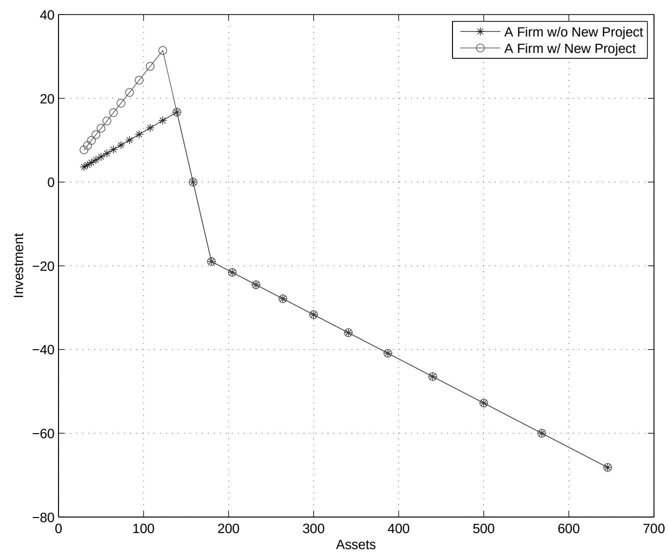
Description: The figure on the top shows the histogram of annual investment rate for Compustat firms in the period 1993-2009. The figure on the bottom shows the dollar values involved in each bin of the investment rate.

Figure 1.3: Debt Issuance and Investment in the Investment Driven Model

Debt Issuance and New Project Arrival



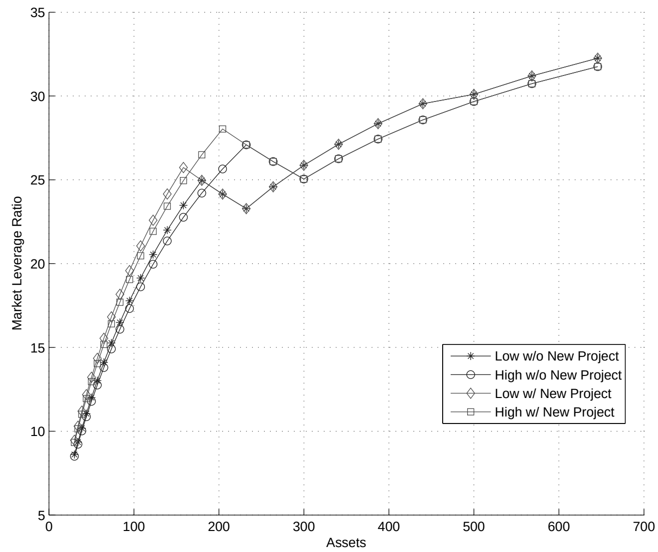
Investment and New Project Arrival



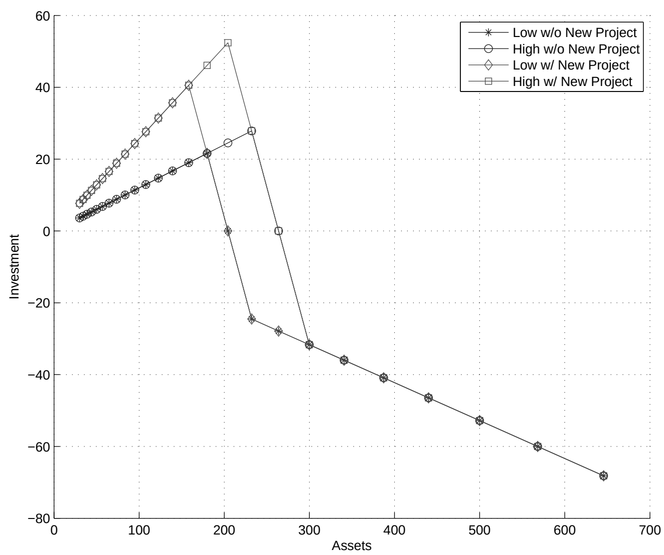
Description: The investment driven model is solved with benchmark parameters. The upper figure shows the ratio of issued debt by a firm with a new project to issued debt by a firm without a new project. The lower figure shows the optimal investment of a firm with a new project and the optimal investment of a firm without a new project. The two firms are identical except that one firm has a new project and the other firm does not.

Figure 1.4: Leverage, Investment, and Profit Shock in the Investment Driven Model

Leverage and Profit Shock



Investment and Profit Shock



Description: The investment driven model is solved with benchmark parameters. The upper figure shows 1) the optimal leverage of two firms that have low profit shocks, one with a new project and the other without, and 2) the optimal leverage of two firms that have high profit shocks, one with a new project and the other one without. The lower figure shows 1) the optimal investment of two firms that have low profit shocks, one with a new project and the other one without, and 2) the optimal investment of two firms that have high profit shocks, one with a new project and the other one without.

1.9 Conclusions

This chapter presents two closely related dynamic models of corporate capital structure to determine whether time-varying real frictions or time-varying financial frictions are the key driving force behind corporate capital structure variation over time. In the capital market driven model, the firm always has real investment opportunities, capital adjustment is frictionless, and the firm faces time-varying financial frictions in the debt market. In the investment driven model, the firm faces uncertainty about the availability of investment opportunities, capital adjustment is not frictionless, and the firm does not face time-varying frictions in the debt market.

Simulations of the calibrated capital market driven model show that adjusting capital structure in response to variation in the debt market results in persistence of dividend, debt, and leverage that is lower than the persistence observed in the data. This result suggests that time-varying financial frictions do not appear to be a key driving force behind corporate capital structure variation over time. Simulations of the calibrated investment driven model show that one can successfully explain the observed persistence of dividend, debt, and leverage. This result suggests that time-varying real frictions do appear to be a key driving force behind corporate capital structure variation over time. Simulations of the calibrated investment driven model also show that real-frictions-based explanation of the persistence of leverage is an alternative to the financial-frictions-based explanation put forth by Leary and Roberts (2005). Further, firms' production technologies along with the real frictions that they face can be an explanation for the persistence and the variation of leverage across firms documented in Lemmon et al. (2008).

A natural question that is not addressed in the chapter is how the investment driven model performs in the presence of a stochastic liquidity premium in the debt market. Table 1.9 shows the results of simulated panels of firms in economies in which the volatility of the profit shock is $\sigma = 15\%$. The first three columns represent economies in which the cost of issuing equity is $\lambda = 7\%$. The second three columns represent

Table 1.9: The Investment Driven Model in the Presence of Stochastic Liquidity Premium in the Debt Market- Low Profit Volatility Firms

Panel data are generated using an extended version of the investment driven model in which firms face stochastic liquidity premium in the debt market. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. The volatility of profit shock is set to be $\sigma = 0.15$.

$\lambda \rightarrow$	7%			2%		
$\bar{l} \rightarrow$	0.5%	1%	2%	0.5%	1%	2%
Average investment to total assets	0.12	0.12	0.12	0.12	0.12	0.12
Volatility of investment to total assets	0.09	0.10	0.09	0.10	0.09	0.09
Average size	169.0	164.0	160.7	173.6	166.9	160.6
Average dividend to total assets	0.05	0.05	0.05	0.05	0.05	0.05
Frequency of equity issuance	0.08	0.07	0.08	0.09	0.08	0.11
Average equity issuance to total assets	0.02	0.02	0.02	0.02	0.02	0.02
Average Tobin's Q	1.61	1.63	1.62	1.58	1.61	1.63
Average book leverage	0.50	0.50	0.50	0.50	0.50	0.50
Average market leverage	0.31	0.31	0.31	0.32	0.31	0.31
Persistence of dividend/assets	-0.09	-0.07	-0.08	-0.08	-0.08	-0.13
Persistence of debt/assets	0.36	0.35	0.39	0.36	0.35	0.38
Persistence of leverage	0.76	0.74	0.68	0.76	0.74	0.66

economies in which $\lambda = 2\%$. Table 1.10 shows the results of simulated panels of firms in economies in which the volatility of the profit shock is $\sigma = 35\%$. The first three columns represent economies in which $\lambda = 7\%$. The second three columns represent economies in which $\lambda = 2\%$.

Tables 1.9 and 1.10 do not support the idea that debt market variation is a major determinant of the firms' choice of capital structure. In particular, adjusting capital structure in response to debt market variation appear to significantly reduce the persistence of dividend, debt, and leverage.

Table 1.10: The Investment Driven Model in the Presence of Stochastic Liquidity Premium in the Debt Market-High Profit Volatility Firms

Panel data are generated using an extended version of the investment driven model in which firms face stochastic liquidity premium in the debt market. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point. The volatility of profit shock is set to be $\sigma = 0.35$.

$\lambda \rightarrow$	7%			2%		
$\bar{l} \rightarrow$	0.5%	1%	2%	0.5%	1%	2%
Average investment to total assets	0.13	0.13	0.13	0.13	0.13	0.13
Volatility of investment to total assets	0.10	0.10	0.11	0.10	0.10	0.10
Average size	187.3	183.9	179.2	186.6	189.6	178.9
Average dividend to total assets	0.06	0.06	0.07	0.06	0.07	0.07
Frequency of equity issuance	0.20	0.20	0.21	0.20	0.22	0.27
Average equity issuance to total assets	0.02	0.02	0.02	0.02	0.03	0.03
Average Tobin's Q	1.82	1.84	1.84	1.83	1.80	1.85
Average book leverage	0.48	0.48	0.48	0.48	0.48	0.48
Average market leverage	0.27	0.27	0.27	0.27	0.27	0.26
Persistence of dividend/assets	0.43	0.36	0.28	0.43	0.36	0.17
Persistence of debt/assets	0.48	0.46	0.45	0.48	0.37	0.39
Persistence of leverage	0.84	0.82	0.78	0.84	0.83	0.75

Chapter 2

Asset Prices and Business Cycles with Financial Frictions

> The first lesson of economics is scarcity: There is never enough of anything to satisfy all those who want it. The first lesson of politics is to disregard the first lesson of economics.
> -Thomas Sowell

2.1 Chapter Summary

Existing dynamic general equilibrium models have not been fully successful at explaining the high volatility of asset prices that we observe in the data. We construct a general equilibrium model with heterogeneous firms and financial frictions that addresses this issue. In each period only a fraction of firms can start new projects, which cannot be fully financed externally due to a financial constraint. We allow the tightness of the financial constraint to vary over time. Fluctuations in the tightness of the financial constraint result in fluctuations in the supply of equity and consequently in the price of equity. We calibrate the model to the U.S. data to assess the quantitative importance of fluctuations in the tightness of the financial constraint. The model generates a volatility

in the price of equity comparable to the aggregate stock market while also fitting key aspects of the behavior of aggregate quantities.[1]

2.2 Introduction

The excess volatility puzzle (Shiller (1981), and LeRoy and Porter (1981)) and the equity premium puzzle (Mehra and Prescott (1985)) are two fundamental challenges to theoretical models that have been developed in the finance and macroeconomics literature. Building a production economy model that would satisfactorily account for both high aggregate stock market volatility and the behavior of aggregate quantities has proven to be difficult and no consensus model has arisen. In this paper we build a model in which variations in firms' ability to raise external capital to take profitable projects lead to asset price volatility. We calibrate the model to the U.S. data and find that it generates about 80% of the observed aggregate stock market volatility. At the same time, the model generates time-series properties of aggregate quantities that match the macroeconomic data.

Our model closely resembles the model described in Kiyotaki and Moore (2008). It is a dynamic stochastic general equilibrium model with heterogeneous entrepreneurs, who face a real and a financial friction. The real friction restricts entrepreneurs' access to new projects. In every period only a fraction of entrepreneurs find new profitable projects. Following the literature, we assume that the arrival of profitable projects is i.i.d. over time and over entrepreneurs, see e.g. Angeletos (2007) and Kocherlakota (2009). We model an entrepreneur's ability to start a profitable project as his ability to produce new capital goods one-to-one from the general consumption good. Entrepreneurs who cannot produce capital are willing to buy claims to returns of other entrepreneurs' projects to replace their depreciated capital. We call these claims equity. Markets are incomplete and equity is the only financial asset that is traded in the economy. The financial friction restricts new issuance of equity. We assume that entrepreneurs can

[1] This chapter is joint work with Ctirad Slavík.

only leverage a fraction of the returns of the newly produced capital, i.e. sell only a fraction of the new project as equity. On its own, this friction is standard in the literature. The novel feature of our model is that the ratio of outside to total financing of projects changes over time.

The interactions between these two frictions and the time variation in the financial friction play an important role in the ability of our model to explain the asset price volatility. Assuming that all entrepreneurs in the economy can produce new capital goods would imply that the price of equity is constant at the cost at which capital is produced, i.e. at price one. No entrepreneur would be willing to pay a higher price. Assuming heterogeneity in entrepreneurs' ability to produce new capital in the absence of the financial friction would imply that the price of equity is always one as well. If the price was higher, an entrepreneur with the ability to produce new capital would find it profitable to increase his investment in the project. He then would sell equity to the newly installed capital at a price that exceeds the costs. However, if the fraction of entrepreneurs that can produce new capital goods and the leverage ratio are relatively low, the price of equity will be greater than one. In that case, fluctuations in the leverage ratio result in fluctuations in the price of equity. The intuition behind this result is as follows. If the leverage ratio decreases, entrepreneurs with the ability to produce new capital goods decrease their investment and their supply of new equity. This decrease in supply increases the value of existing assets and therefore the price of equity will increase. A similar logic applies for an increase in the leverage ratio. Consequently, as the leverage ratio fluctuates over time so does the price of equity.

We calibrate the model and find that it generates about 80% of the quarterly volatility in asset prices relative to the Dow Jones Total Stock Market Index. On the annual basis, our benchmark model generates about 85% of the asset return volatility relative to the value weighted market return. We construct a shadow risk free rate and find that our model generates an annual equity premium of 1.6%. Finally, we find that time variation in the financial friction contributes significantly to the volatility of investment, but not to the volatility of output.

2.3 Related Literature

We build on Kiyotaki and Moore (2008), but our paper is different from theirs in the questions of interest and several modelling features. They are interested in the existence of money in a general equilibrium model and the optimal monetary policy responses to liquidity shocks. We abstract from both money and liquidity shocks. In their model, entrepreneurs can only sell a fraction of their asset holdings in a given time period. In our model, entrepreneurs are able to sell all their financial asset holdings. Finally, entrepreneurs' access to outside capital is constant in Kiyotaki and Moore's model while in our model it is time varying.

Theoretically, it has been argued that frictions in financial markets are important for explaining the fluctuations of the aggregate macroeconomic quantities, see for instance Bernanke and Gertler (1989), Kiyotaki (n.d.) and the review paper of Bernanke et al. (1999). In our model, financial frictions are important for explaining not only the behavior of aggregate quantities but also the behavior of asset prices. This essay contributes to a growing literature that analyzes the effects of exogenous financial shocks. See for example Benk et al. (2005), Christiano et al. (2007) and **?**, whose results suggest that financial shocks play an important role for macroeconomic fluctuations. While these papers are mainly focused on macroeconomic quantities, we are interested in asset prices as well.

Our results are in contrast with the findings of Gomes et al. (2003), who analyze a model in which financing frictions arise endogenously as an outcome of a private information problem with costly monitoring. The only primitive shocks in their model are total factor productivity (TFP) fluctuations. They find that the model generates only modest asset return volatility. Other attempts to build models with financial frictions that would generate a strong propagation of TFP shocks into the real economy and asset prices have not been very successful either[2] . Therefore, a departing assumption of our model is that fluctuations in productivity are not the only source of uncertainty in the economy. The second source of uncertainty in our model are fluctuations in the fraction of a project an entrepreneur can finance with outside capital[3] .

This essay explains the volatility of asset prices by introducing financial frictions into a dynamic general equilibrium model. However, other approaches have been taken to reconcile the asset price behavior with the predictions of consumption based asset pricing models. In endowment economy models, introducing habit formation or Epstein-Zin recursive preferences and changing the structure of the stochastic processes defining the consumption stream have been shown to be able to explain the high volatility of asset prices. Examples of this approach are Campbell and Cochrane (1999), who assume that agents have preferences with habit persistence and Bansal and Yaron (2004), who assume that agents have recursive Epstein-Zin preferences and there is a long run risk component in the consumption process. However, endowment economy models are silent about the behavior of aggregate macroeconomic quantities.

Explaining the volatility of asset prices in production economies has proved more challenging. Following the success of habit formation preferences in endowment economy models, Lettau and Uhlig (2000) incorporate the Campbell and Cochrane (1999) habit formation structure into a production economy[4] . They argue that these preferences make the households locally very risk averse and find that consumption volatility in the model is by an order of magnitude smaller than in the data. This result should not come as a surprise. In the standard one-sector growth model without frictions, firms can adjust their capital to reduce fluctuations in households' consumption. This

[2] See Kocherlakota (2000), Arias (2003), and Cordoba and Ripoll (2004) .

[3] We find that our model generates an asset return volatility very similar to Gomes et al. (2003) if we assume that this fraction is constant and fluctuations in TFP are the only source of uncertainty.

[4] Production economy models with Epstein-Zin preferences have so far not been successful in generating asset price volatility, see e.g. Croce (2010) and Tallarini (2000).

motive is further enforced by habit persistence. To address this shortcoming, Jermann (1998) develops a production economy model with habit persistence, capital adjustment costs and fixed labor. His model generates high asset price volatility and a high equity premium, but it also generates a counterfactually high risk free rate volatility. This is a common problem of general equilibrium models with habit persistence. Further, as documented by Boldrin et al. (2001), output is counterfactually smooth and negatively autocorrelated in Jermann (1998)'s model. In addition, dropping the assumption that labor supply is fixed makes labor supply countercyclical. In our model output is positively autocorrelated and volatile, and labor supply is procyclical.

Boldrin et al. (2001) develop a model with habit persistence and limited mobility of labor and capital across the consumption good and the investment good sector. As in Jermann (1998) their model generates high asset price volatility at the cost of counterfactually high volatility of the risk free rate. Moreover, their model cannot explain the volatility of labor and investment. In contrast, our model generates the investment volatility observed in the data. There is no risk free asset in our model. Therefore we construct a shadow risk free rate and find that its volatility is about 60% of what Boldrin et al. (2001) get[5] .

The rest of this paper is organized as follows. Section 2.4 presents the model and section 2.5 characterizes the solution of the model. Section 2.6 describes our calibration procedure and section 2.7 discusses the quantitative implications of the model and section **??** concludes.

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[5] Christiano and Fisher (2003) add sector specific productivity shocks and adjustment costs to the Boldrin et al. (2001) model. Their model still generates counterfactually high risk free rate volatility and counterfactually low investment volatility.

2.4 The Model

Time is discrete and infinite. There are two types of agents: a unit measure of ex-ante identical entrepreneurs who consume, produce and hold capital, but do not work, and a unit measure of identical hand-to-mouth workers who work and consume, but do not hold capital. There are two types of goods and two production technologies: a consumption good and a capital good, and a technology to produce the consumption good and a technology to produce the capital good. There is one type of financial asset traded: claims to returns of capital. Each period is divided into two subperiods. In the first subperiod consumption good is produced. In the second subperiod, capital good is produced and consumption and asset trading take place. We first describe the details of the two production technologies. Then we describe the asset trading structure and the financial friction. Then we state the entrepreneurs' and workers' optimization problems and define the competitive equilibrium.

2.4.1 Technology

In the first subperiod of each time period t consumption good production takes place. All entrepreneurs have access to the consumption good production technology. Entrepreneurs face a stochastic productivity shock A_t which is common to all of them. An entrepreneur who enters period t with capital k_t and hires labor l_t produces y_t with the technology:

$$y_t = A_t k_t^{\gamma} l_t^{1-\gamma}$$

where, y_t is the consumption good produced by the entrepreneur, $A_t > 0$ is the stochastic productivity shock common to all entrepreneurs, k_t is the capital of the entrepreneur, l_t is the labor hired by the entrepreneur, and γ is the capital share in the production of the consumption good. Capital depreciates at rate δ during the consumption good production, i.e. the entrepreneur enters the second subperiod with capital $(1-\delta)k_t$.

In the second subperiod, only a fraction π of entrepreneurs have the opportunity to start new profitable projects. We model this 'investment opportunity' as the entrepreneurs' ability to access the capital good production technology. This technology enables them to produce new capital one-to-one from the consumption good. The arrival of the opportunity to access the capital good production technology is i.i.d. over time and over entrepreneurs. We call entrepreneurs with access to the capital good production technology investing entrepreneurs and entrepreneurs without this access non-investing entrepreneurs.

2.4.2 Trading and Financial Frictions

In the second subperiod, consumption, capital good production and asset trading take place. There is one type of financial asset traded: claims to capital returns (we refer to these simply as assets or equity). Before we proceed with the discussion of the asset trading structure, we want to emphasize that the return per unit of capital is equal across entrepreneurs independent of their capital holdings and independent of their opportunity to access the capital good production technology. Therefore entrepreneurs are indifferent as to whose equity they hold. To see this, consider the entrepreneur Toyoda with capital k_t^T. In the first subperiod he hires labor on a competitive labor market at wage w_t to maximize his profit $\mathit{Profit}(k_t^T; A_t, w_t) := A_t \left(k_t^T\right)^\gamma \left(l_t^T\right)^{1-\gamma} - w_t l_t^T$. The optimal behavior of Toyoda implies that he hires labor $l_t^T = \left[\frac{(1-\gamma)A_t}{w_t}\right]^{\frac{1}{\gamma}} k_t^T$. This amount of labor equalizes the wage rate with the marginal product of labor, i.e. $w_t = MPL_t = (1-\gamma)A_t \left(k_t^T\right)^\gamma (l_t^T)^{-\gamma}$. Therefore, $\mathit{Profit}(k_t^T; A_t, w_t) = \gamma A_t \left[\frac{(1-\gamma)A_t}{w_t}\right]^{\frac{1-\gamma}{\gamma}} \cdot k_t^T = r_t k_t^T$, where $r_t = \gamma A_t \left[\frac{(1-\gamma)A_t}{w_t}\right]^{\frac{1-\gamma}{\gamma}}$ denotes the return per unit of capital. Since all entrepreneurs face the same stochastic productivity shock A_t and hire labor at the same wage w_t (determined by aggregate market clearing), the return on capital r_t is the same for all entrepreneurs.

To understand the trading structure in our economy we first describe the asset holdings of the entrepreneurs. Entrepreneurs can hold two types of assets: physical capital and equity to other entrepreneurs' capital returns. We define the individual state of the entrepreneur T by (k_t^T, e_t^T, s_t^T), where k_t^T is the physical capital held by the entrepreneur, e_t^T is equity to other entrepreneurs' capital and s_t^T is equity to entrepreneur T's own capital sold to other entrepreneurs.

