

CAPITAL STRUCTURE IN THE LAW AND REGULATION

by

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Abstract

Chapter one provides the reader an introduction to the thesis. Some basic background information on the theory of capital structure is presented. Finally the reader is appraised of where the thesis will go and how it will fit into the theory of capital structure.

Chapter two investigates the properties of various legal regimes when there is the opportunity for bankruptcy. The key result is that strict liability always yields less than the socially optimal level of care, while negligence will never do any worse than strict liability. The paper characterizes the behavior of the firm in terms of the possible values the liability may take. The chapter investigates both the case of a single tortfeasor and joint tortfeasors. The joint tort regimes were ranked based on which regime induced the optimal level of care from the tortfeasors. The advantage of the paper over previous papers is that it conditions the rankings on the level of liability and not the solvency of the firm, which is endogenized in this chapter.

Chapter three provides a theory of regulatory finance that accounts for the full cost of capital. Regulated firms have their prices and capital structure set by the regulator. The price allowed is a transfer from consumers to the firm and is increasing in the bargaining power of the firm, costs and uncertainty, while the debt equity ratio is increasing the firm's bargaining power and decreasing in costs and uncertainty. States in which the firms have large bargaining power will also slower in moving towards deregulation.

The model provides a framework for estimating the bargaining power of consumers. These estimates can be used to make various inferences about the states'

regulatory policies. In addition, these measures can explain the pace of deregulation in the electricity industry.

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Chapter 1

Background

1.1 Introduction

Fifty years ago, the field of finance was no more than a descriptive field where the common wisdom and experiences of business practitioners were imparted upon the students.¹ The foundations of modern finance were sewn with the publication of John von Neumann and Oskar Morgenstern's *Theory of Games and Economic Behavior* in 1947. It was here that the axiomatic utility theory for decisions under uncertainty was introduced and this allowed the emergence of portfolio theory. The field of finance benefitted enormously especially the sub-area of asset pricing. The field of corporate finance, however, remained in its old ways relying on tried and tested prescriptions and institutional descriptions.

In 1958, however, a revolution occurred when Franco Modigliani and Merton Miller published their seminal article.² In their article, they challenged the conventional wisdom that had been taught in business schools and showed that the financing of a firm was irrelevant to its value. The size of the pie does not depend on how you split it is what they said.³

¹Copeland and Weston (1993) give a brief description of this in their preface.

²Modigliani and Miller (1958).

³They also addressed the issue of dividend policy and the value of the firm. Conventional wisdom held that for a firm to be highly valued it needed to have a decent dividend policy, otherwise shareholders

The impact of the article was to force the profession to think about which axiom in the original paper needed to be violated in order for the method of financing to affect the value of a firm. The profession has responded quite well. By citing the obvious reasons such as the differential treatment of interest payments from dividends to using modern theories of asymmetric information, the scholars of finance have identified many reasons why a firm could add value by using debt instead of equity.

In another universe of scholarship, another revolution was taking place. A soft spoken scholar who did not get much respect from two institutions, the University of Buffalo and the University of Virginia, found a home at the law school at the University of Chicago. It was there that Ronald Coase launched "The Problem of Social Cost" which laid the foundations of another field - law and economics.⁴ The *Journal of Law and Economics* followed later by the *Journal of Legal Studies* became the main pages where this field grew up and ultimately crossed over into the mainstream of economics. One of the sub-areas of law and economics was that of torts. It is the marriage of capital structure and torts that the second chapter of my thesis will focus on, and I will expand upon this later.

In another, but more traditional, area of economic research George Stigler was busy examining why some industries were regulated while others were not. Furthermore, he was examining whether regulation achieved the desired impact that it was supposed to. It was out of these studies that he developed the economic theory of regulation. It is this theory that I will use to explain the capital structure of regulated firms in my third chapter.

The reader should see that the common thread in the chapters is capital structure which is the first part of the title of this thesis. The second chapter applies capital structure to an aspect of the law, while the third chapter does the same for regulation. These are great fields of research, and it is worth mentioning that all the scholars mentioned

would lower the value of such a firm. They showed that dividend policy, like capital structure, was irrelevant to the value of the firm.

⁴Coase (1960). Some would add Calabresi (1961) as another founder of field of law and economics.

above have won the Nobel prize in economics and were affiliated with the University of Chicago!

In the pages that will follow, I hope to make a contribution to these exciting fields. The next section in this chapter will review some of the theories of capital structure. I will then outline how capital structure will be discussed in the context of law and regulation. I have deferred the discussion of torts and regulation to the relevant chapters. Chapter two is titled "Torts and Bankruptcy" which examines the interaction between various legal regimes and financial decisions made by firms. Chapter three "A Positive Theory of Regulatory Finance" examines how the capital structure of a regulated firm is set, and furthermore what inferences can be made about the type of regulator by observing the capital structure of such firms. The last chapter is an overview, where I will offer some thoughts on what we have learned from this thesis.

1.2 An Introduction to the Theories of Capital Structure

As stated above, the first paper that started the modern area of corporate finance was Modigliani and Miller (1958). The Modigliani Miller paper makes a number of explicit or implicit assumptions such as perfect capital markets, no costs to bankruptcy, no corporate or personal taxes, perfect information and no agency costs and that the financing decision does not affect the investment decision.⁵ Under these conditions the value of the firm is independent of the method of financing. The proof uses a no arbitrage argument to show this. I will give a different but simple proof of the proposition.⁶ Suppose there is a firm that lives for one period. The firm has a cash flow x that has an expected value of $E[x]$. The face value of debt is D and the equity holders are the residual claimants. The

⁵See Copeland and Weston (1993; p. 439) and Fama (1978) for more detailed exposition of the implicit assumptions.

⁶Ross (1989) gives this.

equityholders will receive the maximum of $x - D$ or 0. The debtholders have first claim on the cash flow if the firm can not pay them D . Hence, the debtholders will receive the minimum of D or x . The value of equity, therefore, is $E[\max[0, x - D]]$, while the value of debt is $E[\min[x, D]]$.⁷ The value of the firm is the value of equity plus the value of debt, which is equal to $E[\max[0, x - D]] + E[\min[x, D]] = E[x]$. Note that the value of the firm is independent of capital structure as only the expected value of x determines the value.

The analysis begins to get complicated when corporate taxes are taken into account.⁸ Suppose interest payments are tax deductible. Then the value of equity is $E[\max[0, x - (1 - t)D]]$, where t is the corporate tax rate, the value of debt is $E[\min[x, D]]$, and the value of the firm is $E[x] + E[tD \mid x > D]$. Now the value of the firm is increasing in the amount of debt and this suggests that the firm should be fully leveraged. We do not observe this and no one seems to believe that this is a reasonable strategy. Hence, various authors have sought to explain what could be constraining the leverage decisions of a firm in the presence of corporate taxes.

Kraus and Litzinberger (1973) argue that as the firm borrows more, there is a higher risk of bankruptcy costs. These costs can be direct, such as the expenses that need to be paid to lawyers when liquidating the assets of a firm.⁹ They can also be indirect, such as lost profits, the disruption of supplies, managers demanding higher compensation for potential unemployment and other such costs that may result if the firm declared bankruptcy. In fact, bankruptcy costs can be thought of as a metaphor for all such disadvantages that high leverage signals to market participants when valuing a firm.

Miller (1977) argued that tax considerations may not explain the decision to leverage since the interest payments, while tax deductible at the firm level, will be taxed at the personal level. Equity is taxed, usually, as a capital gains which can be postponed indefinitely and hence is taxed at a lower expected rate, suggesting that the advantages

⁷This ignores discounting.

⁸Modigliani and Miller (1963).

⁹Baxter (1967).

to debt from the tax treatment may not be as high as suggested. This led another generation of finance theorists to speculate on reasons related to the nature of information and agency costs.

The agency costs explanation for an optimal capital structure, initiated by Jensen and Meckling (1976), gives an alternative way to look at how a firm structures its finances. It recognizes that a company is exactly that: a company of different people. There are the shareholders, the debtholders, the managers, the suppliers, the customers and the employees, where each of these people have conflicting interests. I will add in the second chapter of my thesis another group, third party litigants, while in the third chapter I will add the social regulators. Ignoring these two groups for now, the main agency cost theories of capital structure seek to explain capital structure as a conflict between the various parties such as the shareholders, bondholders and managers. The theories, and attempts at empirically verifying them, are not all in agreement, as Harris and Raviv's (1991) survey shows.