Physical capital k_t^T is used by the entrepreneur T in the consumption good production and it depreciates at rate δ. We assume that physical capital is not traded in the economy. Equity e_t^T entitles the entrepreneur T to the stream of returns of e_t^T units of other entrepreneurs' capital. Since the underlying capital depreciates at rate δ, e_t^T

depreciates at rate δ as well. As we discussed above, entrepreneur Toyoda is indifferent between holding equity of entrepreneur Ford and entrepreneur Durant, as they entitle Toyoda to the same stream of returns per unit of this asset. s_t^T, which denotes claims to own capital returns sold by entrepreneur T depreciates at rate δ as well. Therefore an entrepreneur with the individual state (k_t^T, e_t^T, s_t^T) is entitled to returns from $k_t^T - s_t^T + e_t^T$ units of capital.

In the second subperiod, entrepreneurs are facing a financial constraint, which restricts the amount of external financing. An investing entrepreneur that produces i_t units of new capital can at most sell θ_t fraction of returns from i_t. On the other hand we assume that claims to already installed capital can be traded without restrictions. This implies that the total amount of equity sold by period t (denoted as s_{t+1}^T) can be at most the sum of a fraction θ_t of period t investment i_t^T and the depreciated period t capital holdings $(1-\delta)k_t^T$:

$$s_{t+1}^T \leq \theta_t i_t^T + (1-\delta)k_t^T \tag{2.4.1}$$

To understand this constraint, we define $k_{t+1}^T = (1-\delta)k_t^T + i_t^T$ and rewrite inequality (2.4.1) as:

$$k_{t+1}^T - s_{t+1}^T \geq (1-\theta_t)i_t^T \tag{2.4.2}$$

The left hand side of inequality (2.4.2) captures the net amount of returns to the entrepreneur T's own capital that he must carry into period $t+1$. Since he can sell at most $\theta_t i_t^T$ of 'new' equity he must keep at least $(1-\theta_t)i_t^T$ of the newly produced capital unsold, which is captured in the right hand side of inequality (2.4.2). θ_t is assumed to be a stochastic process which is common to all entrepreneurs.

2.4.3 Entrepreneurs' Maximization Problem

There is a unit measure of ex-ante identical entrepreneurs, who hold capital, trade assets and consume, but do not work. Ex-post, entrepreneurs will differ in their capital and asset holdings. The budget constraint of an entrepreneur with capital and asset holdings (k_t^T, e_t^T, s_t^T) can be written as:

$$c_t^T + i_t^T + q_t[k_{t+1}^T - s_{t+1}^T + e_{t+1}^T] \leq$$
$$r_t[k_t^T - s_t^T + e_t^T] + (1-\delta)q_t[k_t^T - s_t^T + e_t^T] + q_t i_t^T$$

where r_t is the return on capital. Therefore the first term on the right hand side is the return that the entrepreneur T is entitled to. The second term is the market value of his depreciated unsold capital and asset holdings. The third term is the market value of equity to his newly installed capital at the market price q_t. The left hand side sums up his expenditure. He can consume c_t^T, invest i_t^T with investment being generated one-to-one from the consumption good and carry unsold capital $k_{t+1}^T - s_{t+1}^T$ or equity e_{t+1}^T into period $t+1$. These are traded at market price q_t. The maximization problem of this entrepreneur therefore is (we drop the T superscripts for simplicity):

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \log c_t \qquad \text{s.t.}$$
$$(BC) \qquad c_t + i_t + q_t[k_{t+1} - s_{t+1} + e_{t+1}] \leq [k_t - s_t + e_t][r_t + (1-\delta)q_t] + q_t i_t$$
$$(FC1) \qquad k_{t+1} - s_{t+1} \geq (1-\theta_t)i_t$$
$$(FC2) \qquad e_{t+1} \geq 0$$

In this problem expectations are taken over the stochastic processes for θ_t and A_t, equilibrium processes for prices (taken as given and correctly forecasted by the entrepreneur) and the arrival of the investment opportunity. If the entrepreneur happens not to have an investment opportunity he must set i_t to zero. Note that the returns of the unsold capital $k_{t+1} - s_{t+1}$ and claims to returns of other entrepreneurs' capital e_{t+1} are the same state by state. Moreover trades in these assets in period $t+1$ are not subject to any restrictions. Therefore $k_{t+1} - s_{t+1}$ and outside equity e_{t+1} are perfect substitutes and (FC1) binding is equivalent to the no-short-sales (FC2) binding and we can sum them up without loss. The intuition for the equivalence of (FC1) and (FC2) is quite straightforward: an entrepreneur who has the investment opportunity and whose (FC1) is binding will sell all his other assets e_t to take advantage of this profitable opportunity. Therefore, we can simplify the maximization problem by defining net asset holdings $n_t := k_t - s_t + e_t$ and writing:

$$
\begin{aligned}
& \max E_0 \sum_{t=0}^{\infty} \beta^t \log c_t \qquad \text{s.t.} \\
(BC) \qquad & c_t + i_t + q_t n_{t+1} \leq n_t[r_t + (1-\delta)q_t] + q_t i_t \\
(FC) \qquad & n_{t+1} \geq (1-\theta_t) i_t
\end{aligned}
$$

Having stated the maximization problem we can analyze the role of the real friction (only a fraction of entrepreneurs can start a new project) and the financial friction (they can only finance a fraction θ of new investment externally) in our model. Assuming that all entrepreneurs in the economy have the ability to start new projects would imply that $q_t = 1$ as no entrepreneur would be willing to pay more given that he can produce new capital at price one. Assuming that investing entrepreneurs can finance all their new investment externally, i.e. $\theta_t = 1$, would lead to $q_t = 1$ as well. If q_t was larger than one then an investing entrepreneur would be able to decrease his consumption by one unit, increase investment by one unit and sell claims to the newly produced capital at $q_t > 1$. Then he could increase his consumption by one unit back to the original level and he would end up with a net profit of $q_t - 1 > 0$. Therefore this cannot be an equilibrium and $q_t = 1$ at all times. We conclude that we need both these frictions to generate asset price volatility in our model. In fact, we need the financial constraint (FC) to bind otherwise $q_t = 1$ by a reasoning similar to the one for $\theta_t = 1$.

2.4.4 Workers' Maximization Problem

There is a unit measure of identical workers, i.e. agents who do not have access to consumption good and capital good production technologies. In each period, a worker decides how much to consume and how much labor to provide. For simplicity we assume that workers do not participate in asset trading. A worker maximizes the expected lifetime utility subject to a period-by-period budget constraint. His maximization problem is therefore static and can be written as:

$$\max U\left(c'_t - \frac{\omega}{1+\eta}(l'_t)^{1+\eta}\right) \text{ s.t. } c'_t \leq w_t l'_t$$

where c'_t is the consumption of the worker in period t, l'_t is the labor provided by the worker in period t. $U[.]$ is increasing and strictly concave function, $\omega > 0$ and $\eta > 0$.

2.4.5 Equilibrium

A competitive equilibrium is quantities for entrepreneurs $[\{c^j_t, i^j_t, n^j_{t+1}\}^{\infty}_{t=0}]_{j\in[0,1]}$, quantities for workers $[\{c'^j_t, l'^j_t, \}^{\infty}_{t=0}]_{j\in[0,1]}$, and prices $(\{q_t, r_t, w_t\}^{\infty}_{t=0})$, such that quantities solve workers' and entrepreneurs' problems given prices, input prices w_t, r_t are determined competitively, and markets clear.

2.4.6 Comparison with Kiyotaki and Moore (2008)

In this subsection we discuss the differences between our model and Kiyotaki and Moore's. In their model entrepreneurs can hold equity n_t and fiat money m_t. The price of money in terms of the general consumption good is p_t. They assume that the leverage ratio θ is constant over time. An entrepreneur can sell all his money holdings but he can only sell a fraction ϕ_t of his equity holdings. ϕ_t is a stochastic process common to all entrepreneurs. The maximization problem of an entrepreneur in Kiyotaki and Moore's model is:

$$\begin{aligned} & \max E_0 \sum_{t=0}^{\infty} \beta^t \log c_t && \text{s.t.} \\ (BC) \quad & c_t + i_t + q_t n_{t+1} + p_t m_{t+1} &\leq\ & n_t[r_t + (1-\delta)q_t] + q_t i_t + p_t m_t \\ (FC) \quad & n_{t+1} &\geq\ & (1-\theta)i_t + (1-\phi_t)(1-\delta)n_t \end{aligned}$$

In the real world equity trades happen continuously. It is hard to document a restriction that puts a limit on the amount of equity an entrepreneur can sell in a given time period (in our model a time period is a quarter). Therefore in our model entrepreneurs are able to sell all their equity holdings, i.e. $\phi_t = 1$ in every period. The focus of our work is not monetary policy, therefore we have abstracted from fiat money in our model. Finally, we assume that θ varies over time.

2.5 Characterization

In this subsection we solve the model and characterize the solution. We show that the solution is determined by a single equation in the price of equity q_t. This enables us to do a comparative statics exercise in the exogenous shocks A_t and θ_t. Finally, to provide a better understanding of the role of other exogenous parameters, namely δ and π, we derive conditions under which the financial constraint binds in steady state.

2.5.1 Solving the Model

We begin this section with a proof of a lemma that links the financial constraint to the price of equity q_t.

Lemma 2.5.1. *Suppose that $\theta_t < 1$. Then the financial constraint binds for all investing entrepreneurs if and only if $q_t > 1$.*

Proof: The problem of an entrepreneur with asset holdings n_t in this economy is:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \log c_t \qquad \text{s.t.}$$

$$(BC) \qquad c_t + i_t + q_t n_{t+1} \leq n_t[r_t + (1-\delta)q_t] + q_t i_t$$

$$(FC) \qquad n_{t+1} \geq (1-\theta_t)i_t$$

If an entrepreneur does not have an investment opportunity at time t, he must set $i_t = 0$. If he has an investment opportunity, we can derive the above stated result using the first order condition with respect to i_t. We will denote the Lagrange multiplier on the budget constraint by λ_t and the Lagrange multiplier on the financial constraint by μ_t. The budget constraint always binds and therefore $\lambda_t > 0$. The necessary first order condition with respect to i_t is:

$$(q_t - 1)\lambda_t = (1-\theta_t)\mu_t$$

This equation makes it clear that $q_t > 1 \Longrightarrow \mu_t > 0$, the financial constraint binds; and also $\mu_t > 0 \Longrightarrow q_t > 1$. The result does not depend on the initial asset holdings n_t and therefore applies to all investing entrepreneurs. □

The intuition for the sufficient part is as follows. If $q_t > 1$ and the financial constraint does not bind then the solution to the problem does not exist, because there will be arbitrage opportunities for investing entrepreneurs. At any allocation an investing entrepreneur will find it profitable to increase i_t by Δ and consumption by $(q_t - 1)\Delta$ as discussed above.

Simplifying the Workers' Problem

In this section we simplify the workers' problem. We make use of this simplification in our quantitative analysis. We will show that output does not depend on the current realization of θ_t and derive the relationships between labor and consumption and aggregate output.

We can simplify the workers' problems as their decisions do not directly depend on the stochastic processes for A_t and θ_t. The representative worker solves:

$$\max U\left(c'_t - \frac{\omega}{1+\eta}(l'_t)^{1+\eta}\right) \text{ s.t. } c'_t \leq w_t l'_t$$

Therefore:

$$l'_t = \left(\frac{w_t}{\omega}\right)^{1/\eta} \tag{2.5.1}$$

Equation (2.5.1) holds for each worker. Therefore the aggregate labor supply L'_t can be written as:

$$L'_t = \left(\frac{w_t}{\omega}\right)^{1/\eta} \tag{2.5.2}$$

The aggregate labor demand by the entrepreneurs L_t is determined by:

$$w_t = A_t(1-\gamma)K_t^{\gamma}L_t^{-\gamma}$$

In equilibrium supply equals demand, i.e. $L'_t = L_t$ and hence:

$$\begin{aligned} w_t &= \omega^{\frac{\gamma}{\eta+\gamma}}\left[(1-\gamma)A_t\right]^{\frac{\eta}{\eta+\gamma}} K_t^{\frac{\eta\gamma}{\eta+\gamma}} \\ L_t &= \left[\frac{A_t(1-\gamma)}{\omega}\right]^{\frac{1}{\gamma+\eta}} K_t^{\frac{\gamma}{\gamma+\eta}} \end{aligned}$$

For the return on capital r_t we get:

$$\begin{aligned} r_t &= A_t\gamma K_t^{\gamma-1}L_t^{1-\gamma} = A_t\gamma K_t^{\gamma-1}\left\{\left[\frac{A_t(1-\gamma)}{\omega}\right]^{\frac{1}{\gamma+\eta}} K_t^{\frac{\gamma}{\gamma+\eta}}\right\}^{1-\gamma} = \\ &= A_t^{\frac{1+\eta}{\gamma+\eta}}\gamma\left[\frac{1-\gamma}{\omega}\right]^{\frac{1-\gamma}{\gamma+\eta}} K_t^{\frac{\eta(\gamma-1)}{\gamma+\eta}} \end{aligned}$$

Thus we can express L_t, w_t, r_t as functions of parameters and aggregate states K_t, A_t only. Note that L_t, w_t, r_t do not depend on the financial constraint parameter θ_t. Therefore in period t, output Y_t is not a function of θ_t. We can rewrite (2.5.2) as:

$$\begin{aligned} L_t &= \left(\frac{w_t}{\omega}\right)^{1/\eta} = \left(\frac{MPL_t}{\omega}\right)^{1/\eta} = \left(\frac{(1-\gamma)Y_t}{\omega L_t}\right)^{1/\eta} \Longrightarrow \\ L_t^{1+\eta} &= \frac{(1-\gamma)Y_t}{\omega} \Longrightarrow \\ (1+\eta)\log L_t &= \log Y_t + \log\frac{1-\gamma}{\omega} \end{aligned}$$

The implications for the dynamics of labor with respect to output are:

$$\begin{aligned} corr(\log L_t, \log Y_t) &= 1 \\ (1+\eta)^2 var(\log L_t) &= var(\log Y_t) \end{aligned}$$

Since workers cannot save, aggregate workers' consumption equals labor's share in output $C'_t = (1-\gamma)Y_t$. Thus:

$$\begin{aligned} corr(\log C'_t, \log Y_t) &= 1 \\ var(\log C'_t) &= var(\log Y_t) \end{aligned}$$

Since workers consume a large fraction of total consumption in the economy (including entrepreneurs' consumption), this will affect the dynamics of total consumption relative to output.

Solving the Entrepreneurs' Problem

The problem of an entrepreneur is:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \log c_t \qquad \text{s.t.}$$

$$(BC) \qquad c_t + i_t + q_t n_{t+1} \leq n_t[r_t + (1-\delta)q_t] + q_t i_t$$

$$(FC) \qquad n_{t+1} \geq (1-\theta_t) i_t$$

We can rewrite the budget constraint of an investing entrepreneur (denoted with a superscript i) by plugging in for i_t from the financial constraint:

$$c_t^i + q_t^R n_{t+1}^i \leq n_t[r_t + (1-\delta)q_t]$$

where q_t^R is the replacement cost of capital defined as:

$$q_t^R := \frac{1-\theta_t q_t}{1-\theta_t}$$

If $q_t = 1$ and the financial constraint does not bind[6] , the problem of an investing entrepreneur is the same as the problem of a non-investing entrepreneur. Note that in any equilibrium it must be[7] $q_t < \frac{1}{\theta_t}$. Finally note that the no-short-sale constraint $n_{t+1}^s \geq 0$, which is essentially the financial constraint of the non-investing entrepreneur[8] , does not bind. To see this we have to consider two cases. If $q_t = 1$ both types of entrepreneurs are solving the same problem. The financial constraint of an investing entrepreneur with asset holdings n_t is not binding. This implies that the same is true for a non-investing entrepreneur with asset holdings n_t (right hand side of his financial constraint is 0 and therefore lower than for the investing entrepreneur while the left hand sides are the same). If $q_t > 1$ the financial constraint for non-investing entrepreneurs

[6] We will ignore cases in which $q_t < 1$. This is only possible if the level of capital is so high that aggregate investment is 0. This will not happen in our quantitative exercises.

[7] To see that suppose $q_t \geq \frac{1}{\theta_t}$ and consider the following strategy of an entrepreneur with an investment opportunity: take one unit of consumption good, convert it into capital, keep fraction $1-\theta_t$ and sell fraction θ_t of this capital as equity, get $\theta_t q_t \geq 1$ units of consumption good (because of the price assumption). Convert this into capital etc. This strategy makes it possible to increase one's capital holdings beyond bounds, which is inconsistent with equilibrium. This along with $q_t \geq 1$ implies that $0 < q_t^R \leq 1$.

[8] We denote their allocations with a superscript ^{s}.

cannot bind. If it did bind then they would be selling equity as their financial constraint is $n_{t+1} \geq 0$ and their equity holdings at the beginning of the trading subperiod are $(1-\delta)n_t$. This would imply that on aggregate investing entrepreneurs are buying equity at price $q_t > 1$, which they will not do since they can produce capital at price one.

Log utility and linearity of the right hand side of the budget constraint in wealth guarantee that the decision rules are linear. In the appendix, we prove the following lemma, which verifies that this well-known result[9] carries over into our environment with idiosyncratic investment opportunity risk and the possibility of switching between regimes $q_t > 1$ and $q_t = 1$.

Lemma 2.5.2. *Individual policy functions are linear:*

$$\begin{aligned} c_t^i &= (1-\beta)n_t[r_t + (1-\delta)q_t] \\ q_t^R n_{t+1}^i &= \beta n_t[r_t + (1-\delta)q_t] \\ c_t^s &= (1-\beta)n_t[r_t + q_t(1-\delta)] \\ q_t n_{t+1}^s &= \beta n_t[r_t + q_t(1-\delta)] \end{aligned}$$

where n_t denotes the initial asset holdings of an entrepreneur. Superscript i denotes the state in which this entrepreneur has an investment opportunity in period t and superscript s denotes the state in which he does not have an investment opportunity in period t. With linear policy rules, prices are functions of aggregate quantities only. Without linear policy rules one would have to keep track of the whole asset distribution.

We will denote the aggregate quantities with capital letters and use the fact that the arrival of the investment opportunity is i.i.d. This implies that entrepreneurs with an investment opportunity hold fraction π of the total asset holdings in the economy at the beginning of period t and investors without an investment opportunity hold fraction $1-\pi$ of all assets at the beginning of period t. Integrating over individual policies thus

[9] See Samuelson (1969).

yields:

$$C_t^i = (1-\beta)\pi N_t[r_t + (1-\delta)q_t] \quad (2.5.3)$$

$$q_t^R N_{t+1}^i = \beta\pi N_t[r_t + (1-\delta)q_t] \quad (2.5.4)$$

$$C_t^s = (1-\beta)(1-\pi)N_t[r_t + (1-\delta)q_t] \quad (2.5.5)$$

$$q_t N_{t+1}^s = \beta(1-\pi)N_t[r_t + (1-\delta)q_t] \quad (2.5.6)$$

2.5.2 Equilibrium

By definition, aggregate capital in the economy is equal to the aggregate amount of equity N_t. Therefore the dynamics of aggregate capital is determined by aggregate equity holdings of investing and non-investing entrepreneurs: $N_{t+1} = N_{t+1}^i + N_{t+1}^s$.

If $q_t = 1$ the equilibrium aggregate quantities will be determined by the aggregate policy function for capital (one can get the equation below by adding equations (2.5.4) and (2.5.6)):

$$N_{t+1} = \beta N_t[r_t + (1-\delta)]$$

$$r_t = A_t^{\frac{1+\eta}{\gamma+\eta}} \gamma \left[\frac{1-\gamma}{\omega}\right]^{\frac{1-\gamma}{\gamma+\eta}} N_t^{\frac{\eta(\gamma-1)}{\gamma+\eta}}$$

These two equations fully describe the aggregate behavior of the model. The second equation determines r_t through the workers' problem. The rest of the variables are determined using the derived policy functions.

If $q_t > 1$, the dynamics of the model is determined by the aggregate policies for N_{t+1}^i, N_{t+1}^s, market clearing conditions and the financial constraint aggregated over investing entrepreneurs. Therefore the behavior of the model is determined by the following equations:

$$\begin{aligned}
q_t^R N_{t+1}^i &= \beta\pi N_t[r_t + (1-\delta)q_t] \\
q_t N_{t+1}^s &= \beta(1-\pi)N_t[r_t + (1-\delta)q_t] \\
N_{t+1}^i &= (1-\theta_t)I_t \\
N_{t+1}^s + N_{t+1}^i &= (1-\delta)N_t + I_t \\
r_t &= A_t^{\frac{1+\eta}{\gamma+\eta}}\gamma\left[\frac{1-\gamma}{\omega}\right]^{\frac{1-\gamma}{\gamma+\eta}} N_t^{\frac{\eta(\gamma-1)}{\gamma+\eta}} \\
q_t^R &:= \frac{1-\theta_t q_t}{1-\theta_t}
\end{aligned}$$

Plugging in for N_{t+1}^s, N_{t+1}^i and I_t from the first three into the fourth one we get:

$$(1-\delta) = \frac{\beta(1-\pi)}{q_t}[r_t + q_t(1-\delta)] - \frac{\theta_t}{(1-\theta_t)}\frac{\beta\pi}{q_t^R}[r_t + (1-\delta)q_t] \qquad (2.5.7)$$

Since r_t is a function of states N_t, A_t, θ_t only, we can solve for q_t as a function of these states and then use (2.5.4) and (2.5.6) to compute $N_{t+1}(N_t, A_t, \theta_t)$.

2.5.3 Comparative statics in A and θ

In this subsection we study the properties of the solution of our model when $q_t > 1$. We analyze the effects of changes in A_t and θ_y on the price of equity q_t. We can write the net demand for equity by non-investing entrepreneurs as:

$$D^e := N^s_{t+1} - (1-\delta)(1-\pi)N_t = \beta(1-\pi)N_t[\frac{r_t}{q_t} + 1 - \delta] - (1-\delta)(1-\pi)N_t$$

D^e is a downward sloping demand function since $\frac{\partial D^e}{\partial q} < 0$. Net supply of equity by investing entrepreneurs is given by:

$$\begin{aligned} S^e : &= \pi(1-\delta)N_t + I_t - N^i_{t+1} = \pi(1-\delta)N_t + \frac{\theta_t}{(1-\theta_t)}N^i_{t+1} = \\ &= \pi(1-\delta)N_t + \frac{\theta_t}{(1-\theta_t)}\frac{1}{q^R_t}\beta\pi N_t[r_t + (1-\delta)q_t] \end{aligned}$$

S^e is an upward sloping supply function since $\frac{\partial S^e}{\partial q} > 0$. In equilibrium $S^e = D^e$, which is equivalent to equation (2.5.7). Figure 2.1 shows the supply and demand functions for a numerically computed example. In this example, we set $N = 8.6, \beta = 0.99, \eta = 1, \omega = 7.14, \delta = 0.0226, A = 1, \gamma = 0.36, \pi = 0.01, \theta = 0.2$.

Next we analyze what happens when A_t or θ_t change. This is a comparative statics exercise. We fix states N_t, A_t, θ_t, derive the asset supply and demand and the equilibrium price q_t. Then we redo the exercise for a different value of θ_t or A_t.
$\Delta\theta_t$. The equity demand curve D^e does not move. We can simplify S^e to get:

$$\begin{aligned} S^e &= \pi(1-\delta)N_t + \frac{\theta_t}{(1-\theta_t q_t)}\beta\pi N_t[r_t + (1-\delta)q_t] \\ \frac{\partial S^e}{\partial \theta_t} &= \frac{1}{(1-\theta_t q_t)^2}\beta\pi N_t[r_t + (1-\delta)q_t] > 0 \end{aligned}$$

Then if $\Delta\theta_t > 0$, the equity supply curve moves up and the equity price decreases and the quantity of equity traded increases. Figure 2.2 presents this argument through a numerically computed example. In this example, we set $N = 8.6, \beta = 0.99, \eta = 1, \omega =$

$7.14, \delta = 0.0226, A = 1, \gamma = 0.36, \pi = 0.01, \theta_{low} = 0.2, \theta_{high} = 0.3$.

ΔA_t. The demand curve and the supply curve move up with $\Delta A_t > 0$ because:

$$\frac{\partial D^e}{\partial A_t} = \frac{\beta(1-\pi)N_t \frac{\partial r_t}{\partial A_t}}{q_t} > 0 \tag{2.5.8}$$

$$\frac{\partial S^e}{\partial A_t} = \frac{\theta_t}{(1-\theta_t q_t)}\beta\pi N_t \cdot \frac{\partial r_t}{\partial A_t} > 0 \tag{2.5.9}$$

These claims are true since $\frac{\partial r_t}{\partial A_t} > 0$. Thus the volume of equity traded increases unambiguously with A_t. As for the price of equity, equations (2.5.8) and (2.5.9) imply that as long as $1 - \pi - \theta_t q_t > 0$, the demand curve moves more than the supply curve implying an increase in price. Numerically, we find this to be the case around the equilibrium for small values of π. Figure 2.3 shows the effects of changes in A_t. The shift of the supply curve is very small and the two supply curves are not distinguishable. In this example, we set $N = 8.6, \beta = 0.99, \eta = 1, \omega = 7.14, \delta = 0.0226, A_{low} = 1, A_{high} = 1.1, \gamma = 0.36, \pi = 0.01, \theta = 0.2$.

2.5.4 Characterization of Steady State Equilibria

There are two types of steady state equilibria: (1) equilibria in which the financial constraint binds and the price of equity is greater than one, and (2) equilibria in which the financial constraint does not bind and the price of equity is equal to one. Theorem 2.5.3 summarizes the conditions under which each of these equilibria exists. We prove this theorem in the appendix, section 4.2.1.

Theorem 2.5.3. *In steady state the financial constraint binds and the price of equity is greater than one if and only if* $\theta < \frac{\delta - \pi}{\delta}$.

An example of a steady state, in which $q = 1$ is shown in Figure 2.4. It shows that at any price $q > 1$ supply of equity exceeds demand. At price $q = 1$ investing entrepreneurs are willing to supply any amount of equity that will not violate their financial constraint (any amount less or equal to the amount defined by the intersection of the supply curve with the y axis). Supply is indeterminate and asset trades are determined by demand. In this example we set $N = 8.6, \beta = 0.99, \eta = 1, \omega = 7.14, \delta = 0.0226, A = 1, \gamma = 0.36, \pi = 0.1, \theta = 0.2$.

If θ is small then in steady state $q > 1$ and the financial constraint binds. If $q = 1$ investing entrepreneurs would not be willing to produce enough new capital without violating the financial constraint to cover the demand for equity by the non-investing entrepreneurs. This can be seen in Figure 4.1. At price one investing entrepreneurs are willing to supply any amount less or equal to the amount defined by the intersection of the supply curve with the y axis. Any larger amount would violate their financial constraint. Since at price one the demand for equity exceeds supply the price of equity must increase. Therefore $q > 1$ and the financial constraint binds.

2.6 Data and Model Specification

The time period for our data is 1964-2008. We obtain quarterly data from the Current Employment Statistics provided by the Bureau of Labor Statistics, National Income and Product Accounts and Fixed Asset Tables provided by the Bureau of Economic Analysis, COMPUSTAT, Flow of Funds, CRSP and Global Financial Data. Details of the construction of the time series can be found in appendix 4.2.2.

2.6.1 Model Specification

We divide parameters and stochastic processes in the model into two groups. The first group consists of utility and technology parameters. The second group consists of the parameter π capturing the fraction of firms with access to capital production technology, the process for the ratio of outside to total financing of investment projects θ_t, and the process for the total factor productivity A_t.

Utility and Technology Parameters

We divide utility and technology parameters into two groups: 1) parameters that we take from the literature: share of capital in output production $\alpha = 0.36$, subjective discount factor $\beta = 0.99$ (adjusted for quarterly analysis), and the labor supply elasticity parameter $\eta = 1$[10] . 2) parameters that we choose so that our model in steady state matches chosen moments in the data. The average annual nominal investment to nominal capital ratio from 1964 to 2008 is 9.35%. To match this ratio in the steady state of our model we set quarterly depreciation $\delta = 2.26\%$. We set the scaling parameter of the workers' utility function ω so that the labor supply in steady state is equal to

[10] We will perform sensitivity analysis on β and η to check whether our results are affected by our choice of these parameters.

Table 2.1: Benchmark Parameters

Parameter	α	β	η	δ	ω
Value	0.36	0.99	1	0.0226	8.15

$l_s = 0.3$. Table 2.1 summarizes our benchmark parameters.

Parameter π

There is a large literature that analyzes the lumpiness of plant level investment and its effects on the dynamics of aggregate investment[11] . Our specification of the real friction is inspired by this literature. This literature finds that investment is lumpy, i.e. in a given year only a small fraction of plants invest a lot, while a majority of plants do not invest at all or adjust their capital only modestly. In our model firms with an investment opportunity will generally invest a lot relative to their size. Therefore we calibrate π by matching to the fraction of firms (rather than plants) with an investment spike in the data. However, the definition of an investment spike in the literature is not unique. Gourio and Kashyap (2007) use two definitions: investment exceeding 20% and investment exceeding 35% of the beginning of the period capital. We follow their definitions and construct our own firm level measures of investment spikes.

In particular, we construct the series for investment as an increase in "Net property, plant and equipment", i.e. variable *ppent* in the COMPUSTAT database, $investment_t = ppent_t - ppent_{t-1}$. We then determine the fraction of firms whose investment at time t exceeds a given fraction of $ppent_{t-1}$. As in Gourio and Kashyap (2007) we weigh firms by beginning of the period capital $ppent_{t-1}$. Figure 2.5 shows the fraction of firms with an investment spike. In Table 2.2 we report the average fraction of firms with an investment spike over the period 1965 - 2008 for several alternative definitions of the investment spike. We use annual $\pi = 0.06$ in our benchmark calculations and perform

[11] See for example Becker and Haltiwanger (2006), Caballero, Engel, Haltiwanger, Woodford and Hall (1995), Cooper et al. (1999), Cooper and Haltiwanger (2006), Doms and Dunne (1998), Gourio and Kashyap (2007), Khan and Thomas (2003), KHAN and THOMAS (2008) and Thomas (2002).

Table 2.2: Average fraction of firms with an investment spike 1965 - 2008

investment spike threshold	average fraction of firms
20%	10.6%
25%	7.2%
30%	5.2%
35%	4.3%

sensitivity analysis in section ??[12] .

Processes for θ_t and A_t

We construct the series for θ_t from the data as follows. θ in the model stands for the fraction of investment that is financed externally. Using Flow of Funds data we define for the nonfinancial corporate sector:

$$\theta = \frac{\text{Funds Raised in Markets}}{\text{Fixed Investment}}$$

For definitions of these variables, see appendix 4.2.2. The series for θ is shown in figure 2.6.

We construct the series for total factor productivity A_t using the time series of output, capital and labor assuming a Cobb-Douglas production technology with share of capital in output production $\alpha = 0.36$. We define $\hat{z}_t = \log(A_t)$, and use z_t, the linearly detrended version of $\hat{z}_t$ as a realization of the shock process for the consumption good production technology. Having constructed the series for z_t and θ_t we estimate the stochastic processes for z_t and θ_t as follows.

$$\begin{aligned} z_{t+1} &= \rho_z z_t + \varepsilon_{z,t} \\ \theta_{t+1} &= \mu_\theta + \rho_\theta(\theta_t - \mu_\theta) + \varepsilon_{\theta,t} \end{aligned}$$

[12] This is probably a lower bound. **?** analyze monetary policy in a model based on Kiyotaki and Moore (2008). They use a quarterly $\pi = 0.06$ citing plant level data evidence from Cooper et al. (1999) and Doms and Dunne (1998).

Table 2.3: Summary statistics for the TFP shock z and the θ processes

variable x	μ_x	ρ_x	σ_{ε_x}	$corr(\varepsilon_z, \varepsilon_x)$
θ	0.2844	0.6510	0.1679	-0.0736
z	0	0.9498	0.00602	1

$$E\begin{pmatrix} \varepsilon_{z,t} \\ \varepsilon_{\theta,t} \end{pmatrix}^2 = \begin{bmatrix} \sigma^2_{\varepsilon_z} & corr(\varepsilon_z, \varepsilon_x)\sigma_{\varepsilon_z}\sigma_{\varepsilon_\theta} \\ corr(\varepsilon_z, \varepsilon_x)\sigma_{\varepsilon_z}\sigma_{\varepsilon_\theta} & \sigma^2_{\varepsilon_\theta} \end{bmatrix}$$

Table 2.3 summarizes our estimation of the TFP[13] and θ processes. For the TFP process we find that $\rho_z = 0.95, \sigma_z^2 = 0.00602^2$.

2.7 Empirical Results

We solve our model and simulate it by generating random series of the primitive shocks A_t and θ_t using the estimated parameters for these processes[14] . Having simulated the model we compute a set of statistics and compare them to the data. We find that our model matches quite well the behavior of aggregate quantities and prices in the data. Our benchmark model generates about 80% of the volatility in asset prices. We find that most of the volatility in asset prices in our model comes from the volatility in the financial friction parameter θ_t.

Tables 2.4 and 2.5 summarize our benchmark results. In these two tables we present our results for 3 different models to highlight the role of financial frictions. The model in

[13] While the persistence parameter is standard in the literature, the standard deviation of the error term is slightly lower that those used in previous studies (see e.g. Prescott (1986)). This is consistent with the recent decrease in output volatility known as "the great moderation".

[14] We approximate the processes on a 25 point grid in the $z \times \theta$ space using the Tauchen approximation method, see Tauchen (1986), and then use $A_t = \exp(z_t)$.

column (1) in table 2.4 and table 2.5 assumes that the financial constraint never binds. This is the case for example for large values of π. In this case the price of equity q_t is always one and fluctuations in θ are irrelevant for the dynamics of the model. Volatility in reported variables comes from the volatility in the TFP shock A_t. In column (2) in table 2.4 and table 2.5 we present our results for a version of the model in which the financial constraint binds, A_t is stochastic, but θ_t is constant at its mean level. This model highlights the role of the financial constraint as a propagator of TFP shocks. In column (3) in table 2.4 and table 2.5 we present our results for the model in which the financial constraint binds and both θ_t and A_t are stochastic. Relative to the model of column (2) this model highlights the role of fluctuations in θ_t.

2.7.1 Standard Business Cycle Statistics

Table 2.4 summarizes our results for the standard business cycle statistics. We find that financial frictions do not affect output volatility and persistence. This indicates that the process for output in our model is determined by the process for the productivity shock (assumed to be the same in the 3 versions of the model). As discussed in section 2.5 labor and output are perfectly correlated and their relative volatility is determined by the parameter η. Therefore the properties of labor supply are not affected by the financial friction parameter θ_t either.

In contrast to output the behavior of investment is significantly affected by financial frictions. In the model without financial frictions shown in column (1) of Table 6.1 investment is significantly less volatile than in the data. This seems to be at odds with the results for the standard one-sector growth model, in which TFP shocks generate investment volatility observed in the data. Our model of column (1) resembles the standard one sector growth model, but there is one important difference. In our model investment is determined by entrepreneurs only. Log utility implies that they save a fixed fraction of their income $r_tK_t + (1 - \delta)K_t$, which is significantly less volatile than workers' income. This results in the low investment volatility in this version of our model. For the case of constant θ and a binding financial constraint shown in column (2) investment volatility is further decreased by endogenous changes in q. If A_t increases the asset demand increases as discussed in section 2.5. However the increase in the equilibrium quantity demanded will be smaller than if supply was infinitely elastics (column (1)). Therefore relatively less new capital will be produced and investment will be less volatile.

Adding volatility in θ_t increases the investment volatility significantly as shown in column (3) in Table 6.1. In fact investment volatility is slightly higher[15] than in the data. This result indicates that in our model shocks to θ play a more important role in investment fluctuations than shocks to A. This assertion is further supported by the relatively low persistence of investment coming from the lower persistence of θ relative to A. In contrast, we have argued above that output dynamics is driven by shocks to A only. The low correlation between θ and A that we estimated from the data therefore translates into the relatively low correlation between investment and output.

[15] This is an improvement relative to models with habit persistence such as Boldrin et al. (2001) or Christiano and Fisher (2003), whose models do not generate enough investment volatility.

2.7.2 Financial Statistics

Table 2.5 summarizes our results for quarterly asset prices and returns. The return on equity is defined as $r^e = \frac{r_t+(1-\delta)q_t}{q_{t-1}} - 1$. The corresponding counterpart in the data is the real value weighted stock return. We define the total market value in the model as $q_t N_t$. The corresponding counterpart in the data is the series *totval* from he CRSP database. We construct the model risk-free rate as follows. Shadow price of a risk free asset is:

$$p_t(s^t) = \beta E_t \left[\frac{u'(c_{t+1})}{u'(c_t)} \right]$$

Non-investing entrepreneurs are not constrained in their asset holdings whereas the investing entrepreneurs would like to sell more assets, but they cannot because of the financial constraint. Therefore, we construct the risk free rate as the shadow risk free rate of the unconstrained non-investing entrepreneurs[16] . We get:

$$r_t^f = \frac{1}{p_t(s^t)} = \frac{1}{q_t E_t \left[\frac{1}{r_{t+1}+(1-\delta)q_{t+1}} \right]}$$

We compare this model variable to the real return on 3-month T-Bills.

Table 2.5 shows that the model without financial frictions in column (1) generates very little volatility in equity returns and a very small equity premium. Recall that the price of equity $q = 1$ at all times in this model. Therefore there are no capital gains and all volatility in returns comes from the limited volatility of the return r_t. The model in column (2) has a constant θ and the financial constraint binding. It generates a standard deviation of the equity return of 0.77%. This result is similar to Gomes et al. (2003), who get an equity return volatility of about 1% in a model with endogenous borrowing constraints and TFP shocks the only source of uncertainty. This result highlights the

[16] This is similar in spirit to the exercise that Gomes et al. (2003) perform for their incomplete markets model. Alternatively, we could rationalize our choice by thinking about borrowing constrained entrepreneurs. The risk free rate would then be determined by the shadow risk free rate of the non-investing entrepreneurs, because investing entrepreneurs find investing and selling equity more profitable than buying the risk free asset.

Table 2.4: Standard Business-Cycle Statistics

Statistic[a,b]	Data[c]	(1) FC not binding A stochastic	(2) FC binding θ constant A stochastic	(3) FC binding θ stochastic A stochastic
σ_Y	1.52	1.18	1.19	1.18
σ_I	5.00	1.70	1.32	5.12
σ_C	0.85	1.01	1.15	1.93
σ_L	1.73	0.59	0.60	0.59
ρ_Y	0.87	0.68	0.67	0.67
ρ_I	0.85	0.68	0.67	0.40
ρ_C	0.90	0.68	0.67	0.47
ρ_L	0.92	0.68	0.67	0.67
$\rho(Y, I)$	0.90	1.00	1.00	0.23
$\rho(Y, C)$	0.85	1.00	1.00	0.61
$\rho(Y, L)$	0.87	1.00	1.00	1.00

[a] Results for the models are based on 100 replications of size 180.
[b] σ_x is a standard deviation of variable x, ρ_x is the autocorrrelation of x and $\rho(x, y)$ is the correlation between x and y. All variables are logged and HP filtered before statistics are computed. Standard deviations are measured in percentage terms.
[c] This column contains quarterly statistics computed for the U.S. data in 1964:1 - 2008:4. Details of the construction of the series are in the appendix, section 4.2.2.
Column (1) contains results for a version of the model in which the financial constraint is not binding and the process for TFP is estimated using U.S. data 1964:1 - 2008:4.
Column (2) contains results for a version of the model in which the financial constraint is binding, the process for TFP is estimated using U.S. data 1964:1 - 2008:4 and θ is constant at its mean level .2845.
Column (3) contains results for a version of the model in which the financial constraint is binding and both the process for TFP and θ is estimated using U.S. data 1964:1 - 2008:4.

fact that in our model (and theirs as well) the financial constraint is not a strong enough propagator of TFP shocks[17] . With no shocks to θ, investment, output and asset prices are driven by shocks to TFP implying a high correlation between these variables as shown in the second panel in column (2). Finally this version of the model generates only a very modest equity premium.

[17] We find that our model is able to generate high asset price volatility even with constant θ. However, we would need to increase the volatility of TFP shocks significantly generating a counterfactually high volatility in investment and output.

The success of our benchmark model with a stochastic θ is documented in the first panel in column (3). Our model generates high asset return volatility comparable to the data. It generates over 80% of the observed volatility in asset prices and total market value. In addition our benchmark model generates a quarterly equity premium of 0.85%, which is over 70% of what we see in the data. This result is of particular interest considering that entrepreneurs in our economy have logarithmic utility. As with investment, our results imply that the dynamics of asset prices and returns in our model are driven by the dynamics of θ_t. Therefore, we see a low persistence of q_t and a low correlation between q_t and Y_t.

A shortcoming of our model is the counterfactual negative correlation between asset prices and investment. We have shown in section 2.5 and in this section that fluctuations in A will imply a positive correlation between investment and asset prices while fluctuations in θ will imply a negative correlation between investment and asset prices. In this section we have shown that the behavior of investment and asset prices is determined by shocks to θ rather than by shocks to A, which implies the large negative correlation.

A general lesson to be taken from this result is the following. In this class of models changes in the tightness of the financial constraint (parameter θ in our model) directly affect the amount of investment, but do not affect the productivity of existing capital in any way. A tighter constraint implies less investment and less new capital making old capital (and new capital as well) more valuable to agents in the economy. Therefore tighter constraints imply higher asset prices[18] .

In the data we find the correlation between our measure of asset prices and the financial friction parameter θ_t to be 0.18. While this coefficient is not large and in fact not significant our model captures only part of the story. To bring the model closer to

[18] We have found this to be true in the original Kiyotaki and Moore (2008) model in which the friction takes the form of limited resaleability. In this model an entrepreneur can only sell a fraction of his assets at a point in time to finance new investments. Tightening this constraint implies a decrease in investment and an increase in the asset price by the same logic.

Table 2.5: Quarterly Financial Statistics

Statistic[a,b]	Data[c]	(1) FC not binding A stochastic	(2) FC binding θ constant A stochastic	(3) FC binding θ stochastic A stochastic
σ_q	11.85	0	0.93	9.69
σ_{r^e}	8.63	0.07	0.77	10.8
σ_{val}	10.72	0.13	0.92	9.74
ρ_q	0.74	1	0.67	0.38
$\rho(q, Y)$	0.39	0	1.00	0.11
$\rho(q, I)$	0.38	0	1.00	-0.94
$E(r^e)$	1.49	1.01	0.89	1.36
$E(r^f)$	0.30	1.01	0.88	0.51
σ_r^f	0.68	0.06	0.16	5.45
$E(r^e) - E(r^f)$	1.19	0.00	0.008	0.85

[a] Results for the models are based on 100 replications of size 180.
[b] σ_x is a standard deviation of variable x, ρ_x is the autocorrrelation of x and $\rho(x, y)$ is the correlation between x and y. All variables with the exception of the returns are logged and HP filtered before statistics are computed. Standard deviations and returns are measured in percentage terms.
[c] This column contains quarterly statistics computed for the U.S. data in 1964:1 - 2008:4. An exception is the measure for asset prices q, which was computed for 1974:1 - 2008:4. Details of the construction of the series are in the appendix, section 4.2.2.
Column (1) contains results for a version of the model in which the financial constraint is not binding and the process for TFP is estimated using U.S. data 1964:1 - 2008:4.
Column (2) contains results for a version of the model in which the financial constraint is binding, the process for TFP is estimated using U.S. data 1964:1 - 2008:4 and θ is constant at its mean level .2845.
Column (3) contains results for a version of the model in which the financial constraint is binding and both the process for TFP and θ is estimated using U.S. data 1964:1 - 2008:4.

Table 2.6: Yearly Returns

Statistic[a,b]	Data[c]	Benchmark	BCF(2001)
$E(r^e)$	6.03	4.30	7.82
$E(r^f)$	1.23	2.68	1.19
σ_r^e	17.6	15.2	18.4
σ_r^f	2.77	15.3	24.6
$E(r^e) - E(r^f)$	4.80	1.62	6.63

[a] Results for the Benchmark model are based on 100 replications of size 180.
[b] σ_x is a standard deviation of variable x. Returns are measured in percentage terms.
[c] This column contains quarterly statistics computed for the U.S. data in 1964:1 - 2008:4. Details of the construction of the series are in the appendix, section 4.2.2.
Column 'Benchmark' contains results for the benchmark version of our model in which the financial constraint is binding and both the process for TFP and θ is estimated using U.S. data 1964:1 - 2008:4.
Column 'BCF (2001)' contains results from Boldrin et al. (2001).

the data we would need to add e.g. a link between financial frictions and the productivity of current capital[19] . This is the logical next step in this line of research. Building a richer model of this kind would make it possible to determine when the 'investment channel' and when the 'current capital channel' plays a role for aggregate quantities and asset prices.

[19] In a recent paper **?** assume that firms need to borrow money in order to pay their workers, who have to be paid in advance. Tightening of this constraint results in less workers hired, which implies a decrease in productivity and the price of capital.