The theories generally associate costs and benefits with both debt and equity. Since shareholders have all to gain and nothing to lose, other than their initial investment which is sunk, when deciding on what investments to make, thereby putting the interests of the bondholders at risk, especially in the presence of bankruptcy costs, bondholders may decide to put covenants and restrictions on what shareholders can do. Monitoring the shareholders, however, is also a costly affair, and hence this makes debt less attractive despite the tax savings.

Debt may have benefits too. The directors of a corporation, who represent the shareholders, may worry that the managers are not acting in the best interest of the shareholders. For example, suppose there was no debt. A manager who only fears unemployment might not exercise her best effort to maximize the value of the firm. If, on the other hand, the directors set up the capital structure such that there is a sizeable amount of debt that requires constant interest payments, the managers who do not meet these minimum payments will be unemployed. Therefore, debt may force managers to undertake the

activities that give the shareholders the best return on their equity.

Equity also has costs and benefits. It has benefits when the monitoring costs by creditors are too high. This is true, for example, in industries that are characterized by high human capital and not physical capital. These industries, such as the software industry which have been exclusively equity financed, have very little tangible assets that can be liquidated in the event of bankruptcy. Equity has costs, though, when new equity benefits the new shareholders at the expense of the existing ones.

As the reader can see, there are tensions between the various parties. Titman (1984) shows that if the firm's customers need specialized services that may not be available if the firm goes bankrupt, and hence the customers may not purchase from a firm that is highly leveraged, the firm will have less debt in its capital structure. This again is an example of a capital structure satisfying the needs of one of the claimants on the firm's assets.

Myers and Majluf (1984) is an example of the asymmetric information explanations for capital structure. Outside investors have less information about a project that management is thinking of financing. If management truly believes that the project is of superior quality and that it will have a high return and low risk, then management should not fear borrowing from creditors. Creditors will interpret the issue of new debt as a signal of quality, while shareholders will interpret the issue of new equity as a signal of low quality. Hence, firms will want to use debt first and then equity.

Alternatively, if one of the managers is also a shareholder, and the manager has superior information to the investors, the manager may be forced to invest in the equity of the firm. The manager might like to liquidate her holdings of the equity, but this would signal to the market that the manager does not have any faith in the project at hand. Hence, some equity may be required to signal the quality of the projects that manager owners are undertaking.¹⁰

What is clear from the exposition above is that there are various costs and benefits

¹⁰See Leland and Pyle (1977).

to the use of either method for financing a firm.¹¹ What I will do in the next section is set my thesis in the context of the theories mentioned.

1.3 Where does this Thesis Fit in?

As I stated earlier, this thesis examines how a firm may increase its value by adjusting its capital structure when there are other claimants on the assets of the firm. In chapter two, I examine the case when third party claimants have claims over the assets of the firm. In chapter three, I examine the capital structure of a firm that is regulated and hence has consumers and regulators as claimants over its assets.

As I will explain in the next chapter, there are situations where a firm may find itself facing claims from people whom it did not contract with. These are litigants who were harmed as a result of actions by the firm. Furthermore, a firm may find that it faces claims on its assets not just because of its actions but because of actions of other firms. The firm may find that it is advantageous to adjust its capital structure by increasing the amount of debt to minimize the payments to these litigants. Just as debt had tax advantages, in that more debt meant less taxes, debt can have a positive impact when a firm is threatened by litigants. More debt can mean less payments to litigants. In addition, there is an agency issue here. The third party litigants cannot contract in advance with the firm that caused them the harm, and hence cannot prevent the firm from leveraging in order to avoid the liability payments.

In chapter three, I will show that when a regulator sets the price allowed to a regulated firm, the regulator must choose the appropriate capital structure. The regulator is influenced by her concern for consumers as well as the value of the firm, and hence trades off the two concerns when determining what is the proper debt equity ratio. The regulator takes into account the costs of debt and equity, but also determines the cash flows to the firm. Thus the financing and finances of the firm become very dependent.

¹¹The discussion has abstracted from other forms of financing such as preferred stock.

The regulator will set a capital structure that is commensurate with her concern for the consumers. The chapter will develop an empirical framework for inferring the nature of regulator's preferences from observed capital structures.

Chapter 2

Torts and Bankruptcy

2.1 Introduction

The two areas of torts and bankruptcy have been studied extensively but separately in the law and economics literature. Recently, there has been a move to study the two topics together. Shavell (1986), Summers (1983) and Kornhauser and Revesz (1990) have all provided some insight into the efficiency of the various legal regimes that govern the law of torts when bankruptcy is an option. All these papers, however, have kept the bankruptcy decision exogenous. It is the purpose of this chapter to re-examine the various tort regimes when the decision to go bankrupt is endogenous.

The chapter is motivated by two observations. The first is use of the bankruptcy code as a strategic tool to avoid the large liabilities that are being awarded in the courtrooms of America. The Manville Corporation, Texaco and more recently Dow Corning are examples of companies that have used the bankruptcy code to avoid paying litigants the large damages that they were claiming. The second is the abolishment of joint and several liability by various states. Joint and several liability has been a contentious issue in the legal literature and the legislatures alike. We shall see that the decision to go bankrupt by firms facing large liabilities may shed some light on why some states may be abolishing joint and several liability.

I will examine the behavior of a firm that will pay a liability when its product causes an accident. The firm can lower its exposure to the liability either through leverage, care or both. Negligence is shown to dominate strict liability when care is the only instrument that reduces the probability of an accident.¹ When the firm faces an increased liability, we will see that the firm can either increase or decrease care. The response of the firm to increased liability will be the key to evaluating the joint torts regimes. The legal regimes will be ranked conditioned on the magnitude of the liability and other exogenous variables. This is in contradistinction to the previous literature that conditioned the rankings on solvency which was taken as exogenous, but which is endogenous in this study.

Section two will introduce the reader to the concept of torts, followed by section three which discusses the topic of bankruptcy. Section four will review the relevant literature on the topic of torts and bankruptcy. The basic model will follow in section five, with some results concerning the single tortfeasor in section six and seven. Section eight and nine will discuss the case of many tortfeasors, and the paper will conclude in section ten.

2.2 A Primer on Torts

This section will be divided into two subsections. The first provides a brief introduction to the basics of torts that the reader needs as a background in order to understand the paper. The second subsection provides more details on the topic, so that the reader may appreciate the larger issues involved when thinking about the topic.

2.2.1 A Brief Introduction to Torts

A tort is defined as any wrongful act, other than a breach of contract, for which a civil suit may be brought by a private person.² There are two major regimes that govern the

¹This is to distinguish from the cases where the activity level of the firm can also influence the accident. See Shavell (1986).

²See Landes and Posner (1987) and Cooter and Ulen (1988).

law of torts: strict liability and negligence. Under strict liability, a firm is held liable for the wrong it caused whenever the wrong occurs. No regard is given to whether the firm had taken necessary precautions to prevent the damage. Under negligence, however, if the firm can prove that it met some reasonable standard of care, then the firm does not have to pay for the damages. These regimes govern single tortfeasors, or wrongdoers.

When there are two or more firms and an accident occurs, then either the damage can be attributed to one specific firm or it cannot. If it is attributed to a specific firm, then the firm falls under either strict liability or negligence rules of a single tortfeasor. If the damage cannot be linked to a particular firm, then all the companies are jointly liable. This means that all the firms have to share in the damages. Under a joint and several liability regime, all the firms have to contribute to the damages, with any one firm potentially liable for the entire damage. If the other firms are insolvent, then the solvent firm can be held liable for the entire damage. Under a joint and several negligence standard, only those negligent firms will be held liable for the entire damage, with any one negligent firm potentially liable for the entire damage.

When the standard is joint and non-several liability, then the firms are held liable for up to a fraction of the damage. This fraction can be determined in a variety of ways, but, in this paper, we shall discuss the case when damages are divided equally among the various firms.³ Under joint and non-several negligence, the negligent firms are liable for up to a fraction of the damage.