Figure 2.1: Demand and supply of equity as a function of the price of equity

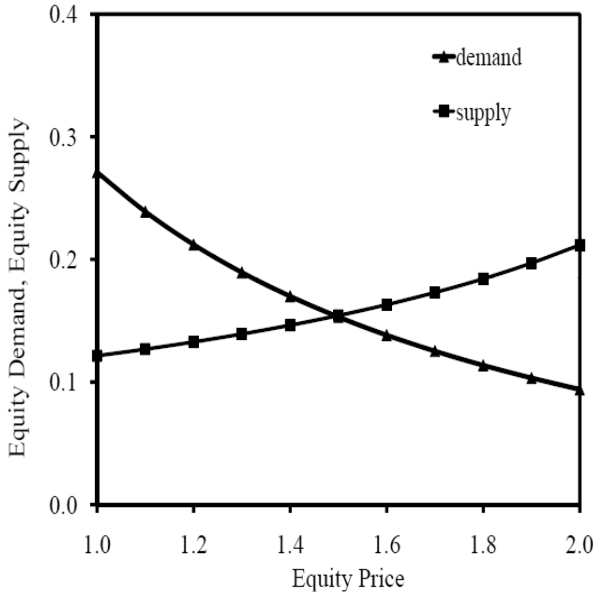


Figure 2.2: Demand and supply of equity for various levels of θ

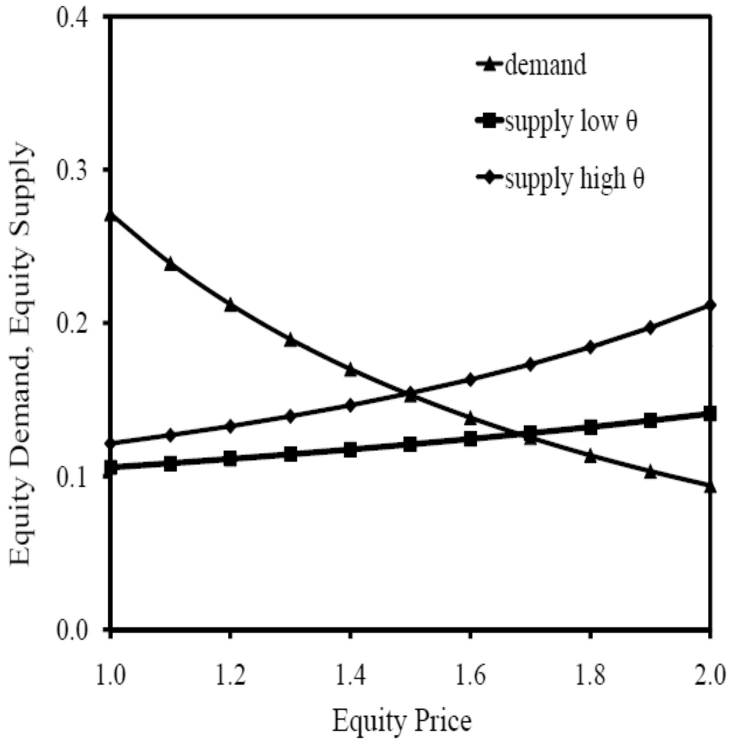


Figure 2.3: Demand and supply of equity for various levels of A

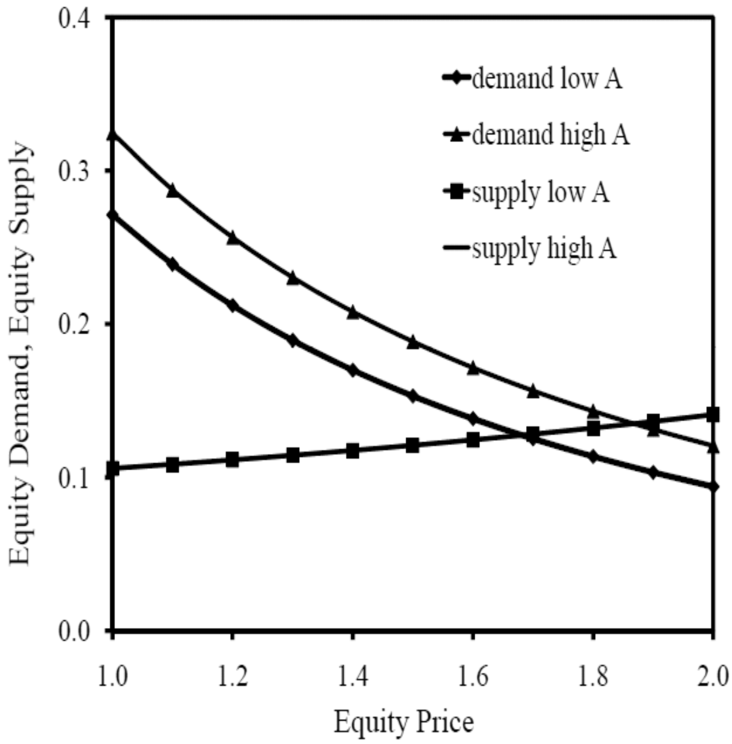


Figure 2.4: Demand and supply of equity as a function of the price of equity

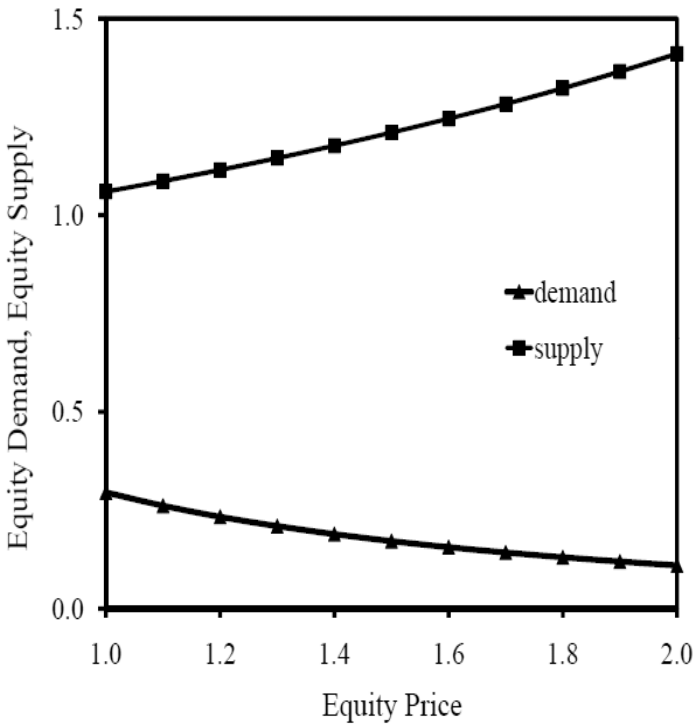
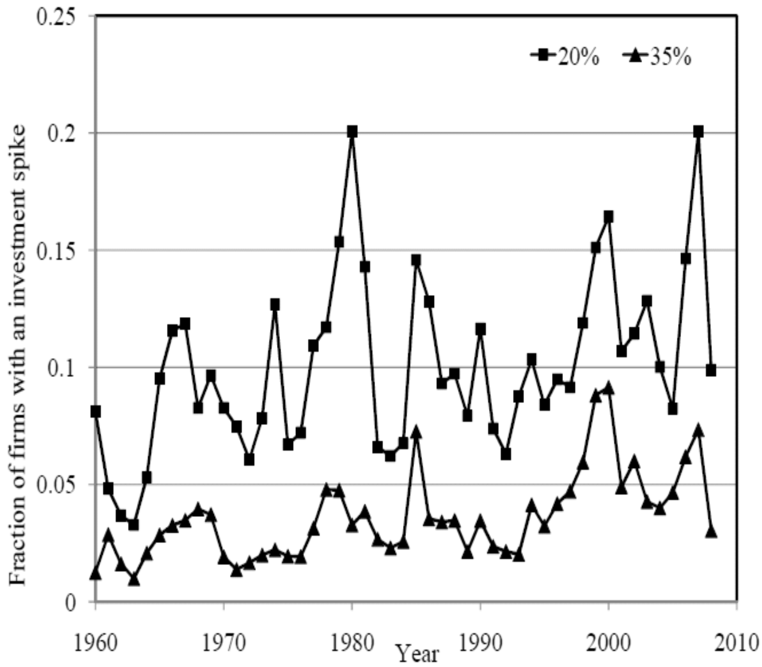
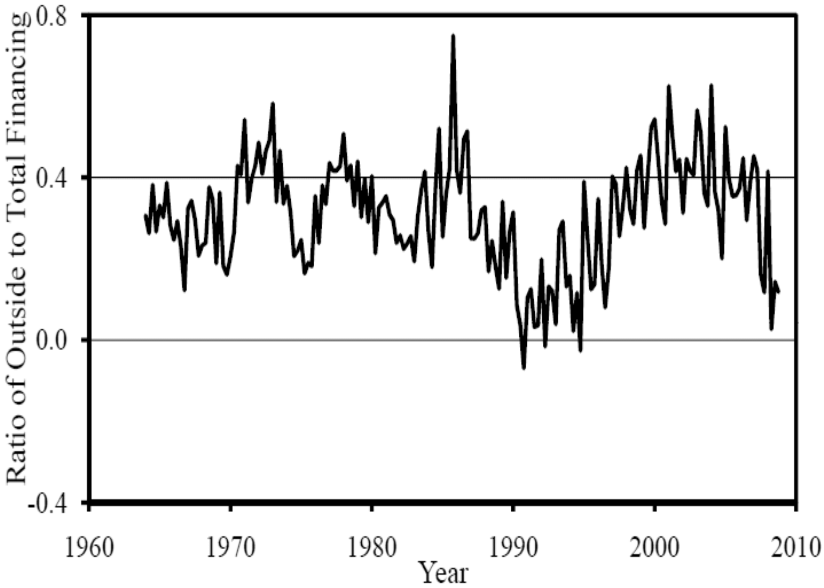


Figure 2.5: Fraction of firms with an investment spike



This figure shows the fraction of firms with an investment spike, defined as a 20%, or a 35%, increase in capital.

Figure 2.6: External financing as a fraction of investment



This figure shows the ratio of outside financing to total investment of the nonfinancial corporate sector.

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Chapter 3

Credit Market Timing

> There are many methods for predicting the future. For example, you can read horoscopes, tea leaves, tarot cards, or crystal balls. Collectively, these methods are known as "nutty methods." Or you can put well-researched facts into sophisticated computer models, more commonly referred to as "a complete waste of time".
> -Scott Adams

3.1 Chapter Summary

In this chapter we compare counterfactual corporate bond issuing dates to actual issuing dates in order to test the ability of firms to time the credit market. The 50 most active bond issuing financial firms and the 50 most active industrial firms are studied using one week, one month, and one quarter windows. The ability to time firm-specific CDS prices is studied from January 2002 - October 2009. The ability to time the risk-free rate (10 year US government bond) is studied from January 1988 - October 2009. We find that: firms do not successfully time the risk-free rate or the credit spreads. There is no evidence of CDS timing ability over one week or one month, but there is some borderline evidence at one quarter. For a typical bond issue, the firm loses about 1% of the face value of the bond relative to a 1 month window, due to their inability to time the market. If the firms could improve their market timing, they could save many hundreds of millions of dollars. Since there is a degree of statistical predictability in the data, we find it surprising that these firms are not able to do a better job of timing the credit market.

3.2 Introduction

In this chapter we study the ability of US firms to time the issuance of their bonds so as to minimize the cost of debt. To do this we compare the market conditions on each bond issue date to the market conditions over a time window around the issue date. A firm that has perfect market timing relative to the window, would find the day with the best market conditions within that window. If firms cannot time the market, then on average their timing should not depart too much from the average. Bootstrapping is used to construct standard errors. Monte Carlo simulation is used to verify the size and power of our testing method. By comparing the actual issue dates to the counter factual sets we can calculate how much individual firms lost by their inability to perfectly time the credit market.

There are two quite distinct versions of market timing. First, there is the traditional idea that a firm's manager has inside information about the firm itself that the market does not have, as in Finnerty (1976) or Myers and Majluf (1984). The firm might exploit this information by issuing securities (raising money) at times when it knows that the market is temporarily particularly optimistic about the firm. Second, there is the idea that the manager does not believe that markets are efficient, and so he issues securities when the market in general is offering money on temporarily particularly good terms, as in Stein (1996).[1]

These two ideas differ over what it is that the manager is attempting to time: the firm's own creditworthiness, or the general market conditions. To test the first idea, we

[1] For a review see Baker et al. (2007). A nice description of the idea is, "Graham's favorite allegory is that of Mr. Market, a fellow who turns up every day at the stock holder's door offering to buy or sell his shares at a different price. Often, the price quoted by Mr. Market seems plausible, but often it is ridiculous. The investor is free to either agree with his quoted price and trade with him, or to ignore him completely. Mr. Market doesn't mind this, and will be back the following day to quote another price. The point is that the investor should not regard the whims of Mr. Market as determining the value of the shares that the investor owns. He should profit from market folly rather than participate in it." http://en.wikipedia.org/wiki/Benjamin_Graham

study the ability to time the price of firm-specific Credit Default Swaps (CDSs). This data starts in January 2002. To test the second idea, we study the ability to time the risk-free rate, which we measure using the 10-year US government bond rate. This data starts in January 1988.

Finance scholars generally take the first idea much more seriously than they take the second idea. CFOs apparently see things differently. "Graham and Harvey (2001) find that interest rates are the most cited factor in debt policy decisions: CFOs issue debt when they feel "rates are particularly low." ... At the same time, CFOs do not confess to exploiting their private information about credit quality, instead highlighting general debt market conditions." Baker et al. (2007). So there is reason to examine both hypotheses.

We study the 50 financial firms, and the 50 industrial firms that were the most frequent bond issuers over the period 1988-2009. If any firms can time the market, it ought to be these firms. There is no theory that defines the length of the time windows. We focus on 1 month, but also provide results for 1 week, and 1 quarter. Most of the reported results are for windows centered on the issue date. However, windows that are strictly before and strictly after were also examined.

Conceptually, perfect market timing and a complete inability to time the market are the simplest benchmarks. A firm that could perfectly time, would always find the minimum over the window. A firm that has no timing ability will, on average issue at the median of the window. We use bootstraps to construct confidence intervals.

Partial market timing ability is trickier to define. A firm that has some imperfect timing ability ought to do better than pure chance. The better the timing ability, the more closely such a firm should approach the perfect market timer.

The key empirical result in this chapter is simple. Firms do not succeed in timing the credit market so as to minimize the cost of their debt. Firms are not able to time their own CDS prices. Firms are not able to time the government bond rate. Firms were not able to time the market before the financial crisis. Firms were not able to time the market during the financial crisis.

The rest of the chapter is organized as follows. Section 3.3 provides a short review of related literature. Section 3.4 provides a short review of institutional information on issuing bond. In section 3.5 the data is described. The basic testing strategy is described in Section 3.6. The main empirical results are presented in section 3.7. In Section 3.8 the dollars lost due to imperfect market timing ability are quantified. Section 3.12 concludes the chapter.

3.3 Literature

When asked, many CFOs claim their bond issuing decisions are guided by their assessments of the credit market conditions. The CFOs' answers have been interpreted as evidence that they are trying to 'time' the market. The survey evidence of Graham and Harvey (2001) is probably the most compelling evidence that managers do pay attention to market conditions. Such behavior may be surprising if credit markets are efficient, but seems easier to understand from the perspective of behavioral finance. Of course, 'actions speak louder than words,' and a controversial series of long horizon event studies have attempted to assess the market timing hypothesis.[2]

Market timing could pertain to macro conditions, or to firm conditions. Financial academics tend to think that it is rather hard to predict short term interest rates and easier to make use of internal firm information. Financial executives in surveys report paying attention to the market-wide component and not making use of internal firm information. In one case we should see evidence that firms time the government bond market. In the other case we should see evidence that firms time the CDS prices.

Much of the previous literature[3] studies whether managers can time long term changes in credit market conditions. Baker et al. (2003) study the ratio of aggregate long-term debt issuance to aggregate short-term plus long-term debt. They find that

[2] See Baker et al. (2003), Butler et al. (2006), Jenter et al. (2010, forthcoming).

[3] See Baker et al. (2003), Barry et al. (2008), Butler et al. (2006), Faulkender (2005), and Vickery (2008).

this ratio helps to predict cumulative 3-year excess returns on long-term government bonds over the period 1953-2000. As a result they infer that corporate managers are timing the debt market in the sense that they change the mix between long-term debt and short-term debt as a function of market conditions at multi-year frequencies.

Despite the influence of Baker et al. (2003), there are reasons for caution. First, the results presented in the paper are not as robust as might be hoped. In Table 6 of the paper they examine robustness across time periods. They find that the results are statistically significant for 1977 to 2000, but *not* for 1954 to 1976. Second, Butler et al. (2006) show that the Baker et al. (2003) results are due to a shift in excess bond returns in 1982 resulting from changes in macroeconomic policies. Ignoring this regime shift creates a spurious impression of market timing. Due to the results in Butler et al. (2006) we do not study the mix between short term and long term bonds. Further study of the slope of the yield curve is certainly of interest, but we leave such issues as beyond the scope of the current chapter.

Barry et al. (2008) report that debt issuance is backward looking. It responds to drops in interest rates relative to the previous decade. They also argue that annual data can be very misleading due to within-year variation. We share their concern over the time window which is why we focus on counterfactuals of 1 week to 1 quarter.

From a different perspective Faulkender (2005) studies the use of derivatives to hedge their new debt issues with interest rate swaps. He focuses on the choice of fixed or floating rate debt. Since the interest rate exposure is largely a function of the slope of the yield curve he rejects the hedging hypothesis in favor of speculation, earnings management or market timing.

A number of studies are devoted to equity market timing. These include Baker and Wurgler (2002), Huang and Ritter (2009), Butler et al. (2005), Butler et al. (n.d.). The results are mixed. Related issues have arisen in other markets, for instance Koijen et al. (2009) study timing of the mortgage market.

The prior literature of credit market timing is thus quite different from what we do.

The previous studies are mainly long term event studies that examine whether credit market actions by firms help predict long term returns. Such studies have all the issues associated with long term event studies.

We construct potentially feasible alternative issuing decisions – counterfactuals. We compare the terms of actual issues to the counterfactuals. This allows us to quantify the potential gains or losses from timing. Then we can examine what proportion of such gains firms actually managed to capture.

3.4 Issuing Bonds

A firm that wishes to issue a bond in the USA must follow the SEC and Finra rules. Changes were made in 2005 that were intended to facilitate market access.

The relevant parties are: the corporate issuer, the broker-dealer, syndicate members, issuer counsel, underwriter counsel, institutional investor, retail investor, trustee. The issuer is interested in raising money. The broker-dealer underwrites the issue. They may buy the issue from the corporation and resell it. They may form a syndicate to sell the issue. If there is a syndicate, then the dominant investment banker is known as the Lead Manager, or the Managing Underwriter. Both the corporation and the underwriters will have counsel to make sure the legal aspects are handled correctly.

There are three main distinct time stages in the process: 1. the initial announcement that the bonds will be available, 2. the deal is closed and priced, 3. the trade is actually executed and money starts changing hands. There are also some more detailed steps along the way as well.

We know the date on which the deal is closed and priced, and the date on when the trade is actually executed. We do not know the initial announcement dates.

3.4.1 Traditional Method

The underwriter will have an institutional sales force to market the issue. Often they will ask their clients to get a sense of suitable pricing for the bond. During the selling process the underwriters are likely to have ongoing contacts with both the corporation and the institutional buyers. It is said that the marketing period is typically about a week for a corporate bond. Once the marketing is done, the issuer holds a public meeting and the bonds are actually sold.

Retail investors may also have access to the bond issue through various programs offered by a number of financial institutions. The terms that retail investors get seem to be quite variable.

The trustee is a bank that administers the bond payments and terms. They often will also act as a transfer agent to transfer the bond to the buyer, and a paying agent to make sure that the interest and principal payments are made to the bond holders.

The dominant regulator is the SEC. They require the issuer to provide a registration statement 20 days before the public offering. They also set the required information to be included in the preliminary prospectus.

In April 1990 an expedited procedure was setup under Rule 144A. This allowed a Qualified Institutional Buyer to buy securities that have not been registered. This facilitated the use of private placements, particularly for below investment grade issues. Typically such issues have a fairly high interest rate. The purchaser signs a letter stating that the purchase is for investment purposes and not for resale. Sometimes such bonds are called letter bonds, and they cannot be resold for 2 years unless special circumstances arise. Oddly, under Rule 144A, institutional investors are permitted to trade such bonds among themselves at any time, and without having to register the securities.

SEC Rule 415 covers shelf registration. The firm registers up to $1 billion worth of bonds at once. The bonds are then sold in much smaller increments over the next 2 years. Commonly shelf registered bonds are sold as best efforts sales. There may be a published offering rate schedule that is distributed to institutional buyers. The maturity date of the issue can be subject to negotiation between the issuer (or the investment bank) and the institutional buyer.

3.4.2 Rule 163

The Securities Act was reformed in December 2005, including the adoption of Rule 163. The idea was to facilitate capital raising by 'well-known seasoned issuers" ("WKSI").

To qualify as a WKSI a firm must have at least \$700 million in market value of equity outstanding, or have raised at least \$1 billion in cash over the past three years, as well as meeting some minor technical criteria. Roughly the top 1/3 of publicly traded firms qualify as WKSI.

Such firms were permitted to undertake unrestricted oral and written offers before filing a registration statement. Prior to the change such offers would have been called 'gun-jumping' and were prohibited. The change allowed such issuers to informally get a feel for the level of potential interest in their bond issue, without formally announcing their intent.

The result appears to have been a major change in the corporate bond underwriting process for the affected firms. In 2004 the typical process for underwriting corporate bonds appears to have taken about a week. After the change, for WKSI firms the process is often truncated to a matter of hours. Indeed, it is apparently not uncommon for the key steps to require just minutes.

For example on April 29, 2009 EnCana issued \$500 million in 10 year bonds at 6.5%. The issue was announced at 8:44 AM via Bloomberg, and by phone. At 9:00 AM the issue was closed, so that no more purchase orders could be considered. That gave potential buyers 16 minutes to consider whether to express interest. At 9:23 AM an indicative pricing range was announced. At 9:30 AM, the preliminary prospectus was made available. At 10:16 AM the final pricing and terms were announced. At 1:15 PM the deal was priced, and the process ended.

Such a truncated process clearly limits the deal evaluations that a potential buyer can undertake. This short time lag has raised some concern, among institutional buyers. There is not even a conference call with management, and there is essentially no time to review the preliminary prospectus. This process also precludes negotiations between seller and buyer.

Nonetheless, there does not seem to be much pressure to reverse this truncated process. In fact, on December 28, 2009, the SEC proposed further easing the reporting requirements on issuers. Under the proposals being considered, representatives of WSKIs will also be able to premarket the issue without triggering 'gun-jumping'.

3.4.3 Key Institutional Points

This institutional description suggests elements that might be important for testing market timing theory. The first element is the distinction between the initiation of the public bond offering process, and the actual sale date. We do not have information on the initial announcements. We do have the date on which the issue is priced, and on the date on which the money changes hands.

The second element that is potentially important is the distinction between a regular bond issue, and an issue that is part of a shelf registration program. An issue that is part of a shelf registration program avoids the 20 day delay in filing the registration statement. Accordingly shelf registered issues might be more flexible for the firm.

In our empirical work we distinguish between regular issues and shelf registered issues. Both is widely used. It is noteworthy that industrial firms make relatively heavy use of shelf registration, and they commonly issue debt with a lower face value for such issue. On the other hand financial firms make heavier use of ordinary issues. Financial firm shelf registered securities are commonly at a higher interest rate.

3.5 Data and Summary Statistics

The data to be considered is of two types: firm-specific debt issues, firm-specific CDS prices, and market data. The firm level debt data is from FactSet. The Credit Default Swap data is from Bloomberg. The market data is from the Federal Reserve Bank of Saint Louis's FRED database.

We measure the term spread as the difference between the 10-year constant maturity Treasury yield and the T-bill 90 days yield. We measure the credit spread as the difference between the Baa yield and Aaa yield. The firms being studied are the 50 most active financials and the 50 most active corporates. The sample of firms is composed by looking at the most active issuers over the period 1988-2009.

For each debt issue we know the date on which it took place, the dollar amount of the issue, the coupon rate, and a variety of more specific terms (rating, seniority, callable, putable, convertible, exchangeable, maturity date). The data is daily from the start of 1988 through October of 2009.

The financial firms are considerably more active than the corporates in the debt market. As a result there are 16760 debt issues by corporate and 86720 debt issues by financials. The mean coupon rate for the financials is 4.42% and for corporates it is 5.91%.

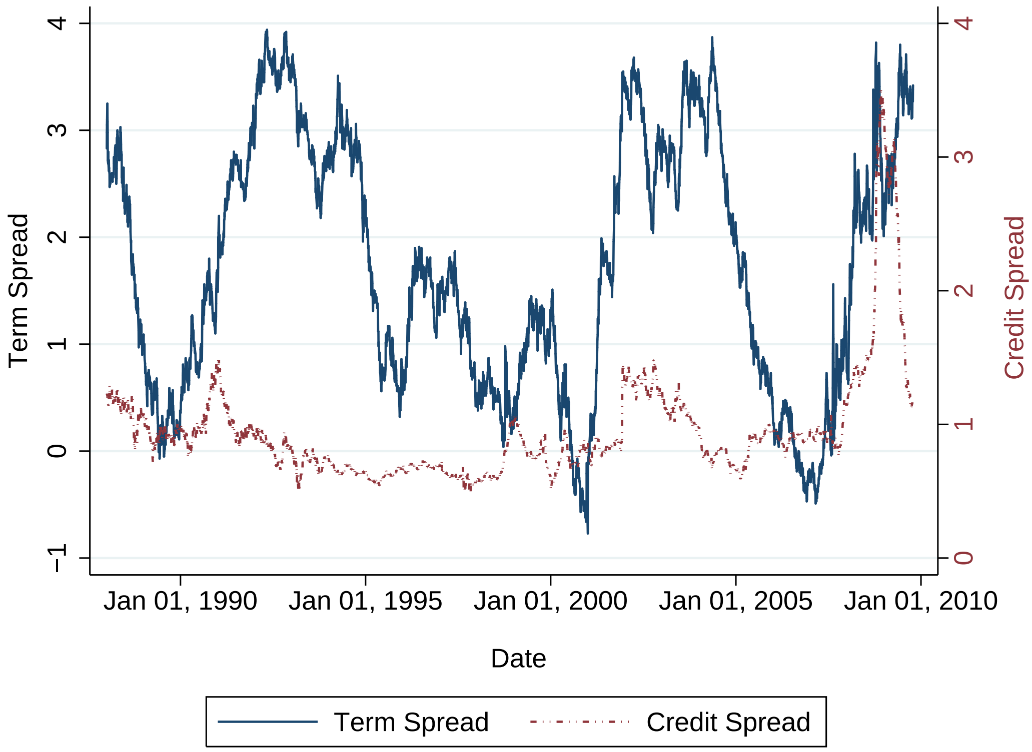
Figure 3.1 plots the terms spread and the credit spread over the sample period. The credit spread is fairly stable until late 2008. The reason that the credit spread is so stable is in good part due to the behavior of the credit rating agencies. If a firm becomes too risky, or not risky enough, they change the firm's credit rating.

3.6 Methodology

3.6.1 Testing Strategy

The basic question is whether the issue date is better or worse than other days in a window around the issue date. The firm wants to minimize the cost of capital. Thus a

Figure 3.1: Time Series of Term Spread and Credit Spread



good date to issue debt is a date on which the market price of a CDS on the firm is low. The cost of buying credit protection on the firm is low. On such a date the market does not think the firm is too risky. A good date is a date on which the government interest rate is low. On such a date the opportunity cost of funds is particularly low. Can the firms manage to find such days?

We present the test procedure in terms of the government bond rate. The procedure for the CDS pricing is essentially equivalent.

Let $c_{j,s}$ denote the coupon rate on a bond issue j that is issued on date s. The 10 year US government bond rate on date s is denoted as r_s. The coupon rate is composed of the government bond component plus a term that can be called markup (m_j) or spread that depends on the other terms of the debt issue. Thus we have,

$$c_{j,s} = r_s + m_j.$$

The spread (m) will depend on the various terms of the debt contract and on any changes in credit spreads that may take place over the event window. For our basic counterfactual analysis we assume that apart from the coupon rate, the other terms of the contract would be unchanged by any time shift.

Define a time window (w), measured in days, around date s. We study time windows of a week (5 trading days), a month (21 trading days) and a quarter (63 trading days). The windows being studied include 'before' windows that are completely before date s, 'after' windows are completely after date s, and 'centered' windows that have equal number of days before and after the issue date. To save space we primarily report results for a one month window that is centered on the issue date.

Over a fixed window there will be a distribution of the going returns on government bonds. Since interest rates fluctuate this distribution is not degenerate. The key question is where r_s fits in the distribution. Let $r_{s,\max}$, $r_{s,mean}$, $r_{s,\min}$ denote the highest, mean, and the lowest government bond rates in the window. If the firm has perfect market timing ability then $r_s = r_{s,\min}$. If the firm has no market timing ability then we expect $r_s = r_{s,mean}$. If the firm had the worst possible timing over this window, then $r_s = r_{s,\max}$. For a firm that has issued S securities the firm's unweighted average issue base rate is given by $\sum_{s=1}^{S} r_s/S$. It is also possible to consider value weighted averages.

The maximal and minimal averages are given by $\sum_{s=1}^{S} r_{s,\max}/S$, and $\sum_{s=1}^{S} r_{s,\min}/S$. The gap between these averages define the maximal possible gains from market timing over the windows. This calculation implicitly assumes that the firm is going to issue, and it is explicitly concerned with short run time shifting over the given event windows.

The approach to testing the CDS prices is essentially similar. In essence we take r_s to represent the firm's own CDS price on date s. Then the same procedures are applied.

3.6.2 Bootstrap Analysis

To construct standard errors we employ a simple bootstrap procedure. We analyze each firm in our database as follows. Consider a firm like Target Corporation that has issued (? get the number) bonds over the time period of ?-2009 for which we have CDS data. Suppose we are considering a 5 day window which is centered at date s. We observe the actual value of CDS prices over this window. Let $\{p^T_{s-2}, p^T_{s-1}, p^T_s, p^T_{s+1}, p^T_{s+2}\}$ denote Target's CDS prices over this window. Using a uniform random number generator we draw a sample from dates in the set $\{s-2, s-1, s, s+1, s+2\}$. We choose the CDS price corresponding to the date that we drew using the uniform random number generator. We repeat this sampling for each day in our database to construct one bootstrap sample of Target's CDS prices. We redo this process for 1,000 times to construct 1,000 bootstrap sample path of Target's CDS prices.

Let $\{t_1, \cdots, t_?\}$ denotes the dates on which Target Corp. has issued bonds and let $\{p^T_{t_1}, \cdots, p^T_{t_?}\}$ denotes the corresponding CDS prices in the market. Let $\overline{p}_{Target}$ denotes the average CDS prices over the dates that Target Corp. has issued bonds, i.e.

$$\overline{p}_{Target} = \frac{p^T_{t_1} + \cdots + p^T_{t_?}}{?}$$

Let $\overline{p}^1_{Target}, \cdots, \overline{p}^{1000}_{Target}$ denote the counterparts of $\overline{p}_{Target}$ when bootstrapped sample path of CDS prices is used instead of the market prices. $\overline{p}^1_{Target}, \cdots, \overline{p}^{1000}_{Target}$ are the possible CDS prices that Target could have achieved if it had no timing ability and was choosing its bond issuing dates by chance over the 5 day window. We study where $\overline{p}_{Target}$ is located in the sample distribution function computed using $\{\overline{p}^1_{Target}, \cdots, \overline{p}^{1000}_{Target}\}$. We repeat the above discussed procedure for each firm in our database.

For government bond rates the procedure is essentially the same. Suppose we are considering a 5 day window which is centered at date s. We observe the actual value of government bond rates over this window. Let $\{r_{s-2}, r_{s-1}, r_s, r_{s+1}, r_{s+2}\}$ denote the government bond rates over this window. Using a uniform random number generator we draw a sample from dates in the set $\{s-2, s-1, s, s+1, s+2\}$. We choose the government bond rate corresponding to the date that we drew using the uniform random number generator. We repeat this sampling for each day in our database to construct one bootstrap sample of government rates. We redo this process for 1,000 times to construct 1,000 bootstrap sample path of the government rates.

We analyze each firm in our database as follows. Consider a firm like Target Corporation that has issued (? get the number) bonds over the time period of 1988-2009. Let $\{t_1, \cdots, t_?\}$ denotes the dates on which Target Corp. has issued bonds and let $\{r_{t_1}, \cdots, r_{t_?}\}$ denotes the corresponding government rates in the market. Let $\overline{r}_{Target}$ denotes the average government bond rates over the dates that Target Corp. has issued bonds, i.e.

$$\overline{r}_{Target} = \frac{r_{t_1} + \cdots + r_{t_?}}{?}$$

Let $\overline{r}^1_{Target}, \cdots, \overline{r}^{1000}_{Target}$ denote the counterparts of $\overline{r}_{Target}$ when bootstrapped sample path of government rates is used instead of the market rates. $\overline{r}^1_{Target}, \cdots, \overline{r}^{1000}_{Target}$ are the possible rates that Target could have achieved if it had no timing ability and was choosing its bond issuing dates by chance over the 5 day window. We study where $\overline{r}_{Target}$ is located in the sample distribution function computed using $\{\overline{r}^1_{Target}, \cdots, \overline{r}^{1000}_{Target}\}$.

3.6.3 Monte Carlo Analysis

The window and bootstrap procedure seems rather natural. However, one should always consider how well a proposed procedure works in finite samples. Accordingly we have carried out a small Monte Carlo.

Suppose that firms could perfectly time the market. Then the observed issue dates would always be the minimal cost dates. This prediction is so grossly incorrect, that there is no point doing any simulation.

Suppose that firms have no ability to time the market. How frequently would our approach report that they can time the market? To answer this question we construct a panel data of 50 firms who issue debts over the time period of 1988-2009 as follows. Each firm issues N_i, $i = 1, \cdots, 50$ debts. The date on which a firm issues debt is uniformly distributed over the time period of 1988-2009. Therefore, by construction the firms do not have any market timing ability.

TO BE DONE: Suppose that firms have some ability to time the market, but it is not perfect. At what point do we pickup the evidence? What are the size and power of our tests?

3.7 Results

3.7.1 Timing Credit Conditions

Table 3.1 presents the first pass at the ability of firms to time the market price of credit. Panel A presents evidence on the ability of firms to time the overall variation in the market's demand for compensation for imperfect credit. Panel B presents evidence on the firm's ability to time their own creditworthiness.

In Panel A over the window we examine the compensation for credit risk over 1988-2009. This is measured by the difference between the going rate on BBB rated issues and the going rate on AAA rated issues. This difference is then added to the 10 year government bond rate. If the gap is big on a given day, then that is day on which the market id demanding a lot of compensation. If the gap is small on a given day, then that is a day on which the market is relatively risk tolerant. Thus it is likely easier to issue on low spread days.

In Panel A. the typical financial firm issued at 5.44%, while the typical financial firm issued at 5.91%. Financial firms had about 20,326 shelf registered issues and 39,360 non-shelf registered issues. The interest rate on the shelf registered issues was 6.3% compared to just 5% on the regular issues. Industrial firms issuing was very different. The industrial firms had 9691 shelf registered issues and only 922 regular issues. The average rate on the shelf registered issues was 5.82% compared to 7.06% on regular issues. Thus industrial firms seem to depend mainly on shelf registered issues. Overall the average interest rate is remarkably close to the mid-point of weekly, monthly, and quarterly windows. This is true for financials and for industrials. This is true for shelf registered issues and for regular issues.

From Panel A we see that neither the financial firms, nor the industrial firms seem to have been timing the overall market credit spread conditions. But perhaps they are timing their own creditworthiness. To examine this in Panel B of Table 3.1 we examine whether the firms succeeded in issuing on days on which their own CDS prices are particularly low. In this panel we use the CDS price to compute the implied coupon markup that would be due on any given day. This requires the existence of CDS prices, and so this Panel covers 2002 to 2009. Over this period financial firms still make use of regular bond issues, while industrial firms have only a few regular bond issues. Industrial firms depend largely on shelf registration.

For the financial firms the average shelf registered issue rate is 6.86%. For one week and one month this is almost exactly the midpoint of the values over the window. For the one quarter window it is a touch below the midpoint, which opens the question of whether the departure is statistically and financially significant. For industrial firms the average shelf registered rate is 4.65%. As with the financial firms, at one week and one month this is almost exactly the midpoint of the window. But at one quarter it is a touch below the mid point of 4.73%.

For non-shelf registered financial issues the average rate is 4.47%. This is very close to the midpoint for one week and one month. At one quarter it is ever so slightly below the window midpoint of 4.485%. For the industrial firms there are relatively few non-shelf issues.

From the results in Table 3.1 there is no evidence of successful timing over a one week or a one month horizon. There is some indication at one quarter that perhaps something more is at work. But this table does not provide any indication of statistical or financial significance.

To get at the issue of significance able presents bootstrapped CDS results for individual financial firms from January 2002 though December 2006. This avoids the financial crisis period. We use bootstrap samples to construct the standard errors. The firms are sorted according the position of the means issue relative the bootstrap sample. The best performance is by Morgan Stanley. Only 14% of the bootstrap samples had lower CDS prices than the actual issue dates. A firm that was exploiting investors should have a very low value in the distribution. Remarkably among the financial firms, a number of firms had unusually bad timing. These include Citigroup, Simon Property, Metlife and a few other firms.

Table 3.3 examines the same issue for industrial firms again for the pre-crisis period. In this case there is a bit of a problem that the number of debt issues is rather low for most of the firms. At a 0.05 critical value only two firms have significant timing ability, and both of these have very few actual issues (2 and 5). Thus, as with the financial firms, there is no evidence that the industrial firms were able to time their own creditworthiness.

3.7.2 Timing the Risk-Free Rate

It is traditional to decompose a corporate interest rate into a risk-free component and a risk markup components. The results provided above focus on the risk-markup component. This subsection examines the risk-free component. As usual there is the question of what empirical proxy to use for the risk-free component. We have considered both 3 month Treasury Bills and 10 year government bonds. The inferences to be drawn are very similar. In 3.4 we provide the results for 10 US government bonds. The exercise is essentially the same as in Table 3.1, but with the focus being on the bond rate rather than on CDS implied rates. The date runs from 1988 to 2009. In Table 3.7 we provide Monte Carlo evidence that the method provides reasonable answers under the null of no timing ability.

Consider the financial firms first. For shelf registered issues, the mean rate is 6.33%, this is almost exactly the midpoint for all three window sizes. For non-shelf registered issues the mean rate is 5.01%, again this is almost exactly the midpoint for all three windows. Next consider the industrial firms. For shelf registered issues the mean rate is 5.83%. This is almost exactly the midpoint for all three windows. The implication of Table 3.4 are very clear cut. These firms are not able to time the risk-free rate overall.

In table 3.5 we examine the fraction of the gains from timing the risk-free rate that were actually captured. We also ask wether the size of the debt issues affects our inferences. To do this we distributions the top and bottom size deciles from the other issues. Both for the financial firms and for the industrial firms the median issue is very close to capturing half of the gains that were potentially available. For financials the value is actually 0.5 while for industrials it is0.48. Given the standard deviations, these are both indistinguishable from one half.

It is natural to conjecture that perhaps firms put more effect into timing the big issues. These are the issues that involve more money. The evidence does not support this conjecture. For the large (and for the small) issues, once again we cannot distinguish the results from one half.

Presumably effective market timing should matter more for longer term bonds than for shorter term bonds. To test this idea in table 3.5 we distinguish short term, medium term and long term bonds. The results for the medium term bonds match the previous results. Interestingly so do the long term bonds. There is no evidence that firms do any better timing their longer term bond issues. This is true both for industrial firms and for financials.

No matter which way we examine it, we find little in the way of evidence that these firms, the most frequent bond issuers in the USA, are able to time the risk-free rate.

3.8 How Much Was Left on the Table? Interest Rates

So far we have documented that neither the industrial firms, nor the financial firms succeeded in credit market timing. But perhaps this is just because successful timing would not make much financial difference. To address this question the next four tables examine the gains and losses the financial and industrial firms could have made. We provide results both as a fraction of the bond face value, and in simple dollar terms. For simplicity we focus on the 1 month horizon. Our focus is on the upper and lower bounds that are feasible, and how these bounds compare to the individual firm's actual performance.

In table 3.8 we examine how much money various financial firms could have captured if they we capable of perfect market timing of the risk-free rate over a one month window. This provides an upper bound on the potential gains. Since we have already documented that the they are typically close to the mid point, it also provides a rough sense of how much damage the typical firm avoided. We see that the loss is typically on the order of about 1% of the face value of the bond. At the low end Advanta lost only about 0.407% of the face value. At the high end Sun Trust lost about 1.77% of the face value. These may losses may not sound like much. However, these firms have many issues, and each issue is for millions of dollars. These things add up. Advanta could potentially have saved $6.98 million if they had done a perfect job of timing. They gained $16 million relative to the worst feasible timing over the one month window. Clearly perfect timing is pretty much inconceivable. But it might still have been worth money to try.

The extremes are, of course, the well-known Fannie and Freddie. They do so much issuing, that timing might really help. The Federal National Mortgage association left $17746 million on the table. The Federal Home Loan Mortgage Corp left $15344 million on the table. Even for private sector financial institutions the numbers are in the hundreds of millions.

Table 3.9 provides a similar analysis for the industrial firms. The order of losses range from 0.479% (Comdisco) to 2.64% (General Motors). The typical firm had a total loss on the order of 100 million due to the large face values involved. As with the financial firms, this is money.

3.9 How Much Was Left on the Table? CDS

Table 3.10 considers the amount lost due to imperfect CDS timing. The financial firms that had the lowest percentage losses were Fannie (0.18) and Freddie (0.222). On the other hand they issue so frequently that the losses are still above a billion for each of them. The prize for particularly bad timing belongs to Istar Financial. But that firm had only 2 debt issues. Thus the true champion of poor luck seem to have been AIG with a weighted loss of 3.56%.

The variation from best to worst firms timing of CDS prices among the industrials is reported in Table 3.11. The most extreme cases at both ends are firms that had fewer than 10 issues. After we restrict attention to firms with a reasonable number of debt issues, we find that the worst performer was Ford Motor and the best performer was Proctor and Gamble. Given the smaller number of issues, the dollar values of the losses was much smaller for the industrial firms. Despite this the losses are still in the tens of millions.

3.10 Interest Rate Forecasting

We have documented that firms do not have a strong ability to time the credit market conditions. Such an inability results in firms leaving hundred of millions uncaptured. But the uncaptured money is relative to a theoretical benchmark. Perhaps this benchmark is asking too much of firms. Perhaps forecasting is simply not feasible.

The feasibility of predictions is the subject of a large econometric literature. Findings of predictability are often interpreted as inconsistent with market efficiency. However it is also well known that such tests are typically joint tests of market efficiency and a particular model or returns. There is an academic literature on predicting interest rates changes.[4] However, there does not seem to be a consensus on whether such changes are predictable or not. Accordingly we checked to see whether off-the-shelf

[4] See, among others, Ang and Piazzesi (2003), Backus et al. (2001), Longstaff (2000).

econometric methods, together with the 'obvious' financial factors are able to predict interest rate changes. Our interpretation of 'off-the-shelf' methods included VARs and ARMA models as well as some basic GARCH-type models. Such models are well known, and can easily be implemented with conventional widely available statistical packages. Our interpretation of 'obvious' financial factors is based on the factors that we commonly see reported in the financial press.

After some exploration of VAR and GARCH type models, we found that it is rather hard to improve on a rather simple AR(1) model. While there is some evidence of GARCH effects, they do not have much power. As a result in Table 3.12 we report the results of a couple of very simple AR(1) models. The more complex models that we tried produced only very minor changes in the amount of variation explained.

From Table 3.12 we draw two inferences and a caution.

1. Interest rate changes are predictable at conventional levels of statistical significance. There is an AR(1) component. Bond futures and the term spread prove to be significant factors. The credit spread term is also frequently statistically significant. These factors are fairly robust to alternative specifications. Thus there is a degree of predictability in the data.

2. Consider the R^2 terms. Only about 2% of the variation in the data is being explained. Thus the predictable component is rather minor. It is far from obvious that any real firm could exploit such a minor amount of predictability.

3. As a note of caution, Table 3.12 is for daily data. We have not yet done the systematic corresponding analysis for weekly and quarterly windows. Our preliminary work suggests that a greater degree of predictability is found over longer horizons.[5]

A basic component of the terms of the bond comes from the current government bond rate. We have already seen that in surveys CFOs claim to pay attention to this

[5] Presumably this must be consistent with some previous studies. We need to get the relevant cites.

rate when deciding when to issue. Furthermore Table 3.12 documents that there is a degree of predictability, albeit with low explanatory power at daily horizon.

Presumably more refined models would forecast better. Given the hundreds of millions of dollars potentially at stake, we find it surprising that these firms are not able to do a better job of credit market timing.

3.11 Robustness Checking

The robustness of our results have been checked across many dimensions. They are very robust. The above results are for windows of 21 trading days (1 month) centered on the actual bond issue date. We have examined 5 day (1 week) and 63 day (1 quarter) windows. We have considered window strictly before the issue date and windows strictly after the issue date. We have considered using government bonds that match the maturity of the bond issue more precisely.[6]

To illustrate this robustness we provide the result for financial firms during 1988-2006 period. In Tables 3.13 and **??** we see that again very few firms are in the lower tail of the distribution.

3.12 Conclusion

In surveys, CFOs say that they pay attention to market conditions when deciding whether to issue new securities. This has been described as 'market timing', and interpreted as support for behavioral finance and a black mark for the efficient market hypothesis. Support for this idea has primarily come from long term event studies. But long run event studies are susceptible to problems in the normalizing model leading to many controversies.

[6] Still further robustness checking is underway. We plan to examine the impact of filtering on the dollar value of the issue, and on alternative terms-to-maturity of bonds. We plan to examine the use of a SWAP curve in place to the government bond rates. These, and several other treatments of the data are currently being studied.

In this chapter we focus instead on constructing counterfactual trading strategies over a window around each observed bond issue. The key idea is simple. If a firm is successfully timing the market relative a given event window, then it will not be possible to shift the issue date inside the window and obtain better terms. Windows before and after are both considered along with windows centered on the issue date. Windows of 1 week, 1 month, and 1 quarter are studied. In each case we ask whether the observed issue date reflects successful market timing. The 50 financial firms and 50 corporates that are the most frequent bond issuers are studied. If any firms can time the market, it ought to be these firms. We study their ability to time the 'risk-free' 10 year US government bond rate. We also study their ability to time the price of their own firm risk in the Credit Default Swap markets.