An example of the joint standards is as follows. Suppose there are two firms that jointly caused a damage of \$1000. Under joint and several liability, each firm has to pay \$500, but if one is insolvent or unable to pay the entire amount, the other firm has to pay its \$500 plus the remaining portion that the other firm could not pay. Under joint and non-several liability, each firm has to pay a maximum of \$500. When the standard is joint and several negligence, then the negligent firm has to pay the full amount unless the other is also negligent, in which case they share as in the joint and several liability

³The reader is referred to Kornhauser and Revsez (1989) for a discussion of these rules.

case. Under joint and non-several negligence, a negligent firm has to pay a maximum of \$500.

2.2.2 Torts: Some More Details

The taxonomy presented above is the most brief one can be when describing this very large body of the law. I will address some of the topics mentioned above in more detail.

The first is that of strict liability. In order for a person or firm to be found liable under strict liability two conditions need to exist.⁴ The first is that the plaintiff or the victim must have suffered some harm. The second is that the defendant or the person being sued must have caused the harm either through an action or lack of action. These two conditions are sufficient for the liability to be assigned to the defendant. If the regime is negligence, then a third condition is needed. The defendant's actions or lack of action must be a violation of some implied duty owed by the injurer to the victim.

That the victim be harmed is important. If a firm is negligent in its actions, but no harm occurs, then no suit can be brought forth. While tangible harm is easy to document, such as an injury due to an accident, other forms of harm are not so easy to verify. Emotional pain and suffering have become more prevalent in the damages being awarded and this has implications in the theory of torts that go beyond the scope of this paper. For example, if such damages are to be accounted for by the firm when deciding on how much precaution to take, what dollar value will the court assign to such harm? In addition, are the courts able to assign the correct value to such harms?

The issue of proximate cause is also of great relevance to torts. Economists like to model the harm as a function of some action that the firm took or did not take, and hence the concept of proximate cause.

The condition for negligence is tied in with the concept of proximate cause. The injurer that caused the harm must have not taken enough care and that lack of care

⁴Cooter and Ulen (1988; p. 265).

caused the harm to the consumer. In contrast with strict liability, as long as the injurer caused the harm regardless of the level of care, the injurer is liable.

The analysis presented so far relies only on the actions of the injurer without regards to the actions of the victim. A car may hit a pedestrian, but if the pedestrian jumped onto oncoming traffic, then is it fair to hold the driver liable? These situations give rise to two other types of liability regimes: contributory liability and comparative liability with the equivalent counterparts under the negligence regime. These two concepts recognize that any accident is the product of the actions of both the injurer and victim. Had the victim not been there, the accident would not have happened. More importantly, the victim may not have taken adequate care when the accident took place. If the liability is always on the injurer regardless of what care the victim was taking, the victim will always take less than adequate care. Under a contributory liability regime, the injurer is only liable when the victim takes adequate care. Again, no attention is paid to the injurer's level of care. Under the comparative liability system, the injurer pays only when the victim was taking reasonable care, but only by the proportion of the injurer's contribution to the accident.

The two regimes discussed also apply to the case of negligence. Under a contributory negligence regime, the injurer is liable only if the victim was taking adequate care and the injurer was not. If the injurer was taking the required care, then she does not pay regardless of the victim's status, and if injurer was negligent but the victim was also not taking proper care, then the injurer owes no damages. A comparative negligence regime imposes a liability if the injurer is negligent and the victim is not, but the liability is set in proportion to the degree to which the negligence caused the accident.

The concepts discussed so far only focus on the level of care that the potential injurer, and for that matter the victim, engages in. What it does not focus on is the level of activity that may cause the accident in the first place. To illustrate consider the following example. A driver who drives her car is engaging in the activity of driving, while her style of driving is her level of care. Now if the liability regime is a negligence

regime, she will only be held liable if she hits a pedestrian while she was not taking care. Under a strict liability regime, however, she might cut down on the number of trips in addition to taking due care when driving. This is one area where strict liability might be superior to negligence in that it forces the potential injurer to monitor the level of activity in addition to the level of care. This study will not deal with situations that involve the activity and will focus on the level of care only.

One of the main assumptions that is implicit in the description above is that the victim will be able to collect the damages from the injurer in the event of accident. Abstracting from the costs of suing and recovering the damages, there is still the question whether the injurer will have any assets to satisfy the claims. In the next section, I will briefly review the subject of bankruptcy for firms, as they are the focus of this chapter, and show how that may thwart any attempt by victims to retrieve the damages that are owed to them due to the actions of a firm.

2.3 Bankruptcy

The reader will recall from the first chapter of this thesis that a firm usually expects an uncertain amount of revenues to flow through the firm's coffers over a period of time. The firm may finance itself using debt or equity.

A firm has some assets that includes cash flows over the next period of time. This firm sells a product that may cause harm to the consumers of this product. If the harm occurs and the consumers successfully sue the firm for the damages that they suffered, they will be entitled to claim the amount owed against the assets and cash flows of the firm. If, however, the amount owing is greater than the assets of the firm plus the cash flow, then the firm will declare bankruptcy. The litigants may liquidate the firm and settle for what is available. More realistically, under U.S. bankruptcy law, the firm will file for Chapter 11 protection. This will enable them to negotiate a settlement with the litigants for an amount less than that being claimed. In addition, the firm will be allowed

to keep on operating.

Suppose that the firm was able to pay the litigants for the damages with the existing assets. The firm would be obligated to pay for the damages and the victims would be fully compensated. If, however, there were other claimants on the assets of the firm, such as creditors who are owed interest payments, the situation might change.

The firm may decide to finance itself with a mixture of equity and debt, where debt is owed a fixed amount in interest payments. Now if the firm harms the consumers and they successfully sue the firm, the litigants will have to share in their claims on the assets of the firm with the creditors. Moreover, and more importantly, if the damages plus the interest payments are greater than the assets of the firm, the firm will declare bankruptcy. The firm will file, most likely, for Chapter 11 protection. This will mean that in the worst case that the creditors will receive their interest payments in full leaving the victims with the residual assets. Even in the best case, the victims will have to share with the creditors in their claims on the assets of the firm, which means that they will not be fully compensated in either case.

The reader can see that a firm will have an incentive to increase the use of debt as a method of financing as it reduces the amount that litigants receive. The bankruptcy code specifies that in the event a firm files for Chapter 11, a creditors committee is formed that is comprised of those "persons, willing to serve, that hold the seven largest claims against the debtor."⁵ Hence, it is in the best interests of the firm to have as many creditors who have relatively large claims on the firm. In the event of a successful lawsuit, the litigants, at best, would be one of seven members of a committee deciding the fate of the assets of the firm.⁶

This chapter will show how the bankruptcy code will allow the firm to use debt in order to avoid paying the litigants their due. It should be mentioned, that another way a firm may avoid the liability is to spin off its activities that are hazardous into separate

⁵United States Code, title 11 section 1102.

⁶See Delaney (1992) for more details on how this has been used.

firms. Therefore, if the company is sued, it will be the smaller one which will be unable to pay the potentially large damages. This does not rely on capital structure, but in some sense is equivalent.⁷

2.4 A Review of Previous Results from the Literature

The main result in the law and economics literature concerning torts is the equivalence between strict liability and negligence, as long as care is the only method for reducing the probability of an accident and the level of care required by the courts for the negligence standard is set at the socially optimal level.⁸ The socially optimal level of care is that which minimizes the cost of care plus the expected damage from the accident.

If the firm is under a strict liability regime, then its objective function is the cost of care plus the expected damages. Hence, it will want to minimize the same objective function as the social planner, and so it will take optimal care.⁹ If it is under a negligence regime, it can either pay for the optimal care only, or pay for the cost of sub-optimal care plus the expected damage. Since the cost of optimal care is always less than the cost of optimal care plus expected damages which is less than the cost of any sub-optimal care plus expected damages, by the definition of minimization, the firm will always prefer to be non-negligent.¹⁰

⁷See Ringleb and Wiggins (1990)

⁸Whether this is possible or not is another issue. See Shavell (1987) for a discussion on accident law.

⁹This assumes that the victim can do nothing to prevent the accident. If the accident depended on the victim's level of care in addition to the injurer's, strict liability would not yield the optimal level of care. However this leads to such topics as strict liability with the contribution, for which the reader is referred to Shavell (1987, pp. 5–16).