The hypothesis of credit market timing is tested against the alternative hypothesis that the timing is purely a matter of chance. The chance hypothesis is consistent with either firms that do not try to time the market, or with firms that try – but have no ability to beat the market.

The evidence is overwhelming and very robust. The observed bond issuing date decisions look almost exactly like what is predicted by the chance hypothesis. The inability of the most active industrial and financial firms to time the risk-free rate seems to cost them about 1% to 2% of the value of the bonds being issued.

There is some mild very mild evidence of predictability at longer horizons relative to the firm's own CDS prices. In subsequent drafts more evidence on that will be provided. At this stage, even for the CDS prices at quarterly horizon, the real surprise is how bad these high profile firms seem to be at timing the credit market.

Table 3.1: How Well Firms Timed the Credit Spread?

Panel A: Market Credit Spread

Financials	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Issue Date	59758	5.44	5.44	39360	5	5	20326	6.3	6.3
One Week	59758	5.42	5.46	39360	4.98	5.02	20326	6.28	6.31
One Month	59758	5.39	5.49	39360	4.94	5.05	20326	6.25	6.34
One Quarter	59758	5.33	5.56	39360	4.88	5.12	20326	6.21	6.4
Industrials	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Issue Date	10726	5.91	5.91	922	7.06	7.06	9691	5.82	5.82
One Week	10726	5.9	5.93	922	7.04	7.07	9691	5.8	5.83
One Month	10726	5.87	5.96	922	7.01	7.1	9691	5.77	5.86
One Quarter	10726	5.82	6.01	922	6.96	7.16	9691	5.73	5.92

Panel B: CDS Prices

Financials	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Issue Date	26015	5.31	5.31	16867	4.47	4.47	9091	6.86	6.86
One Week	26015	5.29	5.32	16867	4.46	4.48	9091	6.83	6.89
One Month	26015	5.25	5.39	16867	4.43	4.52	9091	6.77	7.01
One Quarter	26015	5.21	5.49	16867	4.4	4.57	9091	6.7	7.21
Industrials	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Issue Date	3496	4.69	4.69	130	5.76	5.76	3293	4.65	4.65
One Week	3496	4.65	4.74	130	5.7	5.82	3293	4.61	4.69
One Month	3496	4.58	4.85	130	5.57	5.98	3293	4.54	4.8
One Quarter	3496	4.48	5.06	130	5.46	6.2	3293	4.45	5.01

This table shows the average actual, best and worst coupon rates that firms could have issued by changing the date on which they issued bond. The best and worst rates in Panel A are calculated when firms were timing the market credit spread part of the coupon rates. The best and worst rates in Panel B are calculated when firms were timing the firm's credit spread part of the coupon rates. Column (1) is the number of debts issued. Column (2) is the best rate over the window. Column (3) is the worst rate over the window. Column (4) is the number of non-shelf registered debts. Column (5) is the best rate over the window for non-shelf registered debts. Column (6) is the worst rate over the window for non-shelf registered debts. Column (7) is the number of shelf registered debts. Column (8) is the best rate over the window for shelf registered debts. Column (9) is the worst rate over the window for shelf registered debts.

Table 3.2: Do Financial Firms Time Their Own Creditworthiness? Pre-crisis Period.

Issuer	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MORGAN STANLEY DEAN WITTER & CO	27.15	27.31	26.89	27.83	27.07	27.60	0.14
JPMORGAN CHASE & CO	29.19	29.22	28.98	29.46	29.10	29.35	0.35
WASHINGTON MUTUAL INC	37.67	38.05	35.79	40.60	36.62	39.73	0.36
BANK OF AMERICA CORP	22.78	22.80	22.59	23.05	22.69	22.93	0.42
TRAVELERS COMPANIES INC	34.33	34.65	31.50	37.50	32.17	37.17	0.44
C I T GROUP INC NEW	39.01	39.01	38.10	39.89	38.60	39.44	0.49
FEDERAL NATIONAL MORTGAGE ASSN	20.28	20.28	20.09	20.43	20.19	20.37	0.53
LEHMAN BROTHERS HOLDINGS INC	37.70	37.70	37.37	38.17	37.53	37.90	0.54
CAPITAL ONE FINANCIAL CORP	62.30	62.16	59.10	64.66	60.62	63.60	0.54
M B I A INC	48.28	48.16	46.28	50.45	47.07	49.28	0.58
SUNTRUST BANKS INC	23.15	23.16	21.30	26.88	21.85	25.09	0.58
PRUDENTIAL FINANCIAL INC	26.41	26.36	25.89	26.88	26.14	26.61	0.65
GENWORTH FINANCIAL INC	24.56	24.11	21.90	26.19	22.65	25.62	0.68
FEDERAL HOME LOAN MORTGAGE CORP	19.35	19.32	19.17	19.54	19.23	19.41	0.70
HARTFORD FINANCIAL SVCS GROUP IN	27.41	27.33	26.90	27.87	27.10	27.60	0.70
AMERICAN INTL GROUP INC	28.16	28.00	27.56	28.45	27.77	28.23	0.85
GOLDMAN SACHS GROUP INC	37.73	37.55	37.15	37.96	37.35	37.75	0.92
ALLSTATE CORP	24.06	23.70	23.00	24.45	23.32	24.09	0.94
AMERICAN EXPRESS CO	27.77	27.44	26.96	27.90	27.20	27.67	0.99
WELLS FARGO & CO NEW	18.41	18.20	17.95	18.51	18.07	18.34	1.00
SIMON PROPERTY GROUP INC NEW	56.24	54.62	53.13	56.28	53.75	55.58	1.00
S L M CORP	29.60	29.27	28.96	29.63	29.11	29.43	1.00
CITIGROUP INC	18.16	17.87	17.73	18.02	17.79	17.94	1.00
METLIFE INC	30.84	29.61	28.91	30.38	29.23	30.01	1.00

Column (1) is the average of each firm's CDS over the dates that the firm has issued bonds. 1,000 bootstrap samples with a symmetric window of 21 days around each issue date are used to construct the bootstrap distribution for each firm. Column (2) is the mean, Column (3) is the minimum, Column (4) is the maximum, Column (5) is the 5th percentile, Column (6) is the 95th percentile of the bootstrap distribution. Column (7) shows where Column (1) in the bootstrap distribution is located, e.g. 0.14 in row "MORGAN STANLEY DEAN WITTER" means that 14% of bootstrap samples were smaller than the average CDS of 27.15.

Table 3.3: Do Industrial Firms Time Their Own Creditworthiness? Pre-crisis Period.

Name	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DEVON ENERGY CORP NEW	2	80.50	83.71	79.92	88.63	81.00	87.63	0.02
TYCO INTL GROUP S A	5	198.85	234.26	189.57	289.35	201.49	279.84	0.02
INTERNATIONAL BUSINESS MACHS COR	64	50.75	51.87	49.49	54.90	50.55	53.15	0.08
SARA LEE CORP	1	17.25	19.88	17.25	22.25	17.25	22.25	0.09
FORD MOTOR CO DEL	914	297.93	300.77	294.02	308.24	296.72	304.80	0.13
RYDER SYSTEMS INC	5	34.82	35.63	33.83	38.00	34.34	36.98	0.18
PFIZER INC	4	10.00	10.36	9.63	11.13	9.88	10.88	0.21
DOW CHEMICAL CO	102	130.38	132.24	125.67	139.89	128.59	136.08	0.22
INGERSOLL RAND CO	3	26.34	27.42	24.10	30.73	25.06	29.69	0.28
ANADARKO PETROLEUM CORP	9	44.40	45.02	41.48	48.59	43.20	46.96	0.30
BOEING CO	99	69.85	70.82	65.66	76.98	68.00	73.99	0.31
REYNOLDS AMERICAN INC	15	133.74	135.39	122.25	145.77	128.00	141.77	0.33
DISNEY WALT CO	16	62.18	62.74	58.47	69.46	60.33	65.82	0.39
ALTRIA GROUP INC	4	161.54	163.06	144.27	185.29	151.94	174.60	0.40
DEERE & CO	78	31.89	31.93	31.17	32.72	31.51	32.35	0.45
MACYS INC	6	55.18	55.68	51.36	59.32	52.58	58.64	0.45
HEWLETT PACKARD CO	13	58.67	58.07	50.00	65.34	51.90	64.15	0.53
SUPERVALU INC	2	103.72	104.96	100.91	112.29	101.13	110.87	0.54
NAVISTAR INTERNATIONAL CORP	2	235.00	234.77	221.33	251.67	223.67	248.33	0.54
OCCIDENTAL PETROLEUM CORP	3	65.00	64.97	62.67	67.50	63.50	66.50	0.55
INTERNATIONAL PAPER CO	10	77.09	76.84	72.51	81.09	74.42	79.29	0.55
NORTHROP GRUMMAN CORP	1	45.27	45.41	44.72	46.50	44.72	46.50	0.60
GENERAL MTRS CORP	16	286.85	285.37	271.65	303.56	276.34	296.69	0.62
ALCOA INC	4	47.50	47.17	45.00	49.38	45.50	48.88	0.63
KROGER COMPANY	4	76.14	75.57	72.48	79.97	73.25	78.52	0.65
DU PONT E I DE NEMOURS & CO	6	22.56	22.45	21.84	23.03	22.07	22.81	0.67
WEYERHAEUSER CO	6	91.97	90.39	83.50	97.03	86.09	94.49	0.70
PROCTER & GAMBLE CO	34	22.85	22.69	21.91	23.44	22.23	23.13	0.73
ASHLAND INC NEW	1	39.50	38.98	37.50	40.50	37.50	40.50	0.73
TARGET CORP	6	44.22	43.26	39.51	47.59	40.82	45.63	0.74
CONOCOPHILLIPS	18	50.07	48.94	45.94	52.51	46.80	51.22	0.80
GENERAL MILLS INC	35	90.86	88.78	80.59	95.19	85.01	92.54	0.82
PULTE HOMES INC	17	92.02	89.36	82.82	96.62	85.28	93.53	0.85
CATERPILLAR INC	852	27.16	27.06	26.78	27.36	26.92	27.22	0.85
TENET HEALTHCARE CORP	4	434.60	421.98	376.73	454.06	403.31	436.66	0.92
GENERAL ELECTRIC CO	1467	35.57	35.32	34.79	35.85	35.08	35.58	0.94
MCDONALDS CORP	13	31.73	31.03	29.77	32.78	30.29	31.76	0.94
TEXTRON INC	49	39.86	38.77	36.46	41.01	37.75	39.89	0.95
WAL MART STORES INC	19	16.41	16.03	15.32	16.63	15.67	16.38	0.97
XEROX CORP	3	168.33	98.25	88.00	114.00	88.00	114.00	1.00

Column (0) is the number of bonds issued by each firm. Column (1) is the average of each firm's CDS over the dates that the firm has issued bonds. 1,000 bootstrap samples with a symmetric window of 21 days around each issue date are used to construct the bootstrap distribution for each firm. Column (2) is the mean, Column (3) is the minimum, Column (4) is the maximum, Column (5) is the 5th percentile, Column (6) is the 95th percentile of the bootstrap distribution. Column () shows where Column (1) in the bootstrap distribution is located, e.g. 0.02 in row "DEVON ENERGY CORP NEW" means that 2% of bootstrap samples were smaller than the average CDS of 80.50.

Table 3.4: How Well Firms Timed the 10-Year Government Bond During 1988-2009 Period?

Financials	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Issue Date	59557	5.46	5.46	39278	5.01	5.01	20207	6.33	6.33
One Week	59557	5.39	5.52	39278	4.94	5.07	20207	6.27	6.4
One Month	59557	5.27	5.63	39278	4.82	5.19	20207	6.16	6.51
One Quarter	59557	5.11	5.79	39278	4.65	5.35	20207	6	6.66
Industrials	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Issue Date	10705	5.92	5.92	920	7.07	7.07	9672	5.83	5.83
One Week	10705	5.86	5.99	920	7.01	7.14	9672	5.76	5.89
One Month	10705	5.75	6.11	920	6.89	7.26	9672	5.65	6.01
One Quarter	10705	5.58	6.27	920	6.71	7.41	9672	5.48	6.17

This table shows the average actual, best and worst coupon rates that firms could have issued by changing the date on which they issued bond. Column (1) is the number of debts issued. Column (2) is the best rate over the window. Column (3) is the worst rate over the window. Column (4) is the number of non-shelf registered debts. Column (5) is the best rate over the window for non-shelf registered debts. Column (6) is the worst rate over the window for non-shelf registered debts. Column (7) is the number of shelf registered debts. Column (8) is the best rate over the window for shelf registered debts. Column (9) is the worst rate over the window for shelf registered debts.

Table 3.5: How Much of the Available Gain Firms Capture During 1988-2009 Period?

Panel A:

		Financials			Industrials		
		(1)	(2)	(3)	(1)	(2)	(3)
Small	mean	0.58	0.53	0.53	0.62	0.50	0.50
	min	0.35	0.41	0.41	0.36	0.00	0.00
	max	0.86	0.77	0.86	0.88	0.90	0.90
	median	0.54	0.53	0.53	0.62	0.51	0.51
	std	0.08	0.02	0.03	0.36	0.04	0.04
Medium	mean	0.51	0.50	0.51	0.50	0.48	0.48
	min	0.00	0.05	0.28	0.29	0.34	0.36
	max	0.90	0.79	0.55	0.79	0.57	0.57
	median	0.51	0.50	0.51	0.50	0.48	0.48
	std	0.01	0.02	0.02	0.07	0.03	0.03
Large	mean	0.51	0.48	0.50	0.50	0.51	0.51
	min	0.23	0.16	0.23	0.14	0.11	0.25
	max	0.97	0.86	0.65	0.91	0.92	0.92
	median	0.51	0.48	0.51	0.50	0.52	0.52
	std	0.03	0.04	0.03	0.14	0.09	0.08

Panel B:

		Financials			Industrials		
		(1)	(2)	(3)	(1)	(2)	(3)
Short Term	mean	0.52	0.51	0.52	0.50	0.48	0.49
	min	0.22	0.11	0.11	0.06	0.17	0.11
	max	0.80	0.67	0.80	1.00	0.82	1.00
	med	0.52	0.52	0.52	0.47	0.49	0.49
	std	0.02	0.03	0.02	0.17	0.05	0.05
Medium Term	mean	0.51	0.49	0.50	0.51	0.49	0.49
	min	0.16	0.04	0.38	0.29	0.31	0.33
	max	0.97	1.00	0.58	0.73	0.65	0.64
	med	0.51	0.49	0.51	0.49	0.49	0.49
	std	0.02	0.03	0.02	0.07	0.04	0.04
Long Term	mean	0.51	0.50	0.51	0.47	0.48	0.48
	min	0.04	0.20	0.20	0.16	0.21	0.25
	max	0.90	0.79	0.68	0.91	0.62	0.58
	med	0.52	0.50	0.52	0.47	0.49	0.49
	std	0.02	0.03	0.02	0.10	0.05	0.05

Column (1) shows the statistics for the fraction of the maximum feasible gain over a window of 21 days that firms actually capture on the average for non-shelf registered debts. Column (2) shows the statistics for the fraction of the maximum feasible gain over a window of 21 days that firms actually capture on the average for shelf registered debts. Column (3) shows the statistics for the fraction of the maximum feasible gain over a window of 21 days that firms actually capture on the average for all debts. Statistics are computed for small, medium and large size debts. 10th and 90th percentile of issued amount of debts in our database are used to associate each debt into small, medium or large debt.

Table 3.6: Bootstrap Results for Government Bond Market Timing of One Month

Panel A:

		Financials			Industrials		
	(0)	(1)	(2)	(3)	(1)	(2)	(3)
Short Term	0.05	0.00	0.02	0.00	0.00	0.02	0.02
	0.10	0.00	0.02	0.00	0.02	0.04	0.06
	0.90	0.36	0.34	0.20	0.64	0.38	0.30
	0.95	0.30	0.34	0.14	0.62	0.36	0.28
Medium Term	0.05	0.02	0.06	0.00	0.00	0.10	0.08
	0.10	0.08	0.10	0.08	0.00	0.16	0.14
	0.90	0.06	0.08	0.02	0.12	0.00	0.04
	0.95	0.02	0.06	0.00	0.12	0.00	0.02
Long Term	0.05	0.00	0.08	0.06	0.00	0.12	0.14
	0.10	0.06	0.10	0.14	0.02	0.16	0.18
	0.90	0.10	0.06	0.04	0.16	0.06	0.08
	0.95	0.06	0.06	0.02	0.16	0.06	0.06

Panel B:

		Financials			Industrials		
	(0)	(1)	(2)	(3)	(1)	(2)	(3)
Small	0.05	0.00	0.02	0.02	0.00	0.00	0.00
	0.10	0.00	0.02	0.02	0.00	0.00	0.00
	0.90	0.62	0.54	0.38	0.94	0.50	0.46
	0.95	0.62	0.52	0.38	0.94	0.50	0.46
Medium	0.05	0.00	0.06	0.04	0.00	0.10	0.08
	0.10	0.02	0.12	0.10	0.00	0.18	0.14
	0.90	0.06	0.02	0.02	0.10	0.00	0.00
	0.95	0.04	0.02	0.00	0.08	0.00	0.00
Large	0.05	0.02	0.06	0.04	0.00	0.04	0.02
	0.10	0.02	0.06	0.10	0.02	0.08	0.04
	0.90	0.10	0.12	0.04	0.34	0.18	0.12
	0.95	0.08	0.12	0.04	0.28	0.12	0.10

Column (0) show the percentiles that are used to calculate the statistics in Columns (1), (2), and (3). (Column (1), Row (1)) shows the fraction of firms whose achieved average 10-year government rate are below 5% of bootstrap distribution. (Column (1), Row (2)) shows the fraction of firms whose achieved average 10-year government rate are below 10% of bootstrap distribution. (Column (1), Row (3)) shows the fraction of firms whose achieved average 10-year government rate are above 90% of bootstrap distribution. (Column (1), Row (4)) shows the fraction of firms whose achieved average 10-year government rate are above 95% of bootstrap distribution. For Column (1) achieved average 10-year rates are calculated on dates that a firm issued non-shelf registered bonds. For Column (2) achieved average 10-year rates are calculated on dates that a firm issued shelf registered bonds. For Column (3) achieved average 10-year rates are calculated on dates that a firm issued bonds. Statistics are computed for short, medium and long term bonds.

Table 3.7: Bootstrap Results for Government Bond Market Timing of One Month for Monte Carlo Panel Data

	Financials			Industrials		
	0.01	0.05	0.10	0.01	0.05	0.10
mean	3.27	5.25	6.94	3.13	5.51	7.36
min	0	0	0	0	0	0
max	10	14	15	10	13	16
p1	0	1	2	0	1	2
p5	1	2	3	1	2	3
p10	1	3	4	1	3	4

1000 panel data is generated. Each panel data is bootstrapped. The statistics in rows are computed using the data in each panel. 3.27 in the first row and the first column means that for financial firms on average 3.27 out of 50 firms by luck achieve rates that belong to 1%(0.01) tail of the distribution of the interest rates. 3 in the last row and the second column means that 90% (p10) of times 3 firms by luck achieve rates that belong to 5%(0.05) tail of the distribution of the interest rates.

Table 3.8: Money Left on the Table by Financial Firms due to Lack of Risk Free Rate Timing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ADVANTA CORP	97	.518	.407	.0719	17.7	6.98	1715	16
S L M CORP	990	1.05	.602	.622	103	616	102227	630
FEDERAL AGRICULTURAL MORT CORP	286	.786	.637	.164	25.8	46.9	7365	61.5
C I T GROUP INC NEW	712	.837	.797	.767	96.2	546	68462	558
INVESCO LTD	15	.882	.812	2.2	270	32.9	4056	35.2
FEDERAL NATIONAL MORTGAGE ASSN	13595	1.06	.833	1.31	157	17746	2129160	16831
POPULAR INC	74	.713	.861	.67	77.8	49.6	5755	52.7
FEDERAL HOME LOAN MORTGAGE CORP	12864	1.11	.863	1.19	138	15344	1777257	14465
FINOVA GROUP INC	88	.838	.865	1.04	120	91.5	10581	96
HUNTINGTON BANCSHARES INC	42	.792	.867	.74	85.4	31.1	3586	34.5
BLACKSTONE GROUP L P	23	.91	.871	1.82	209	41.9	4811	52.2
WASHINGTON MUTUAL INC	83	.908	.915	2.56	279	212	23196	250
GENWORTH FINANCIAL INC	70	1.41	.924	.805	87.1	56.4	6100	52.9
CAPITAL ONE FINANCIAL CORP	56	1.11	.937	3.25	347	182	19451	206
AMERICAN INTERNATIONAL GROUP INC	1717	.668	.938	.58	61.9	996	106268	1104
SIMON PROPERTY GROUP INC NEW	63	1	.949	2.91	306	183	19295	222
ISTAR FINANCIAL INC	26	.851	.968	2.96	306	76.9	7943	70.4
MARSHALL & ILSLEY CORP NEW	220	1.17	1	.442	44.2	97.3	9727	105
AMERICAN EXPRESS CO	54	.98	1.01	5.91	584	319	31560	483
WELLS FARGO & CO NEW	450	.859	1.03	2.92	283	1316	127552	1606
MORGAN STANLEY DEAN WITTER & CO	647	.745	1.04	1.94	187	1255	120672	1406
CITIGROUP INC	1972	.928	1.04	1.34	129	2651	254660	3046
KIMCO REALTY CORP	48	1.03	1.06	.898	84.4	43.1	4050	45.9
PROTECTIVE LIFE CORP	137	1.26	1.1	.314	28.6	43.1	3924	64.7
BANK OF AMERICA CORP	1991	1.28	1.15	1.54	134	3073	267594	3160
B B & T CORP	25	1.28	1.16	3.71	320	92.7	8004	106
JPMORGAN CHASE & CO	2327	.697	1.16	.879	75.5	2045	175720	1979
LEHMAN BROTHERS HOLDINGS INC	940	.991	1.2	.932	77.8	876	73161	757
U S BANCORP DEL	76	1.25	1.22	4.06	334	308	25362	315
HOST HOTELS & RESORTS INC	44	.983	1.23	4.48	364	197	16035	156
P N C FINANCIAL SERVICES GRP INC	96	1.5	1.23	3.19	260	306	24925	366
BANK OF NEW YORK MELLON CORP	649	1.8	1.25	.399	31.9	259	20682	274
ALLSTATE CORP	37	1.15	1.26	4.89	389	181	14387	194
LOEWS CORP	47	1.2	1.28	3.59	281	169	13219	252
SCHWAB CHARLES CORP NEW	61	.97	1.35	.385	28.6	23.5	1743	23
METLIFE INC	46	1.36	1.36	6.84	503	315	23146	259
REGIONS FINANCIAL CORP NEW	34	1.14	1.36	4.3	315	146	10722	149
Berkshire Hathaway Finance Corp	498	1.35	1.37	1.97	144	983	71913	1049
HARTFORD FINANCIAL SVCS GROUP IN	506	1.02	1.39	.344	24.7	174	12484	164
PRINCIPAL FINANCIAL GROUP INC	533	1.13	1.4	.277	19.7	148	10523	134
TRAVELERS COMPANIES INC	97	1.32	1.44	1.65	115	160	11108	217
WILMINGTON TRUST CORP	7	1.01	1.45	1.77	123	12.4	858	9.57
WEINGARTEN REALTY INVESTORS	62	1.3	1.45	.589	40.5	36.5	2513	43.9
M B I A INC	35	1.19	1.49	1.17	78.9	41	2761	46.2
GOLDMAN SACHS GROUP INC	341	.785	1.49	3.83	257	1306	87765	1047
UNITEDHEALTH GROUP INC	42	1.59	1.51	5.61	372	236	15617	222
PRUDENTIAL FINANCIAL INC	630	1.24	1.65	.571	34.6	360	21785	315
COMERICA INC	18	1.48	1.71	3.23	189	58.2	3402	50.2
KEYCORP NEW	57	1.53	1.73	3.66	212	209	12061	157
SUNTRUST BANKS INC	36	1.62	1.77	5.54	313	200	11285	168

Column(1) is the number of fixed listing bonds that have the available data to do the calculations in this table. Column(2) is the percentage loss relative to the face value of the bond. Column(3) is the weighted percentage loss relative to the face value of the bond (real face value of bonds are used as weights). Column(4) (in millions) is the average dollar lost on each bond. Column(5) (in millions) is the average face value of bonds. Column(6) (in millions) is the total dollar lost. Column(7) (in millions) in total bonds issued. Column(8) (in millions) is the dollars that firms could have lost if they they would have issued on worst day in the one month window. All the dollars are year 2000 dollar.

Table 3.9: Money Left on the Table by Industrial Firms due to Lack of Risk Free Rate Timing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
COMDISCO INC	100	.416	.479	.339	70.7	33.9	7067	48.1
P H H CORP	127	.905	.643	.231	36	29.4	4568	21.2
INGERSOLL RAND PLC	88	.734	.663	.741	112	65.2	9836	124
PACCAR INC	282	.505	.671	.0655	9.76	18.5	2753	15
DISNEY WALT CO	66	1.22	.893	3.09	346	204	22815	293
INTERNATIONAL BUSINESS MACHS COR	322	.696	.898	1.43	159	460	51259	553
PENNEY J C CO INC	34	.897	.91	3.41	375	116	12734	189
NAVISTAR INTERNATIONAL CORP	16	.9	.914	2.06	225	32.9	3603	30.7
ASHLAND INC NEW	79	1.14	.94	.638	67.9	50.4	5366	127
RYDER SYSTEMS INC	151	.84	.949	.305	32.2	46.1	4855	50.7
DEERE & CO	215	.699	.957	1.16	121	250	26110	276
CATERPILLAR INC	1518	.988	1.02	.23	22.5	349	34173	400
ALTRIA GROUP INC	54	1	1.04	5.24	501	283	27080	279
TEXTRON INC	48	1.02	1.05	2.12	203	102	9739	83.5
WAL MART STORES INC	56	1.03	1.06	8.19	772	459	43223	664
PULTE HOMES INC	42	1.05	1.06	2.39	225	101	9453	142
WEYERHAEUSER CO	73	1.08	1.06	2.62	246	191	17969	428
REYNOLDS AMERICAN INC	65	1.15	1.07	4.92	458	320	29781	299
PEPSICO INC	157	1.16	1.1	2.27	206	356	32348	406
KROGER COMPANY	241	1.18	1.11	1.07	96.6	258	23277	280
OFFICEMAX INC NEW	48	.943	1.11	.679	61.3	32.6	2941	33.5
ABITIBIBOWATER INC	28	1.23	1.12	3.36	301	94.1	8425	140
EXXON MOBIL CORP	33	1.08	1.13	2.25	198	74.2	6538	98.4
FORD MOTOR CO DEL	1194	.882	1.14	1.57	138	1871	164465	1516
CHEVRON CORP NEW	149	.972	1.18	1.94	164	288	24402	297
DU PONT E I DE NEMOURS & CO	51	1.02	1.22	3.93	323	200	16483	262
GENERAL ELECTRIC CO	2096	1.14	1.22	1.42	116	2967	242517	2540
XEROX CORP	103	1.17	1.22	2.97	243	306	25016	265
PROCTER & GAMBLE CO	75	1.19	1.26	4.96	393	372	29486	393
MACYS INC	61	1.48	1.28	4.11	320	250	19548	283
OCCIDENTAL PETROLEUM CORP	74	1.19	1.29	2.03	157	150	11651	191
DOW CHEMICAL CO	236	1.32	1.3	1.62	124	382	29245	356
HEWLETT PACKARD CO	44	1.37	1.31	6.89	526	303	23139	331
ALCOA INC	71	1.3	1.39	2.79	200	198	14205	183
DEVON ENERGY CORP NEW	39	1.52	1.42	5.92	416	231	16213	188
GENERAL MILLS INC	99	1.21	1.43	1.44	101	142	9958	87.4
TYCO INTERNATIONAL LTD SWTZLND	43	1.35	1.44	10.1	702	435	30180	555
SARA LEE CORP	53	.879	1.46	1.8	124	95.5	6549	64.5
U S AIRWAYS GROUP INC NEW	49	1.26	1.46	2.58	177	126	8667	119
SUPERVALU INC	81	1.24	1.49	2.14	144	173	11633	127
TENET HEALTHCARE CORP	37	1.41	1.49	8.31	557	307	20600	211
BOEING CO	314	1.03	1.49	.916	61.4	288	19271	266
INTERNATIONAL PAPER CO	75	1.44	1.51	4.19	277	314	20807	332
TARGET CORP	51	1.35	1.51	5.67	375	289	19138	338
NORTHROP GRUMMAN CORP	69	1.28	1.51	3.85	255	266	17563	260
ANADARKO PETROLEUM CORP	73	1.39	1.65	4.87	295	356	21506	254
CONOCOPHILLIPS	90	1.34	1.69	8.13	483	732	43434	750
MCDONALDS CORP	62	1.61	1.77	4.1	231	254	14331	185
PFIZER INC	45	1.34	1.94	14.1	724	633	32574	256
GENERAL MTRS CORP	51	1.66	2.64	14.4	547	736	27915	718

Column(1) is the number of fixed listing bonds that have the available data to do the calculations in this table. Column(2) is the percentage loss relative to the face value of the bond. Column(3) is the weighted percentage loss relative to the face value of the bond (real face value of bonds are used as weights). Column(4) (in millions) is the average dollar lost on each bond. Column(5) (in millions) is the average face value of bonds. Column(6) (in millions) is the total dollar lost. Column(7) (in millions) in total bonds issued. Column(8) (in millions) is the dollars that firms could have lost if they they would have issued on worst day in the one month window. All the dollars are year 2000 dollar.

Table 3.10: Money Left on the Table by Financial Firms due to Lack of Creditworthiness Timing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FEDERAL NATIONAL MORTGAGE ASSN	6289	.201	.122	.18	148	1131	929813	1524
FEDERAL HOME LOAN MORTGAGE CORP	5435	.196	.136	.222	164	1207	890289	1306
SUNTRUST BANKS INC	10	.203	.186	.486	261	4.86	2610	4.33
M B I A INC	25	.264	.222	.134	60.5	3.36	1512	5.4
TRAVELERS COMPANIES INC	8	.227	.223	.869	390	6.95	3116	7.43
PRINCIPAL FINANCIAL GROUP INC	25	.342	.285	.0105	3.68	.262	92	1.69
SIMON PROPERTY GROUP INC NEW	34	.314	.34	1.21	358	41.3	12163	90.5
WELLS FARGO & CO NEW	173	.133	.424	1.31	309	227	53541	258
HARTFORD FINANCIAL SVCS GROUP IN	400	.267	.44	.0738	16.8	29.5	6701	46.2
LEHMAN BROTHERS HOLDINGS INC	632	.428	.467	.265	56.8	168	35921	409
ALLSTATE CORP	14	.454	.504	2.23	442	31.2	6189	57.5
BANK OF AMERICA CORP	1129	.269	.512	.657	128	742	144828	912
JPMORGAN CHASE & CO	1715	.167	.529	.279	52.7	478	90373	615
WEINGARTEN REALTY INVESTORS	1	.546	.546	.442	81	.442	81	3.33
GOLDMAN SACHS GROUP INC	296	.357	.556	1.43	258	424	76221	624
METLIFE INC	28	.465	.573	2.93	511	82.1	14315	213
MORGAN STANLEY DEAN WITTER & CO	341	.239	.634	1.19	188	407	64225	912
SCHWAB CHARLES CORP NEW	2	.797	.657	2.69	410	5.38	820	4.9
S L M CORP	202	.199	.711	.293	41.2	59.2	8326	116
WASHINGTON MUTUAL INC	17	.743	.807	4.03	499	68.5	8491	86.1
PRUDENTIAL FINANCIAL INC	402	.338	.906	.283	31.2	114	12556	228
CAPITAL ONE FINANCIAL CORP	15	.78	.946	5.39	570	80.9	8544	127
CITIGROUP INC	438	.277	1	2.55	255	1118	111546	1801
C I T GROUP INC NEW	376	1.2	1.28	.781	61	294	22926	347
GENWORTH FINANCIAL INC	17	4.8	1.47	.251	17	4.26	289	5.69
AMERICAN EXPRESS CO	32	1.04	1.56	10.2	656	328	21005	300
AMERICAN INTERNATIONAL GROUP INC	912	.399	3.56	1.92	54	1751	49253	1782
ISTAR FINANCIAL INC	2	8.87	10.7	27.9	260	55.8	520	107

Column(1) is the number of fixed listing bonds that have the available data to do the calculations in this table. Column(2) is the percentage loss relative to the face value of the bond. Column(3) is the weighted percentage loss relative to the face value of the bond (real face value of bonds are used as weights). Column(4) (in millions) is the average dollar lost on each bond. Column(5) (in millions) is the average face value of bonds. Column(6) (in millions) is the total dollar lost. Column(7) (in millions) in total bonds issued. Column(8) (in millions) is the dollars that firms could have lost if they they would have issued on worst day in the one month window. All the dollars are year 2000 dollar.

Table 3.11: Money Left on the Table by Industrial Firms due to Lack of Creditworthiness Timing

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PENNEY J C CO INC	2	.045	.0494	.209	424	.418	848	5.97
NORTHROP GRUMMAN CORP	3	.241	.198	.878	442	2.63	1327	8.35
PROCTER & GAMBLE CO	35	.161	.208	.896	430	31.4	15060	19.2
WAL MART STORES INC	22	.214	.224	2.07	924	45.5	20329	53.9
INGERSOLL RAND PLC	3	.209	.24	.502	209	1.51	627	.759
MACYS INC	14	.335	.3	1.43	474	20	6641	19.3
GENERAL MILLS INC	36	.364	.33	.435	132	15.6	4736	18.1
DEERE & CO	72	.293	.331	.605	183	43.5	13153	85.9
MCDONALDS CORP	16	.281	.365	1.13	309	18.1	4944	28.6
WEYERHAEUSER CO	6	.291	.417	.779	187	4.68	1121	12.7
REYNOLDS AMERICAN INC	20	.441	.454	1.35	297	27	5940	42.1
HEWLETT PACKARD CO	16	.294	.459	2.74	597	43.9	9556	68.4
TARGET CORP	6	.611	.493	3.1	630	18.6	3777	9.4
DU PONT E I DE NEMOURS & CO	15	.417	.529	3.02	571	45.2	8559	20
ANADARKO PETROLEUM CORP	11	.603	.537	2.9	540	31.9	5945	65.1
INTERNATIONAL BUSINESS MACHS COR	64	.488	.561	1.49	266	95.6	17044	54.6
PULTE HOMES INC	14	.584	.572	1.79	314	25.1	4392	45.4
PFIZER INC	10	.397	.585	8.59	1469	85.9	14689	71.8
ALCOA INC	12	.876	.67	3.92	585	47	7017	41.4
PEPSICO INC	8	.437	.677	5.75	849	46	6791	45.9
RYDER SYSTEMS INC	8	.658	.693	1.45	210	11.6	1676	2.96
DISNEY WALT CO	13	.683	.699	4.03	576	52.3	7490	60
CHEVRON CORP NEW	3	.72	.713	9.76	1368	29.3	4105	16.4
DEVON ENERGY CORP NEW	4	.666	.715	3.3	462	13.2	1848	9.38
ALTRIA GROUP INC	6	.764	.741	4.34	586	26	3515	37
OCCIDENTAL PETROLEUM CORP	5	.486	.776	3.02	389	15.1	1945	5.15
DOW CHEMICAL CO	165	.771	.782	.573	73.2	94.6	12086	732
NAVISTAR INTERNATIONAL CORP	2	.804	.806	2.9	360	5.81	721	4.32
P H H CORP	1	.933	.933	1.66	178	1.66	178	4.83
SUPERVALU INC	3	.998	.966	7.02	727	21.1	2180	43.4
CONOCOPHILLIPS	19	.585	.995	7.99	803	152	15265	129
INTERNATIONAL PAPER CO	12	.879	1.05	6.4	608	76.8	7291	102
TEXTRON INC	24	.794	1.1	2.29	209	55	5012	86.3
GENERAL ELECTRIC CO	813	.462	1.11	1.43	128	1162	104431	1566
CATERPILLAR INC	983	.256	1.17	.248	21.1	244	20759	116
KROGER COMPANY	9	1.32	1.27	4.91	388	44.2	3490	25.6
XEROX CORP	8	1.29	1.29	7.12	551	57	4404	86.8
BOEING CO	105	1.19	2.7	2.09	77.5	220	8136	99.5
FORD MOTOR CO DEL	577	1.34	2.94	1.67	56.6	961	32647	1396
GENERAL MTRS CORP	8	2.5	3.41	50.5	1482	404	11854	256
TENET HEALTHCARE CORP	7	4.41	4.9	32.6	665	228	4658	216
TYCO INTERNATIONAL LTD SWTZLND	6	5.08	7.37	86.3	1172	518	7033	59
ASHLAND INC NEW	2	9.45	11.8	50.1	426	100	851	101

Column(1) is the number of fixed listing bonds that have the available data to do the calculations in this table. Column(2) is the percentage loss relative to the face value of the bond. Column(3) is the weighted percentage loss relative to the face value of the bond (real face value of bonds are used as weights). Column(4) (in millions) is the average dollar lost on each bond. Column(5) (in millions) is the average face value of bonds. Column(6) (in millions) is the total dollar lost. Column(7) (in millions) in total bonds issued. Column(8) (in millions) is the dollars that firms could have lost if they they would have issued on worst day in the one month window. All the dollars are year 2000 dollar.

Table 3.12: Are Interest Rate Changes Predictable?

To forecast daily 10-year US Government Bond interest rates ('Bond'), a number of financial indicators were examined. The (t) indicates the day and Δ represents the change between the indicated day and the previous day. The credit spread is the difference between corporate BAA and AAA bond interest rates. The term spread is the difference between the interest rate on a 10 year US government bond and a 3 month US Treasury Bill. All of the above data items are from FRED2 ($http://research.stlouisfed.org/fred2/$). The Bond Futures is from Global Financial Data. The symbol for the series is USc1D. They construct the series by means of a rolling contract for its futures contract data. In each case the data includes the price for the futures contract closest to maturity. The Vix is the CBOE S&P 100 VOLATILITY INDEX - VXO(sm). Libor is the US INTERBANK O/N (LDN:BBA) - OFFERED RATE. The SP500_Index is the S&P 500 index.

	(1) Δ Bond(t)	(2) Δ Bond(t)
Δ Bond(t-1)	0.111***	0.108***
	(0.0430)	(0.0264)
Bond Futures(t-1)	0.000863***	0.000406***
	(0.000290)	(0.000113)
Term Spread(t-1)	-0.0827**	-0.0493**
	(0.0351)	(0.0228)
Credit Spread(t-1)	-0.168**	-0.110**
	(0.0826)	(0.0546)
Δ VIX_Close(t-1)	0.00194	
	(0.00196)	
Δ SP500_Index(t-1)	8.05e-05	
	(0.000250)	
Δ Libor Overnight(t-1)	-0.00989	
	(0.00907)	
Constant	-0.0955***	-0.0448***
	(0.0326)	(0.0122)
Observations	1246	3099
R^2	0.017	0.011
F	3.004	8.364
$Prob > F$	0.0039	0.0000
Log Likelihood	1586	4140

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.13: Bootstrap Results for Government Bond Market Timing of One Month, During 1988-2006.

		Financials			Industrials		
	(0)	(1)	(2)	(3)	(1)	(2)	(3)
Short	0.05	0.00	0.02	0.00	0.00	0.02	0.02
	0.10	0.00	0.02	0.02	0.02	0.04	0.06
	0.90	0.36	0.42	0.24	0.64	0.38	0.30
	0.95	0.34	0.40	0.22	0.62	0.36	0.26
Medium	0.05	0.02	0.04	0.02	0.00	0.06	0.04
	0.10	0.04	0.10	0.10	0.02	0.16	0.12
	0.90	0.10	0.10	0.04	0.14	0.00	0.02
	0.95	0.06	0.08	0.02	0.14	0.00	0.00
Long	0.05	0.00	0.02	0.02	0.00	0.14	0.12
	0.10	0.06	0.08	0.06	0.02	0.18	0.16
	0.90	0.12	0.10	0.08	0.16	0.06	0.06
	0.95	0.10	0.10	0.08	0.16	0.06	0.06

		Financials			Industrials		
	(0)	(1)	(2)	(3)	(1)	(2)	(3)
Small	0.05	0.00	0.02	0.02	0.00	0.00	0.00
	0.10	0.00	0.02	0.02	0.00	0.00	0.00
	0.90	0.70	0.62	0.52	0.94	0.52	0.48
	0.95	0.70	0.56	0.46	0.94	0.52	0.48
Medium	0.05	0.00	0.04	0.02	0.00	0.10	0.08
	0.10	0.02	0.10	0.06	0.02	0.22	0.16
	0.90	0.10	0.06	0.08	0.10	0.00	0.00
	0.95	0.08	0.02	0.04	0.08	0.00	0.00
Large	0.05	0.02	0.04	0.02	0.00	0.02	0.00
	0.10	0.02	0.04	0.02	0.02	0.06	0.00
	0.90	0.10	0.22	0.08	0.36	0.16	0.16
	0.95	0.08	0.20	0.06	0.32	0.16	0.14

Description of this table is the same as Table 3.6. The time period for this table is 1988-2006.

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Chapter 4

Appendix

4.1 Appendix to Chapter 1

4.1.1 Capital Market Driven Model

This subsection reports sensitivity analyses in the baseline capital market driven model.

Profit Volatility and Firms' Behavior

How does profit volatility affect a firm's behavior? Should a firm with high profit volatility choose lower leverage than a firm with low profit volatility? Should a firm with high profit volatility issue more equity than a firm with low profit volatility? How large are the magnitudes of differences, for instance, between the market leverage of a firm with high profit volatility and that of a firm with low profit volatility?

Table 4.1 shows the results of a simulated panel of firms in economies in which profit volatility is $\sigma = 10\%, 15\%, 20\%, 25\%, 30\%$, and 35%.

Table 4.1 shows that as the profit volatility increases, 1) the average investment increases significantly, 2) the volatility of investment increases significantly, 3) the change in dividend payments is insignificant, 4) the relationship between profit volatility and equity issuance is not linear; for instance, a firm with higher profit volatility does not

Table 4.1: How Does Profit Volatility Affect Firms' Behavior in the Baseline Capital Market Driven Model?
Panel data are simulated using the baseline capital driven model to generate the calculations. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point.

$\sigma \rightarrow$	10%	15%	20%	25%	30%	35%
Average investment to total assets	0.14	0.17	0.21	0.25	0.32	0.38
Volatility of investment to total assets	0.23	0.34	0.48	0.58	0.78	0.91
Average size	170.8	185.9	194.8	203.2	218.2	237.9
Average dividend to total assets	0.04	0.04	0.04	0.04	0.03	0.03
Frequency of equity issuance	0.00	0.00	0.00	0.10	0.03	0.11
Average equity issuance to total assets	0.00	0.00	0.00	0.01	0.03	0.02
Average Tobin's Q	1.59	1.63	1.78	1.99	2.29	2.56
Average book leverage	0.51	0.50	0.50	0.49	0.49	0.49
Average market leverage	0.32	0.32	0.31	0.28	0.27	0.25
Persistence of dividend/assets	0.07	0.06	0.16	0.02	0.04	0.12
Persistence of debt/assets	0.56	0.55	0.56	0.57	0.43	0.51
Persistence of leverage	0.55	0.57	0.58	0.60	0.59	0.59

necessarily issue equity more often, and 5) the book leverage and the market leverage decrease. More importantly, firms with low profit volatility borrow more than the value of their assets, whereas firms with high volatility borrow less than the value of their assets.

Cost of Issuing Equity and Firms' Behavior

How does the cost of issuing equity affect the firm's behavior? Table 4.2 shows the results of solving and simulating the model for $\lambda = 2\%$ and $\lambda = 7\%$. Table 4.2 shows that the cost of issuing equity affects the firm's investment, but the change in the frequency of equity issuance is not prominent.

Why doesn't the firm issue more debt when the cost of issuing equity is low? This is

Table 4.2: How Does the Cost of Issuing Equity Affect Firms' Behavior in the Baseline Capital Market Driven Model?
Panel data are generated using the baseline capital market driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point.

$\sigma \rightarrow$	15%		35%	
$\lambda \rightarrow$	7%	2%	7%	2%
Average investment to total assets	0.17	0.17	0.38	0.40
Volatility of investment to total assets	0.34	0.34	0.91	1.03
Average size	185.9	186.4	237.9	243.5
Average dividend to total assets	0.04	0.04	0.03	0.04
Frequency of equity issuance	0.00	0.00	0.11	0.13
Average equity issuance to total assets	0.00	0.00	0.02	0.07
Average Tobin's Q	1.63	1.63	2.56	2.52
Average book leverage	0.50	0.50	0.49	0.49
Average market leverage	0.32	0.32	0.25	0.26
Persistence of dividend/assets	0.06	0.06	0.12	0.05
Persistence of debt/assets	0.55	0.54	0.51	0.56
Persistence of leverage	0.57	0.56	0.59	0.58

due to endogeneity of investment and the debt capacity of the firm. The firm does not issue more debt, because it is already at its optimal level of investment and dividend. Moreover, the debt capacity of the firm makes the creditors unwilling to lend to the firm. It can be seen that for high volatility of profit shock, the firm issues equity more often when the cost of issuing equity is low. Similar to the low profit volatility case, it can be seen that neither book nor market leverage depend on the cost of issuing equity. However, the dividend is more persistent when the cost of issuing equity is low, because the firm can access the equity market at a cheaper price to smooth the shocks to profitability.

Table 4.3: How Does Profit Volatility Affect Firms' Behavior in the Investment Driven Model?
Panel data are generated using the investment driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point.