¹⁰To demonstrate, suppose there is a firm that faces a liability, L , for an action it engages in. The firm will only face the liability in the case of an accident which will happen with probability $p(a)$, where a is the level of care the firm engages in. Hence, this probability of the accident is dependent on how much care the firm engages in. In addition, the probability of the accident is decreasing in care, i.e., $p'(a) < 0$. Suppose that the cost of care is $c(a)$, then the firm is facing the following problem in the case of strict liability: $\min_a c(a) + p(a)L$ which implies that $c'(a) = -p'(a)L$. This will yield an optimal level of care a^* . Notice that this is also the socially optimal level of care. The firm, alternatively, could have faced a

When there is more than one firm, say two, and joint and several liability is the regime, the social planner will want to minimize the cost of care for both firms plus the expected damage, where the probability of the accident is a function of both firms' care.¹¹ The optimal care for both firms is the socially optimal level of care at which the negligence standard is set. Each firm can be held liable for the entire damage, and hence will minimize the cost of care plus the entire expected damage. This will result in both firms taking the optimal amount of care. If it is a joint and several negligence standard, then each firm will be held liable for the entire damage if it is negligent and the other is non-negligent, held liable for half the damages if it is negligent and the other firm is negligent, or not held liable at all if it is non-negligent.

In the first situation, it will want to minimize the cost of care plus the entire damage, and hence will take the optimal level of care. In the second, both firms will minimize the costs of their care plus the damages that they both have to pay, or the entire damage, and hence both will take optimal care. In the third case, the firm will take optimal care. Hence, under all three scenarios, both firms will take optimal care.¹²

When the standard is joint and non-several liability, then each firm is held liable for up to half the damages. In this situation, each firm only minimizes the cost of care plus half the expected damages yielding sub-optimal care. Under a negligence standard, if the firm is negligent, it will face a maximum of half the damages regardless of the other firm's negligence. The firm may choose to be negligent, as it may be worth its while to spend

negligence regime. In this case, the firm will face a cost of $c(a)$ if $a \geq a^*$, or $c(a) + p(a)L$, otherwise. It is obvious that the firm will pick $a = a^*$, since $c(a^*) < c(a^*) + p(a^*)L < c(a) + p(a)L$.

¹¹The analysis in this and the following paragraph is taken from Landes and Posner (1980; 1987).

¹²This can be seen as follows. There are two firms that can take care a_1 and a_2 . Their joint care will cause a damage, L , with probability $p(a_1, a_2)$, where $p_{a_1} < 0$ and $p_{a_2} < 0$. The socially optimal levels a_1^* and a_2^* will be ascertained by $\min_{a_1, a_2} c(a_1) + c(a_2) + p(a_1, a_2)L$. Now, if one is negligent, say firm 1, and the other is not, then the firm bears the cost $c(a_1) + p(a_1, a_2^*)L > c(a_1^*) + p(a_1^*, a_2^*)L > c(a_1^*)$. Hence, firm 1 will always engage in optimal behavior. Similarly for firm 2. If both are negligent, then suppose they share the damage equally, the firms will pay $c(a_1) + p(a_1, a_2)L/2$ and $c(a_2) + p(a_1, a_2)L/2$. Now, $c(a_1) + c(a_2) + p(a_1, a_2)L > c(a_1^*) + c(a_2^*) + p(a_1^*, a_2^*)L > c(a_1^*) + c(a_2^*)$. Again, both firms will choose to be non-negligent. Under strict liability, firm 1 will want to $\min_{a_1} c(a_1) + p(a_1, a_2)L$, and hence will yield $a_1 = a_1^*$.

less on care and only pay half the damage. Hence, joint and non-several liability is not efficient, while its negligence counterpart may also not be efficient.¹³

When there is a potential for bankruptcy then strict liability for a single firm will be inefficient. This is because the firm discounts paying the full expected damage by the probability of bankruptcy, and hence only takes enough care to minimize expected damages when the firm is solvent. Both Shavell (1986) and Summers (1983) show this result. Shavell models a firm that has assets less than the amount of the damage, while Summers models a firm that has a fixed probability of bankruptcy. Negligence, they both show, is now superior to strict liability, because the firm will choose to be non-negligent unless the solvency level is very low or the probability of bankruptcy is very high.¹⁴ This chapter will model the solvency decision of the firm and make the probability of bankruptcy endogenous.

When there are many firms, Kornhauser and Revesz (1990) show that there is nothing definitive that can be said about the ranking of the various regimes. In their model, there are two firms, where the second firm is insolvent. They condition their ranking of the various regimes on the solvency of the first firm. Since the second firm is insolvent, it is taking as little care as possible.

Suppose the regime is joint and several negligence and both firms should take care equal to a^* which is the optimal level of care. The second firm is taking no care since it is insolvent, and suppose firm one takes a^* in care. The social harm will still be quite high,

¹³A joint and non-several negligence standard may yield inefficiencies, as $c(a_1) + p(a_1, a_2^*)L/2$ may be less than $c(a_1^*)$. Strict liability always yields inefficient behavior. To see this, consider firm 1. Its problem is $\min_{a_1} c(a_1) + p(a_1, a_2)L/2$, which implies $c' = -p_{a_1}L/2 < -p_{a_1}L$ and thus we have less than optimal care. The same is true of the other firm.

¹⁴Shavell (1986) points out that if the firm has a solvency, S , that is less than the liability L , the firm will face a different problem of $\min_a c(a) + p(a)S$ which implies $c' = -p'S < -p'L$. This implies that the firm will engage in sub-optimal care. In the case of negligence, the firm will still engage in optimal behavior until $c(a^*) < c(a) + p(a)S$, for $a < a^*$. Summers (1983) assumes that the firm faces an exogenously given probability of bankruptcy α . Then, the firm under strict liability faces the problem of $\min_a c(a) + (1 - \alpha)p(a)L$, which implies $c' = -p'(1 - \alpha)L < -p'L$, again implying less than optimal care. In the case of negligence, the firm will still engage in optimal care as long as, $c(a^*) < c(a) + p(a)(1 - \alpha)L$, which implies that optimal behavior will be followed as long as $\alpha < 1 - \frac{c(a^*) - c(a)}{p(a)L}$.

because of firm two's negligence. If the regime was joint and several liability, however, and firm one had enough solvency to pay the liability, then it will take care $a^{JSL} > a^*$, because it has to account for firm two's inferior care. In this case they would rank joint and several liability above joint and several negligence. If firm one did not have enough solvency to pay the liability, it may decide to take no care also. In this case it may have been better to impose the joint and several negligence regime since the firm only pays when it is negligent and it may have taken a^* in care under the negligence regime. Their analysis is similar when looking at the joint and non-several regimes.

Kornhauser and Revesz show that the ranking of the regimes depend on the solvency of firm one and nothing definitive can be said. Landes (1990) in a note on their article argues that joint and several negligence still dominates joint and several liability and the other two regimes. This is because he claims that Kornhauser and Revesz did not define the negligence standard appropriately. They defined it for firm one independently of firm two's care. Landes defines the negligence standard for firm one as a function of firm two's level of care. Hence, if firm two is negligent, the level of care required from firm one is higher than if firm two were non-negligent. By doing so, Landes shows that joint and several negligence is superior to the other regimes.

The difference of opinion comes about because Kornhauser and Revesz (1990) and Landes (1990) are conditioning their ranking on the solvency of the firm which is exogenous in their models.¹⁵ Solvency, as I will show, is endogenous and the more appropriate variable to condition the rankings upon are the truly exogenous variables such as the magnitude of liability and bankruptcy costs. Another aspect of Kornhauser and Revesz (1990) is that they used a static game where it was assumed that one firm was bankrupt while the second was not. This paper will allow both firms to move simultaneously by choosing both care and debt at the same time. This paper will rank the regimes conditionally on the liability level but will endogenize the insolvency decision.

¹⁵Kornhauser and Revesz (1990, footnote 65) state that modelling the capital structure would have been an alternative way of modelling the firms' behavior.

2.5 The Basic Model

In this section, I will set up the general model of a tortfeasor that is sued for the harm caused by its actions. The model is general, but will be parametrized in a subsequent section. It will setup the basics needed for the joint tortfeasors section later.

2.5.1 The Players and Their Payoffs

There are three players: the firm, the victims who are also the litigants and the social planner.

The firm is deciding on how to finance a project. The project requires an investment today of K dollars that will yield a return x that is random with distribution $G(x)$ and p.d.f. $g(x)$. This return will be realized the next period. In addition it must raise either equity, debt or a mixture of both for this project. If it raises B' in debt then the remainder $K - B'$ will be equity. The firm's project may cause an accident that has magnitude L . The accident will occur with probability $p(a)$, where a is the level of care that the firm takes. The more care the firm takes the less likely the probability of an accident, so that $p'(a) < 0$ and $p''(a) > 0$. In a strict liability regime, the firm will have to pay L to the victims of the accident, regardless of its level of care. Under a negligence regime, the firm will not pay unless its care level is below some socially optimal level.

The care that the firm may exert to reduce the probability of an accident will cost $c(a)$, where $c'(a) > 0$, and $c''(a) > 0$. This is spent from the shareholders' wealth.

Since the revenues are random, there is a possibility that the firm will not have enough cash to pay the debtholders at the end of the next period. Next period the firm will have x , and the debtholders will receive either x or $(1 + \rho)B'$, where ρ is the risk adjusted interest rate, whichever is the smaller. The risk adjusted interest rate is set in order to let the expected return to debtholders be equal to the return from investing B' in a risk free asset. The debtholders' return is x in those situations where $x < (1 + \rho)B'$ and

$(1 + \rho)B'$ when $x > (1 + \rho)B'$. Formally, the risk adjusted rate is determined as follows:

$$\int_{(1+\rho)B'}^{\infty} (1 + \rho)B'g(x)dx + \int_0^{(1+\rho)B'} (x - Q((1 + \rho)B'))g(x)dx = B', \quad (2.1)$$

where we have assumed the risk free interest rate to be zero, and $Q((1 + \rho)B')$ are the bankruptcy costs associated with the process of bankruptcy.¹⁶ These costs are a function of the level of debt that is involved, where $Q' > 0$, and $Q'' > 0$. The lefthand side of (2.1) is the value of debt, or the expected return to the debtholders. Denote $(1 + \rho)B'$, the face value of debt, by B .

The random nature of the revenues will also affect the shareholders. They will be plagued by the potential liability. Under a strict liability regime, the victims will claim L . However, they can only get the firm to pay when the firm has enough money above and beyond its debt obligations. This is due to the nature of the bankruptcy code that gives the debtholders first claim over the firm's assets.¹⁷

Figure 2.1 summarizes who has a claim on the assets of the firm under strict liability. The horizontal axis represents the possible values of x . In the next period, if $x > B + L$, the firm will pay L to the victims and the shareholders will take the residual. If $B < x < B + L$, then the victims will receive $x - B$, while the shareholders get nothing. If $x < B$, the debtholders are paid as in the previous paragraph, while the victims and shareholders receive nothing.

[INSERT FIGURE 2.1 HERE]

We can summarize the value of the equity, or the expected return to the shareholders

¹⁶The risk free rate plays no central role in this paper, and therefore, this is a reasonable simplification.

¹⁷While this may not be true for all cases, it is a good approximation for what happens in practice. See Delaney (1992). I address the issue of what happens if the creditors are not senior to the litigants in appendix B.

under strict liability as

$$p(a) \int_{B+L}^{\infty} (x - B - L)g(x)dx + (1 - p(a)) \int_B^{\infty} (x - B)g(x)dx - c(a). \quad (2.2)$$

The value of the firm under strict liability, V^{SL} , is the sum of the value of debt and equity and is given, using (2.1) and (2.2), as follows:

$$\begin{aligned} V^{SL} \equiv & p(a) \int_{B+L}^{\infty} (x - B - L)g(x)dx + (1 - p(a)) \int_B^{\infty} (x - B)g(x)dx + \\ & \int_B^{\infty} Bg(x)dx + \int_0^B (x - Q(B))g(x)dx - c(a). \end{aligned} \quad (2.3)$$

The victims receive payoff 0 when no accident happens and $-L$ when it does. If the accident happens, the victims will sue successfully and costlessly for the amount of their damages. They cannot take any care to avoid the accident nor can they influence the level of the damages.

The social planner's payoff, the social welfare function, is the value of a firm that issues debt minus the full expected damage minus the cost of care. Formally, this is

$$\begin{aligned} & \int_B^{\infty} (x - B)g(x)dx + \int_B^{\infty} Bg(x)dx + \int_0^B (x - Q(B))g(x)dx \\ & - p(a)L - c(a), \end{aligned} \quad (2.4)$$

The socially optimal level of care and debt can be derived from maximizing the social welfare function (2.4). The social welfare function is the with respect to B and a . Let a^* be the socially optimal a .

Under a negligence regime, the firm will only be liable if the level of care is less than a^* . So the value of the firm will be

$$V^N = \int_B^{\infty} (x - B)g(x)dx + \int_B^{\infty} Bg(x)dx + \int_0^B (x - Q(B))g(x)dx - c(a), \quad (2.5)$$

if $a \geq a^*$, and V^{SL} otherwise.

The payoff to the firm is either V^{SL} if the regime is strict liability or V^N if the regime is negligence.

The social planner does not have any active strategy in this model or the subsequent ones. She is only mentioned in order to specify the social welfare function. The only active player is the firm. There are a number of assumptions implicit in the setup. These are:

1. There are injurer(s) and victims.
2. The victims are different from the injurer(s).
3. Litigation is costless and damages will be assessed accurately.
4. The courts will set the negligence standard at the socially optimal level of care.
5. There are no contractual agreements between the injurer(s) and the victims.
6. Care by the injurer is the only method to avoid the accident.

2.6 An Analysis of the Single Tortfeasor

The firm has to decide how much debt and care to pick. In the model presented above, debt has an advantage and a cost. The advantage for the firm is that it allows the firm to escape from paying the victims in those situations where revenues are not enough to cover the liability from the accident, while still allowing debtholders to collect from the firm. The reader should note that we have ignored all the other potential advantages that debt offers such as tax benefits and the various advantages listed in the corporate finance literature.¹⁸ The cost that debt imposes is the bankruptcy costs. The firm is penalized in the risk adjusted rate for these costs. However, since debt allows the firm to

¹⁸See Jensen and Meckling(1976) and Harris and Raviv (1991) for such issues.

partially escape the liability L , there is an implicit subsidy in the risk adjusted interest rate. The firm will leverage until the marginal benefit from debt equals its marginal cost. See Figure 2.2.

[INSERT FIGURE 2.2 HERE]

As for care, there is also an advantage and a cost. The advantage is that care will lower the probability of the accident. In a strict liability regime this is desirable, as this will reduce the expected liability that the firm will have to pay out. The cost is that the firm will have less money in the next period. Therefore, the firm will invest in care until its marginal benefit equals the marginal cost in the strict liability regime.

In a negligence regime, the firm will escape the liability completely if it exerts the socially optimal level of care. Under a negligence regime, it will have to decide whether to invest in the socially optimal level of care or not. By investing in the socially optimal amount it avoids the entire liability, but this costs the firm $c(a^*)$. On the other hand, by investing in less than a^* , it saves a bit on the cost, but now faces a potential liability. If the net savings are greater than the cost of investing in a^* , then the firm will follow the strict liability method of weighing the marginal costs with the marginal benefits of care, otherwise it will invest in the socially optimal level a^* .

This discussion and the model will now allow us to state the following propositions, for which the proofs are in appendix A.

Proposition 1 *Under the assumptions listed above, the socially optimal level of debt is zero, while the socially optimal level of care is a^* .*

The socially optimal level of debt is zero because debt serves no purpose other than escaping liability. The bankruptcy costs must be borne by the firm, and hence there is a cost with no advantage to debt. With debt equalling zero, the social welfare function is equal to

$$\int_0^{\infty} xg(x)dx - p(a)L - c(a), \quad (2.6)$$

and so the socially optimal level of care a^* is derived by solving

$$c'(a) = -p'(a)L.$$

Proposition 2 *Strict liability yields an inefficient level of debt and care.*

Since the firm can escape paying the liability some of the time by borrowing, the firm has less of an incentive to invest in care. Care is costly and lowers cash available next period, while the firm does not have to bear the full consequences of its negligence. However, outlawing debt will not suffice. This is because the firm will still face situations where its revenues are not sufficient to pay for the full liability. Again, the firm will not bear the full liability and will choose to invest in sub-optimal amounts of care. What is needed is either a legislated level of a^* , or some sort of unlimited liability for the shareholders. While unlimited liability would allow the full recovery from the shareholders, this is not the focus of this paper.¹⁹ Lender liability has also been proposed by Pitchford (1995) as a solution.²⁰

The firm is able through leverage to inflict an externality upon the victims. It shifts wealth away from them and to the creditors. Had the firm not leveraged at all, the victims may have been able to recover some of their damages. Now the firm will be able to avoid paying even more by "giving" it to the creditors. Furthermore, it takes inadequate care which inflicts even more harm upon the victims.