$\sigma \rightarrow$	10%	15%	20%	25%	30%	35%
Average investment to total assets	0.12	0.13	0.13	0.13	0.13	0.13
Volatility of investment to total assets	0.09	0.10	0.10	0.10	0.10	0.10
Average size	165.2	176.3	177.3	178.9	182.9	195.4
Average dividend to total assets	0.04	0.04	0.04	0.05	0.06	0.06
Frequency of equity issuance	0.00	0.00	0.00	0.17	0.17	0.16
Average equity issuance to total assets	0.00	0.00	0.00	0.00	0.01	0.02
Average Tobin's Q	1.58	1.57	1.63	1.69	1.75	1.79
Average book leverage	0.51	0.50	0.50	0.49	0.49	0.49
Average market leverage	0.32	0.32	0.31	0.30	0.28	0.28
Persistence of dividend/assets	0.48	0.36	0.58	0.48	0.46	0.42
Persistence of debt/assets	0.67	0.60	0.62	0.57	0.60	0.59
Persistence of leverage	0.76	0.82	0.82	0.83	0.85	0.88

4.1.2 Investment Driven Model

This subsection reports sensitivity analyses in the investment driven model.

4.1.3 Profit Volatility and Firms' Behavior

Table 4.3 shows the results of simulated panels of firms in economies in which profit volatility is $\sigma = 10\%, 15\%, 20\%, 25\%, 30\%$, and 35%. Table 4.3 shows that as the profit volatility increases, 1) the relationship between profit volatility and equity issuance is not linear; for instance, a firm with higher profit volatility does not necessarily issue equity more often, 2) the book leverage and the market leverage decrease, and 3) the persistence of debt and the persistence of market leverage increase.

Table 4.4: How Does the Cost of Issuing Equity Affect Firms' Behavior in the Investment Driven Model?
Panel data are generated using the investment driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point.

$\sigma \rightarrow$	15%		35%	
$\lambda \rightarrow$	7%	2%	7%	2%
	15%	15%	35%	35%
Average investment to total assets	0.13	0.12	0.13	0.13
Volatility of investment to total assets	0.10	0.10	0.10	0.10
Average size	176.3	176.7	195.4	195.1
Average dividend to total assets	0.04	0.04	0.06	0.06
Frequency of equity issuance	0.00	0.00	0.16	0.20
Average equity issuance to total assets	0.00	0.00	0.02	0.02
Average Tobin's Q	1.57	1.57	1.79	1.78
Average book leverage	0.50	0.50	0.49	0.49
Average market leverage	0.32	0.32	0.28	0.28
Persistence of dividend/assets	0.36	0.36	0.42	0.52
Persistence of debt/assets	0.60	0.60	0.59	0.52
Persistence of leverage	0.82	0.83	0.88	0.88

4.1.4 Cost of Issuing Equity and Firms' Behavior

Table 4.4 shows the results of simulated panels of firms in economies in which the cost of issuing equity is $\lambda = 2\%$ and 7%. The first two columns in Table 4.4 represent economies in which the volatility of profit shock is $\sigma = 15\%$. The last two columns represent economies in which the volatility of profit shock is $\sigma = 35\%$. It can be seen that for low profit volatility, the cost of issuing equity does not play a role in the firm's decisions.

Table 4.5: How Does the Size of the Projects Affect Firms' Behavior in the Investment Driven Model?

Panel data are generated using the investment driven model. One thousand firms are simulated for 200 periods. The first 100 observations are dropped in order to allow the firm to work its way out of a possibly suboptimal starting point.

$\sigma \rightarrow$	15%			35%		
$f(k) \rightarrow$	0.13k	0.29k	0.47k	0.13k	0.29k	0.47k
Average investment to total assets	0.13	0.13	0.14	0.13	0.13	0.14
Volatility of investment to total assets	0.10	0.15	0.19	0.10	0.17	0.23
Average size	176.7	176.0	170.1	194.0	199.9	201.8
Average dividend to total assets	0.04	0.04	0.04	0.06	0.06	0.06
Frequency of equity issuance	0.00	0.00	0.00	0.16	0.20	0.19
Average equity issuance to total assets	0.00	0.00	0.00	0.02	0.02	0.01
Average Tobin's Q	1.57	1.59	1.64	1.79	1.84	1.90
Average book leverage	0.50	0.50	0.50	0.49	0.49	0.49
Average market leverage	0.32	0.32	0.31	0.28	0.27	0.27
Persistence of dividend/assets	0.36	0.31	0.27	0.41	0.41	0.37
Persistence of debt/assets	0.60	0.54	0.59	0.59	0.55	0.62
Persistence of leverage	0.83	0.67	0.68	0.88	0.85	0.82

4.1.5 Size of New Projects in the Investment Driven Model

How does the size of new projects affect a firm's behavior? Table 4.5 shows the results of simulated panels of firms in economies in which the size of new projects is $f(k) =$, where k is the firm's capital. The first three columns in Table 4.5 represent economies in which the volatility of profit shock is $\sigma = 15\%$. The last three columns represent economies in which the volatility of profit shock is $\sigma = 35\%$. It can be seen that as the size of new investment projects increases, 1) the volatility of investment increases, and 2) the correlation between debt and lagged debt decreases, as does the correlation between lagged market leverage and market leverage.

4.2 Appendix to Chapter 2

4.2.1 Proof of Theorem 2.5.3

Theorem 2.5.3 says: $\theta < \frac{\delta - \pi}{\delta} \iff$ in steady state FC binds and $q > 1$.

Proof: (i) $\Longrightarrow$ We will prove this part by contradiction. We will assume $q_t = 1, p_t = 0$ and show that the supposition implies that the FC must be violated for some investing entrepreneurs.

Denote by J the set of indexes identifying entrepreneurs with investment opportunity at time t and use capital letters for aggregate variables. Since the arrival of the investment opportunity is iid, investing entrepreneurs will hold a fraction π of the total equity holdings at the beginning of period t : $\int_{j \in J} n_t^j dj = \pi N_t$. Since they solve the same problem as non-investing entrepreneurs, they will hold a fraction π of total equity holdings in period $t+1$ as well: $\int_{j \in J} n_{t+1}^j = \pi N_{t+1}$. Now we will show that the financial constraint of some of these entrepreneurs is violated. Suppose it was satisfied. Integrating over the set J we get:

$$\begin{aligned} \int_{j \in J} n_{t+1}^j dj &\geq (1-\theta) \int_{j \in J} i_t^j dj \\ \pi N_{t+1} &\geq (1-\theta) I_t \end{aligned}$$

In steady state $N_t = N_{t+1} = N$ and $I_t = \delta N$. Thus we can rewrite the above as:

$$\pi - (1-\theta)\delta \geq 0$$

This contradicts our supposition. □

The proof makes it clear that $\theta \geq \frac{\delta - \pi}{\delta} \iff \exists$ an equilibrium with the FC slack and $q = 1$.

(ii) $\Longleftarrow$ Suppose in steady state the financial constraint binds and $q > 1$. The behavior of the model is then determined by the system of equations defined in section

2.5.2. Using the steady state conditions $N_{t+1} = N_t$ and $I_t = \delta N_t$ and dropping the time indexes, we can rewrite the system as:

$$\begin{aligned} q^R N^i &= \beta\pi N[r + (1-\delta)q] \\ qN^s &= \beta(1-\pi)N[r + (1-\delta)q] \\ N^i &= (1-\theta)\delta N \\ N^s + N^i &= N \end{aligned}$$

This can be simplified to:

$$\begin{aligned} q^R(1-\theta)\delta N &= \beta\pi N[r + (1-\delta)q] \\ q\left[1-\delta(1-\theta)\right] N &= \beta(1-\pi)N[r + (1-\delta)q] \end{aligned}$$

Plugging in for $\beta N[r+q(1-\delta)]$ from the first one into the second one and simplifying further we get:

$$\begin{aligned} \pi q\left[1-\delta(1-\theta)\right] &= (1-\pi)(1-\theta q)\delta \\ \pi q\left[1-\delta(1-\theta)\right] &= (1-\pi)\delta - \theta\delta(1-\pi)q \\ q\left[\pi - \pi\delta + \pi\delta\theta + \theta\delta - \pi\theta\delta\right] &= (1-\pi) \\ q &= \frac{(1-\pi)\delta}{\pi - \pi\delta + \theta\delta} \\ q &= \frac{(1-\pi)\delta}{(1-\pi)\delta + \pi - \delta + \theta\delta} \end{aligned}$$

Both the numerator and the denominator are positive and therefore $q > 1 \Longrightarrow \pi - \delta + \theta\delta < 0$, which is equivalent to $\theta < \frac{\delta-\pi}{\delta}$. □

4.2.2 Construction of Time Series

Macroeconomic variables

Databases used for 1964q1 - 2008q4:

1. CES-BLS: Current Employment Statistics survey published by the Bureau of Labor Statistics.

2. FAT-BEA: Fixed Asset Tables published by the Bureau of Economic Analysis.

3. NIPA-BEA: National Income and Product Accounts published by the Bureau of Economic Analysis.

4. Flow of Funds.

Series generated:

1. Hours L: from CES-BLS:

   - Hours = average weekly hours · average number of workers.
   - Average weekly hours: in private sector, series CES0500000036.
   - Average number of workers: average number of workers in private sector over a quarter computed using monthly data in series CES0500000001.

2. Real capital K : we generate quarterly data by interpolating the yearly " Fixed assets and consumer durable goods", line 2 in table 1.2 in FAT-BEA.

3. Output Y: real GDP, line 1 in table 1.1.6 in NIPA-BEA.

4. TFP series A_t: generated from the capital and hours series as:

$$A_t = \frac{Y_t}{L_t^{.64} \cdot K_t^{.36}}$$

5. Nominal capital NK : we generate quarterly data by interpolating the yearly " Fixed assets and consumer durable goods", line 2 in table 1.1 in FAT-BEA.

6. Nominal Investment NI = nominal private fixed investment + nominal durable consumption good expenditure + nominal government gross investment.

    - nominal private fixed investment: line 7 in table 1.1.5 in NIPA-BEA.
    - nominal durable consumption good expenditure: line 4 in table 1.1.5 in NIPA-BEA.
    - nominal government gross investment: line 3 in table 3.9.5 in NIPA-BEA, does not include investment in inventories.

7. Real investment I: Nonfarm nonfinancial corporate businesses fixed investment, line 12 in the Flow of Funds table F.102 deflated using the deflator for Gross private domestic investment constructed using line 7 in NIPA-BEA 1.1.5 and 1.1.6. We choose this series because we use it to estimate θ. The time series properties of various real investment measures are very similar. Excluding government, inventories and durable consumption makes the series slightly more volatile (standard deviation of 5.00% versus 4.41%).

8. Real consumption C = Nondurable goods + Services.

    - Nondurable goods: line 4 in table 1.1.5 in NIPA-BEA.
    - Services: line 6 in table 1.1.5 in NIPA-BEA.

      The real counterparts of these nominal series are only reported starting in 1995.

      To generate the real series we deflated these nominal series by a Personal consumption expenditure deflator constructed from line 2 in tables 1.1.5 and 1.1.6. The correlation between the deflator for Personal consumption expenditure and Nondurable goods and Services from 1995 onwards is .991 and .997, respectively.

Financial Variables

1. Asset price q was constructed from the Dow Jones Total Stock Market Index (Wilshire 5000) for the priod 1974 - 2008. We have constructed the same series for the S&P 500 Composite Price Index for the 1964 - 2008 period. The time series properties of HP filtered logged versions of these indexes are very similar. Dow Jones Total Stock Market Index is slightly more volatile. Both raw series were recovered from the Global Financial Data database and computed as averages over the given quarter.

2. Asset return r^e: series *vwretd* from the CRSP database (Center for Research in Security Prices), value weighted returns including distributions from NYSE, AMEX and NASDAQ. We constructed quarterly data from monthly observations.

3. Total market value *val*: series *totval* from he CRSP database. We constructed quarterly data as averages over monthly observations.

4. Real risk free rate r^f is the 3-month T-bill as priced on the secondary market recovered from the Global Financial Data database deflated by CPI.

5. CPI: nominal returns are deflated using the CPI series from the BLS database, series ID: CPI-U, BLS CUUR0000SA0.

Construction of θ

We construct a measure of θ from the Flow of Funds data for the non-financial corporate sector:

$$\theta = \frac{\text{Funds Raised in Markets}}{\text{Fixed Investment}}$$

The variables are:

- Net funds raised in markets: line 38 in table F.102, equals: net new equity issuance (line 39) plus credit market instruments (line 40) for non-farm nonfinancial corporate businesses

- Fixed investment: line 12 in table F.102, for non-farm nonfinancial corporate businesses

4.2.3 Sensitivity Analysis

Table 4.6: Quarterly Statistics - Sensitivity to Parameters of the θ Process

Statistic[a,b]	Data[c]	(1) $\sigma^2_{\varepsilon_\theta} = .17^2$ $E(\theta) = .28$	(2) $\sigma^2_{\varepsilon_\theta} = .12^2$ $E(\theta) = .28$	(3) $\sigma^2_{\varepsilon_\theta} = .17^2$ $E(\theta) = .43$	(4) $\sigma^2_{\varepsilon_\theta} = .12^2$ $E(\theta) = .43$
σ_Y	1.52	1.18	1.17	1.17	1.18
σ_I	5.00	5.12	3.77	2.93	2.07
σ_C	0.85	1.93	1.63	1.36	1.16
σ_L	1.73	0.59	0.58	0.59	0.59
ρ_Y	0.87	0.67	0.68	0.68	0.67
ρ_I	0.85	0.40	0.41	0.38	0.48
ρ_C	0.90	0.47	0.52	0.53	0.61
ρ_L	0.92	0.67	0.68	0.68	0.67
$\rho(Y, I)$	0.90	0.23	0.30	0.48	0.73
$\rho(Y, C)$	0.85	0.61	0.72	0.80	0.92
$\rho(Y, L)$	0.87	1.00	1.00	1.00	1.00
σ_q	11.85	9.69	7.39	5.36	3.08
σ_{r^e}	8.63	10.77	8.15	6.37	3.71
σ_{val}	10.72	9.74	7.42	5.38	3.10
ρ_q	0.74	0.38	0.39	0.28	0.27
$\rho(q, Y)$	0.39	0.11	0.16	0.11	0.13
$\rho(q, I)$	0.38	-0.94	-0.89	-0.81	-0.57
$E(r^e)$	1.49	1.36	1.18	1.13	1.04
$E(r^f)$	0.30	0.51	0.63	0.83	0.92
σ^f_r	0.68	5.45	4.08	3.54	2.19
$E(r^e) - E(r^f)$	1.19	0.85	0.55	0.30	0.11

[a] Results for the models are based on 100 replications of size 180.
[b] σ_x is a standard deviation of variable x, ρ_x is the autocorrrelation of x and $\rho(x, y)$ is the correlation between x and y. All variables with the exception of the returns are logged and HP filtered before statistics are computed. Standard deviations and returns are measured in percentage terms.
[c] This column contains quarterly statistics computed for the U.S. data in 1964:1 - 2008:4. An exception is the measure for asset prices q, which was computed for 1974:1 - 2008:4. Details of the construction of the series are in the appendix, section 4.2.2.
Column (1) contains results for the benchmark model. In this model the financial constraint is binding and both the process for TFP and θ is estimated using U.S. data 1964:1 - 2008:4.
Columns (2), (3) and (4) contain results for versions of the model with various values for the parameters of the θ process. In column (2) the variance of innovations in θ is 50% of the benchmark value. In column (3) the mean value of θ is increased by 50% relative to benchmark. In column (4) both of these changes apply. Other than that the models are the same as the benchmark model.

Table 4.7: Quarterly Statistics - Sensitivity to π

Statistic[a,b]	Data[c]	(1) $\pi = .01$	(2) $\pi = .015$	(3) $\pi = .02$	(4) $\pi = .025$
σ_Y	1.52	1.21	1.18	1.19	1.19
σ_I	5.00	9.99	5.12	2.10	1.71
σ_C	0.85	3.12	1.93	1.16	1.02
σ_L	1.73	0.60	0.59	0.59	0.60
ρ_Y	0.87	0.68	0.67	0.68	0.67
ρ_I	0.85	0.42	0.40	0.48	0.67
ρ_C	0.90	0.47	0.47	0.59	0.67
ρ_L	0.92	0.68	0.67	0.68	0.67
$\rho(Y, I)$	0.90	0.03	0.23	0.74	1.00
$\rho(Y, C)$	0.85	0.47	0.61	0.92	1.00
$\rho(Y, L)$	0.87	1.00	1.00	1.00	1.00
σ_q	11.85	16.02	9.69	3.07	0
σ_{r^e}	8.63	17.31	10.77	3.84	0.07
σ_{val}	10.72	16.12	9.74	3.09	0.13
ρ_q	0.74	0.43	0.38	0.21	1
$\rho(q, Y)$	0.39	0.16	0.11	0.10	0
$\rho(q, I)$	0.38	-0.97	-0.94	-0.59	0
$E(r^e)$	1.49	1.88	1.36	1.05	1.01
$E(r^f)$	0.30	-0.26	0.51	0.93	1.01
σ_r^f	0.68	8.16	5.45	2.32	0.06
$E(r^e) - E(r^f)$	1.19	2.14	0.85	0.12	0.00

[a] Results for the models are based on 100 replications of size 180.
[b] σ_x is a standard deviation of variable x, ρ_x is the autocorrrelation of x and $\rho(x, y)$ is the correlation between x and y. All variables with the exception of the returns are logged and HP filtered before statistics are computed. Standard deviations and returns are measured in percentage terms.
[c] This column contains quarterly statistics computed for the U.S. data in 1964:1 - 2008:4. An exception is the measure for asset prices q, which was computed for 1974:1 - 2008:4. Details of the construction of the series are in the appendix, section 4.2.2.
Column (2) contains results for the benchmark model with $\pi = .015$. In this model the financial constraint is binding and both the process for TFP and θ is estimated using U.S. data 1964:1 - 2008:4.
Columns (1), (3) and (4) contain results for versions of the model with various values of π. Other than that the models are the same as the benchmark model.

Table 4.8: Quarterly Statistics - Sensitivity to Labor Supply Elasticity

Statistic[a,b]	Data[c]	(1) $\eta = .5$	(2) $\eta = 1$	(3) $\eta = 2$	(4) constant labor
σ_Y	1.52	1.41	1.18	1.03	0.79
σ_I	5.00	5.02	5.12	5.05	5.19
σ_C	0.85	2.75	1.93	1.55	1.79
σ_L	1.73	0.94	0.59	0.35	0
ρ_Y	0.87	0.68	0.67	0.67	0.67
ρ_I	0.85	0.41	0.40	0.40	0.39
ρ_C	0.90	0.46	0.47	0.51	0.43
ρ_L	0.92	0.68	0.67	0.68	1
$\rho(Y,I)$	0.90	0.26	0.23	0.16	0.13
$\rho(Y,C)$	0.85	0.52	0.61	0.69	0.46
$\rho(Y,L)$	0.87	1.00	1.00	1.00	0
σ_q	11.85	9.49	9.69	9.71	10.07
σ_{r^e}	8.63	10.45	10.77	10.71	11.10
σ_{val}	10.72	9.54	9.74	9.76	10.12
ρ_q	0.74	0.40	0.38	0.39	0.39
$\rho(q,Y)$	0.39	0.15	0.11	0.13	0.10
$\rho(q,I)$	0.38	-0.91	-0.94	-0.95	-0.97
$E(r^e)$	1.49	1.35	1.36	1.36	1.42
$E(r^f)$	0.30	0.66	0.51	0.48	0.62
σ_r^f	0.68	5.36	5.45	5.45	5.61
$E(r^e) - E(r^f)$	1.19	0.69	0.85	0.88	0.80

[a] Results for the models are based on 100 replications of size 180.

[b] σ_x is a standard deviation of variable x, ρ_x is the autocorrrelation of x and $\rho(x,y)$ is the correlation between x and y. All variables with the exception of the returns are logged and HP filtered before statistics are computed. Standard deviations and returns are measured in percentage terms.

[c] This column contains quarterly statistics computed for the U.S. data in 1964:1 - 2008:4. An exception is the measure for asset prices q, which was computed for 1974:1 - 2008:4. Details of the construction of the series are in the appendix, section 4.2.2.

Column (2) contains results for the benchmark model with $\eta = 1$. In this model the financial constraint is binding and both the process for TFP and θ is estimated using U.S. data 1964:1 - 2008:4.

Columns (1) and (3) contain results for versions of the model with various values of η.

Column (4) contains results for a version of the model with constant labor supply. Other than that the models are the same as the benchmark model.

Table 4.9: Quarterly Statistics - Sensitivity to β

Statistic[a,b]	Data[c]	(1) $\beta = .98$	(2) $\beta = .99$	(3) $\beta = .999$	(4) $\beta = .9999$
σ_Y	1.52	1.21	1.18	1.18	1.20
σ_I	5.00	7.85	5.12	1.36	1.20
σ_C	0.85	2.07	1.93	1.23	1.20
σ_L	1.73	0.60	0.59	0.59	0.60
ρ_Y	0.87	0.68	0.67	0.68	0.68
ρ_I	0.85	0.40	0.40	0.61	0.68
ρ_C	0.90	0.48	0.47	0.64	0.68
ρ_L	0.92	0.68	0.67	0.68	0.68
$\rho(Y, I)$	0.90	0.13	0.23	0.87	1.00
$\rho(Y, C)$	0.85	0.60	0.61	0.96	1.00
$\rho(Y, L)$	0.87	1.00	1.00	1.00	1.00
σ_q	11.85	7.78	9.69	12.67	13.00
σ_{r^e}	8.63	8.54	10.77	14.27	14.68
σ_{val}	10.72	7.85	9.74	12.68	13.00
ρ_q	0.74	0.40	0.38	0.37	0.37
$\rho(q, Y)$	0.39	0.16	0.11	0.07	0.08
$\rho(q, I)$	0.38	-0.95	-0.94	-0.42	0.02
$E(r^e)$	1.49	2.21	1.36	0.85	0.80
$E(r^f)$	0.30	1.63	0.51	-0.51	-0.63
σ_r^f	0.68	4.42	5.45	7.20	7.44
$E(r^e) - E(r^f)$	1.19	0.58	0.85	1.36	1.44

[a] Results for the models are based on 100 replications of size 180.

[b] σ_x is a standard deviation of variable x, ρ_x is the autocorrrelation of x and $\rho(x, y)$ is the correlation between x and y. All variables with the exception of the returns are logged and HP filtered before statistics are computed. Standard deviations and returns are measured in percentage terms.

[c] This column contains quarterly statistics computed for the U.S. data in 1964:1 - 2008:4. An exception is the measure for asset prices q, which was computed for 1974:1 - 2008:4. Details of the construction of the series are in the appendix, section 4.2.2.

Column (2) contains results for the benchmark model with $\beta = .99$. In this model the financial constraint is binding and both the process for TFP and θ is estimated using U.S. data 1964:1 - 2008:4.

Columns (1), (3) and (4) contain results for versions of the model with various values of β. Other than that the models are the same as the benchmark model.