Proposition 3 *A negligence regime is superior to strict liability in that it will achieve the socially optimal level of care and debt in more situations than strict liability.*

The proof of this is straightforward. The firm can always choose to be negligent in which case it will act like a firm operating under a strict liability regime. The firm,

¹⁹Unlimited liability can be impractical. Personal bankruptcy could be declared by individual shareholders if recovery was ever attempted.

²⁰A contrary result to all of this was shown by Beard (1990), where he showed that overcompliance could also result. If I had added cash on hand and allowed the cost of care to affect the cash flow of the firm, then my model could achieve such a result. However, it would complicate the rest of the analysis.

therefore, can either be non-negligent and take optimal care or be negligent in which case it takes that level of care it would have taken under strict liability. Hence, a negligence regime does no worse than a strict liability regime and it may do better.

When the cost of investing in care is low compared to the potential liability, a firm will find it more profitable to invest in a^* and avoid the liability completely under a negligence regime. Since the firm is no longer threatened by any liability, there is no need to borrow and issue debt. Only when care is very costly to invest in, will it choose to face the liability.

The courts and legislatures alike have been trying various mechanisms that may entice firms to take optimal care. One such is punitive damages, which are a form of increased liability, and are becoming quite popular in the courtrooms as a means for punishing negligent firms. In order to evaluate these legal mechanisms, we must investigate the impact of an increased liability upon the firm's care. This will help assess the issue of joint and several liability versus joint and non-several liability.

The next proposition addresses the issue of what happens when the liability the firm faces increases. In the case where bankruptcy is not an option, the answer would be obvious: an increase in care. In the current situation, however, the firm also can use debt to avoid the liability.

Proposition 4 *Under a strict liability regime, an increase in L can lead to any one of the three following scenarios:*

- (i) An increase in debt and care.*
- (ii) An increase in debt and a decrease in care.*
- (iii) A decrease in debt and an increase in care.*

The firm is picking between debt and care as a method of avoiding liability. Debt and care can either be "complements" or "substitutes" in avoiding the liability. When they are complements, both care and debt rise in the face of increased liability. When they are substitutes, the cheapest is picked increasing one while decreasing the other. The only case that is not possible is a decrease in both care and debt.

Consider (i). Although the firm now faces an incentive to borrow more, it may not be able to borrow enough due to high bankruptcy costs. It now has to make up for the extra liability by investing in more care. If it had not borrowed, it would have invested in more care. But because of the extra leverage, it is now able to invest in a smaller increase in care.

In (ii) an increase in L increases the incentive to borrow to avoid the liability even more than in case (i). This increase in leverage will lessen the amount of liability the firm faces, and will therefore lower the amount of care it invests in.

Case (iii) is somewhat obvious. The firm may decide to decrease debt, because now it is cheaper to minimize exposure to the liability by taking care, and hence debt is not needed as much to avoid care.

A numerical example will demonstrate proposition 4. Figure 2.3 shows a distribution of revenues for a firm. The revenues are distributed over the $[0, 1]$ interval. A firm that is operating under a strict liability regime will choose when facing a liability of $L = 0.1$, a level of care $a = 3.16$ and a debt of $B = 0.0905$.²¹ The low debt level should not surprise the reader as the revenues are concentrated in the upper tail which benefits the shareholders. In addition, the socially optimal level of care is $a^* = 3.68$. As stated above, the firm does not take the socially optimal level of care.

When L goes up to 0.12, care goes up to 3.46, while debt also goes up to 0.099. When the cost of care is more expensive, repeating the experiment yielded care going down from 0.246 to 0.238, while debt went up from 0.66 to 0.67.²² Notice that the initial debt level is quite high now, as care is quite costly and hence the entire reliance is on debt.

[INSERT FIGURE 2.3 HERE]

Figure 2.4 shows another distribution, where revenues are concentrated in the lower tail. This should imply higher debt levels. Using the specifications of the first case in the

²¹In addition, I am assuming that $c(a) = 0.001a^2$, $Q(B) = 0.001B^2$, and the distribution is a Beta (4,2) distribution. The probability of an accident $p(a) = 1/a$.

²² $c(a) = 0.1a^2$.

previous paragraph, raising the liability from 0.1 to 0.12 raised care from 0.29 to 0.37, while debt fell from 0.95 to 0.94.²³ Numerous simulations give similar results.

[INSERT FIGURE 2.4 HERE]

These examples illustrate the three possibilities when liability increases for the choice of debt and care. While stating that negligence is no worse than a strict liability regime in terms of the level of care it induces, not much else can be stated. To be more specific requires some parametrization of the general model presented. I will do this in the next section. This will allow the analysis to be refined and will set up the model for the case of joint tortfeasors.

2.7 The Parametrized Model

Having introduced a general model, I will now put some more structure on it. I could have introduced the model from the beginning, but I wanted to convince the reader that this model is faithful to the general model qualitatively and preserves its main features.

2.7.1 The model

I will introduce a model that is general enough to convey the general results, but that has enough parametrization to give tractable solutions. The model is a special case of the general model introduced above. The specific assumptions about the model are as follows:

1. The revenues x are distributed according to a uniform distribution: $g(x) = 1, G(x) = x, 0 \leq x \leq 1$.
2. The cost of care $c(a) = a$.

²³The distribution here is a Beta(2,4).

3. The probability of the accident $p(a) = \frac{1}{a}, 0 < a \leq 1$. This is actually the kernel of the probability function. For simplicity, I will deal with the kernel only.
4. The costs of bankruptcy are fixed: $Q(B) = Q$.
5. In order to generate tractable results and ensure the existence of solutions, I will assume that $1 - B - L < 0$. One way to ensure this is to assume that $B, L < \frac{1}{2}$.
6. Denote the maximum that the firm can borrow as $\bar{B} < \frac{1}{2}$.

The key feature of this model is that the bankruptcy costs are fixed. This feature gives rise to corner solutions when solving for the optimal level of debt. The intuition is as follows. In the general model, the firm trades off a fixed liability L against a varying cost of bankruptcy $Q(B)$. When the marginal expected cost of the bankruptcy equals the expected savings from avoiding the liability, then that is the amount of debt the firm will choose. When the cost of bankruptcy is fixed, however, the situation changes. The marginal cost of bankruptcy is zero, but there is a fixed cost. Hence, the firm has to trade off two fixed amounts, L and Q . In this case, if the expected costs are less than the expected savings from avoiding the liability, the firm will borrow as much as it can. This is because the creditors are charging a fixed penalty for their fixed expected bankruptcy costs, while the firm is receiving an implicit premium from debt when it avoids paying another fixed amount: the liability. The firm trades off two fixed amounts and picks an all or nothing debt in its capital structure. If the expected costs are less than the expected gains, then the firm will choose no debt.

The level of care is picked using the calculus developed in the general model. The firm trades off the marginal cost of care against the marginal benefit of care which is the reduced liability. Since debt could be all or nothing, the firm is essentially limited to two choices in the level of care: a high level of care when debt is zero or a low level of care when debt is huge.

I would like to convince the reader that qualitatively, the results are not different from the general model. In general, a firm either has a low level of debt equity ratio

or a high level, as the three numerical examples in the previous section showed. Hence, saying the firm borrows all or nothing can be taken as a "metaphor" for high or low debt equity ratios. The advantage of this model is that it makes it easier to solve and analyze the joint liability issues in the next section.

2.7.2 Analysis

In this section I will give some results concerning the behavior of the firm and the efficiency of the various regimes. The results will be conditional on two exogenous variables L and Q .

The social welfare function, in general, is given by (2.6), which in the context of this model is

$$\frac{1}{2} - \frac{L}{a} - a.$$

This implies that the socially optimal level of care is $a^* = \sqrt{L}$.

The value of the firm as shown in (2.3) when facing a strict liability regime will be

$$V^{SL} = \frac{1}{2} - \frac{\left(1 - B - \frac{L}{2}\right) L}{a} - QB - a. \quad (2.7)$$

The value of the firm is linear with respect to B , as the first order condition for a firm maximizing V^{SL} with respect to B is

$$V_{B=} = \frac{L}{a} - Q \quad (2.8)$$

which is independent of B . The first order condition is the expected liability minus the bankruptcy costs. If (2.8) < 0, then $B = 0$. If (2.8) > 0, then $B = \bar{B}$, which is the maximum that the firm can borrow.

The first order condition for maximizing V^{SL} with respect to a is

$$\frac{\left(1 - B - \frac{L}{2}\right) L}{a^2} - 1.$$

Setting equal to zero and solving for a yields

$$a^{SL} = \sqrt{L \left(1 - B - \frac{L}{2}\right)}.$$

Substituting back into (2.7) yields

$$V^{SL} = \frac{1}{2} - QB - 2\sqrt{L \left(1 - B - \frac{L}{2}\right)}. \quad (2.9)$$

The firm can either borrow $B = 0$ or $B = \bar{B}$. Hence, we do not need to evaluate the first order condition for B . Rather, we can carry out the following exercise. The firm compares $V^{\bar{B}}$ with V^0 , where $V^{\bar{B}}$ is V^{SL} evaluated at $B = \bar{B}$ and V^0 is V^{SL} evaluated at $B = 0$. Hence, if

$$\begin{aligned} & V^{\bar{B}} - V^0 = \\ & -Q\bar{B} + 2\sqrt{L} \left(\sqrt{1 - \frac{L}{2}} - \sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) > 0, \text{ or} \\ & 2\sqrt{L} \left(\sqrt{1 - \frac{L}{2}} - \sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) > Q\bar{B} \text{ then } B = \bar{B}. \end{aligned}$$

Similarly if

$$2\sqrt{L} \left(\sqrt{1 - \frac{L}{2}} - \sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) < Q\bar{B} \text{ then } B = 0.$$

Define L^s as the value of L that solves

$$2\sqrt{L} \left(\sqrt{1 - \frac{L}{2}} - \sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) = Q\bar{B}$$

This allows us to state the following proposition for which the proof and the proofs for all propositions in this section are in Appendix C.

Proposition 5 *Under a strict liability regime, when $L < L^s$ the firm will choose a zero leverage and high care level, and when $L > L^s$ the firm will pick full leverage with a low*

level of care.

When $L < L^s$ it is not worth incurring the bankruptcy costs $Q \bar{B}$ since the benefit from escaping the liability is not large enough. It is better to have no leverage and pay the small amount of liability in case the accident happens. The firm will take care $a^{SL0} = \sqrt{L \left(1 - \frac{L}{2}\right)} < \sqrt{L}$ which is the socially optimal level of care. So even when debt is zero, the firm takes an inadequate amount of care, since there always a probability that the firm will not be able to pay. When the firm fully leverages, the level of care will be $a^{SL\bar{B}} = \sqrt{L \left(1 - \bar{B} - \frac{L}{2}\right)} < a^{SL0} = \sqrt{L \left(1 - \frac{L}{2}\right)} < a^* = \sqrt{L}$. The firm now does not have to take as much care.

Proposition 6 *Under a strict liability regime, when $L < L^s$ the level of care a^{SL0} is increasing in L . When $L > L^s$, the level of care $a^{SL\bar{B}}$ while less than a^{SL0} is also increasing in L .*

The firm will increase its care when it has no leverage until it reaches a point where it is no longer worth taking a high level of care. It then takes a one time drop in care, but increases as L increases.²⁴

If the regime was negligence, then the firm has to take adequate care which is $a^* = \sqrt{L}$. The value of the firm if it takes a level of care equal to a^* is

$$V^N = \frac{1}{2} - \sqrt{L}.$$

If it chooses to be negligent, then the value of the firm is equal to V^{SL} .

The firm has to decide whether to be negligent and face the full liability or be non-negligent and only pay the cost of the socially optimal level of care. To do this, the firm will compare the value of the firm V^N with the value of the firm $V^{SL} \in \{V^0, V^{\bar{B}}\}$. As the next proposition shows, the firm only has to compare V^N with $V^{\bar{B}}$.

²⁴When the firm fully leverages, the level of care could increase and then decrease, since $\text{sign} \frac{da^{SL\bar{B}}}{dL} = \text{sign} (1 - \bar{B} - L)$ which could be less than zero if I had not imposed the constraint in the basic assumptions of the model. This would have validated two of the predictions from proposition 4.

Proposition 7 *If the firm chooses to be negligent, then it will choose to fully leverage.*

The proof is in appendix C. Intuitively, when the firm does borrow, it is facing a liability L but has no method of escaping it except that it may not be able to pay the entire amount. It is cheaper to be non-negligent. If the firm wanted to be negligent, it might as well fully leverage and escape the liability as much as possible. It will be incurring the bankruptcy costs.

The firm will choose to fully leverage and be negligent if $V^{\bar{B}} - V^N > 0$ which implies that

$$\begin{aligned} -Q \bar{B} - 2\sqrt{L\left(1 - \bar{B} - \frac{L}{2}\right)} + \sqrt{L} &> 0 \Rightarrow \\ \sqrt{L}\left(1 - 2\sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)}\right) &> Q \bar{B}. \end{aligned}$$

From this last condition, we can define L^c where $\sqrt{L^c}\left(1 - 2\sqrt{\left(1 - \bar{B} - \frac{L^c}{2}\right)}\right) = Q \bar{B}$.

Proposition 8 *When $L < L^c$, the firm will choose to be non-negligent and when $L > L^c$ the firm will be negligent choosing full leverage and a low level of care.*

As L increases so does the cost of the optimal level of care \sqrt{L} . Hence, the firm will remain non-negligent as long as the cost of avoiding the liability is not too high. When the liability is too high, it becomes worth incurring the expected bankruptcy costs and fully leveraging in order to avoid the liability. It now takes a small amount of care and fully leverages.

The final point is to compare L^s with L^c . We know that $V^N > V^0$ and that $V^N = V^{\bar{B}}$ at $L = L^c$. When $L = L^c$,

$$V^{\bar{B}} - V^0 = (V^{\bar{B}} - V^N) + (V^N - V^0) > 0.$$

This implies that $L^c > L^s$. Figure 2.5 shows the various ranges of L and the levels of care that the firm takes under the various regimes.

[Insert Figure 2.5 here]

Under strict liability when $L < L^s$, the firm takes a high level of care and has no debt. When $L > L^s$, the firm switches to high leverage and lowers its level of care. Notice that the care level increases as the liability does within the two zones, but the overall level when $L > L^s$ is lower than when $L < L^s$. Under a negligence regime, the firm takes the optimal level of care and has no debt as long as $L < L^c$, but then switches to high leverage and low level of care corresponding to the same level of care under strict liability with high leverage. We can see, therefore, that negligence does no worse than strict liability in terms of what level of care it induces the firm to take. Figure 2.6 shows the leverage decision for the firm over the range of possible L and for the various regimes.

[Insert Figure 2.6 here]

The firm has no debt when $L < L^s$ under the strict liability regime, but then switches to full leverage as L increases. When $L < L^c$ the firm has zero leverage when the regime is negligence and fully leverages otherwise. Figure 2.5 is a graphic representation of proposition 3.

Proposition 9 *When $L < L^c$, negligence dominates strict liability in terms of the level of care that the firm takes, while for $L > L^c$, it does no worse.*

The results presented serve two purposes. They bolster the claims of the general model. They also allow the evaluation of the different regimes conditional on exogenous parameters such L and Q . This is an improvement over the models in Shavell (1986) and Kornhauser and Revesz (1990) since they conditioned their results on an exogenous solvency. As the models have shown, solvency is endogenous through the use of the capital structure and hence the results take the analysis one step further.

2.8 An Analysis of Multiple Torts

In the case of multiple torts, the accident cannot be attributed to one specific firm. Hence, the courts apportion the damages among the various firms. I shall assume that there are two identical firms. A general discussion will be presented below followed by the parametrized model which will allow a more definitive analysis.

As stated, in the case of joint tortfeasors, the courts will apportion the damages among the various parties. This apportionment can be done in four different ways:

1. The first is through a joint and several liability regime. Under this regime, the firms are all liable for the damage, with any firm expected to pay the entire damage. The first firm is expected to pay half the damage plus any amount that the second firm cannot pay due to insolvency.
2. The second is a joint and several negligence regime. Any negligent firm will have to pay the entire damage, or a portion of the damage if the other is also negligent. If the other firm cannot pay, or does not have to pay because it was non-negligent, then the first firm will have to pay the entire portion.
3. The third regime is joint and non-several liability. Each firm has to pay up to half the damage, regardless of the other's ability to pay.
4. The fourth is joint and non-several negligence, where the negligent firm only has to pay up to half the damage.

I will introduce the model in a general format and then put some structure on it.

2.8.1 The Players and Their Payoffs

There are victims, a social planner and two firms. The victims' payoff is 0 if no accident occurs and $-L$ if it does.

There are two identical firms whose revenues x_1 and x_2 are distributed according to a distribution density $g(x)$ and cumulative $G(x)$. The accident will occur with probability $p(a_1, a_2)$, where a_1 , and a_2 are the care levels exerted by firm one and two respectively. This is the key difference between the payoffs for the two firms and the payoff for the single firm in the single tortfeasor case. The probability of the accident is a function of both firms' care. Let B_1 and B_2 denote the debt levels of firm one and two respectively.

Let L represents the damage caused by the accident, denote the liability that each firm has to pay by Λ . If the regime is joint and non-several liability, then

$$\Lambda = \Lambda_{JL} = \frac{L}{2}.$$

Under the joint and several liability regime firm 1 faces $\frac{L}{2}$ plus any amount that firm 2 cannot pay. Now, firm two will not be able to pay its share of the liability when revenues are below its debt, B_2 . This will happen with probability $G(B_2)$. Firm 2 will be able to make partial payments when $B_2 < x_2 < B_2 + L$. Hence, firm 1 will face a liability of

$$\Lambda = \Lambda_{JSL} = \frac{L}{2}(1 + G(B_2)) + \int_{B_2}^{B_2+L} (B_2 + L - x_2)g(x_2)dx. \quad (2.10)$$

Note that in (2.10), the liability Λ_{JSL} is higher than that of the joint and non-several case $L/2$.

The social welfare function is given by

$$2 \int_0^\infty xg(x)dx - p(a_1, a_2)L - \{c(a_1) + c(a_2)\}. \quad (2.11)$$

The socially optimal level of care for firm one and two are derived from the first order conditions

$$c'(a_1) = -\frac{\partial p(a_1, a_2)}{\partial a_1}L$$

$$c'(a_2) = -\frac{\partial p(a_1, a_2)}{\partial a_2} L.$$

These two imply a socially optimal level of care for both firms $a_1^* = a_2^* = a_j^*$.

The payoff to firm one depends on the legal regime in place:

1. When the regime is joint and non-several liability, the payoff to firm one is

$$\begin{aligned} V^{JL} \equiv & p(a_1, a_2) \int_{B_1+L/2}^{\infty} (x_1 - B_1 - L/2)g(x_1)dx_1 + \\ & (1 - p(a_1, a_2)) \int_{B_1}^{\infty} (x_1 - B_1)g(x_1)dx_1 + \\ & \int_{B_1}^{\infty} B_1g(x_1)dx_1 + \int_0^{B_1} (x_1 - Q(B_1))g(x_1)dx_1 - c(a_1), \end{aligned} \quad (2.12)$$

2. Under joint and non-several negligence, the payoff to firm one is

$$V^N = \int_0^{\infty} x_1g(x_1)dx_1 - c(a_1),$$

if $a_1 \geq a_1^*$, and (2.12) otherwise. Recall from proposition 3 that when the firm is non-negligent it chooses zero leverage.

3. When the regime is joint and several liability, the payoff to firm one is

$$\begin{aligned} V^{JSL} \equiv & p(a_1, a_2) \int_{B_1+\Lambda_{JSL}}^{\infty} (x_1 - B_1 - \Lambda_{JSL})g(x_1)dx_1 + \\ & (1 - p(a_1, a_2)) \int_B^{\infty} (x_1 - B_1)g(x_1)dx_1 + \\ & \int_{B_1}^{\infty} B_1g(x_1)dx_1 + \int_0^B (x_1 - Q(B_1))g(x_1)dx_1 - c(a_1). \end{aligned} \quad (2.13)$$

4. Under a joint and several negligence regime, the value of the firm is

$$V^N = \int_0^{\infty} x_1 g(x_1) dx_1 - c(a_1),$$

if $a_1 \geq a_1^*$, and (2.13) otherwise.

The payoffs to firm two are similar to firm one's payoffs.

2.8.2 The Strategies and Equilibrium

Each firm will want to maximize their payoff, whichever it is depending on what the legal regime is. They will maximize their payoff by choosing an appropriate level of debt and care. Hence the set $\{(a_1, B_1), (a_2, B_2)\}$ represents the possible strategies in this game. Given that the firms are maximizing their payoffs jointly, the equilibrium will be a Nash equilibrium. I will discuss the nature of these in the next section, where I will re-introduce the parametrized model.

Before proceeding, the reader should note that there are two externalities at play here. The first is that the two firms impose on the victims, much like the case of the single tortfeasor. By leveraging and taking less than adequate care, the two firms impose a higher probability of damages upon the victims and furthermore they reduce the amount of the liability that the victims can recover. The second externality is between the firms themselves. Each firm by leveraging and lowering its care can shift some of the liability onto the other firm, especially in the joint and several liability case.

2.9 The Parametrized Model: The Joint Liability Case

In this section, I will analyze the behavior of each firm under the various regimes. After that I will rank the regimes according to which regimes induces the firms to take the optimal amount of care.

2.9.1 The Model

The model retains all the features and assumptions of the single tortfeasor model. The only difference is that the probability of the accident $p(a_1, a_2) = \frac{1}{a_1 a_2}$, where $0 < a_1, a_2 < 1$.

The firms will face a liability depending on the regime they operate in. Under a joint and non-several liability regime each firm will be expected to pay $\frac{L}{2}$. Under a joint and several liability regime the liability as in (2.10) will be $\Lambda = \frac{L}{2} (1 + B_2 + L)$. In the next subsections, I will analyze the firms' behavior under the various regimes.

The social welfare function give by (2.11) is

$$\frac{1}{2} + \frac{1}{2} - \frac{L}{a_1 a_2} - a_1 - a_2$$

which implies that the socially optimal levels of care are

$$a_1^* = a_2^* = \sqrt[3]{L}$$

Given the symmetry of the firms, the equilibrium strategies of debt will be either $\{B_1 = 0, B_2 = 0\}$ or $\{B_1 = \bar{B}, B_2 = \bar{B}\}$. The equilibrium strategies of care will also be those values of care that correspond to a zero leverage or full leverage.

2.9.2 Joint and non-Several Liability and Negligence

I will focus on firm 1 and infer the behavior of firm 2 by symmetry. The value of firm 1 in a joint and non-several liability regime according to (2.12) is

$$V^{JL} = \frac{1}{2} - \frac{\frac{L}{2} \left(1 - B_1 - \frac{L}{4}\right)}{a_1 a_2} - Q B_1 - a_1.$$

The firm will want to maximize V^{JL} with respect to B_1 and a_1 . Again, with respect to B_1 the firm compares V^{JL0} , which is V^{JL} evaluated at $B_1 = 0$, with $V^{JL\bar{B}}$, which is V^{JL}

evaluated at $B_1 = \bar{B}$. Maximizing with respect to a_1 yields

$$a_1 = \sqrt{\frac{\frac{L}{2}(1 - B_1 - \frac{L}{4})}{a_2}}. \quad (2.14)$$

The firm will exercise a level of care that is inverse to the level of care that the other firm takes. If the other firm is taking a high level of care, then the probability of the accident, and hence the expected liability, will be low which means that firm 1 can lower its level of care. Meanwhile if firm 2 is taking a very low level of care, then firm 1 has to compensate by raising its level of care. The relationship between a_1 and a_2 in (2.14) is firm 1's reaction function as a response to firm 2's care. Fortunately due to symmetry, in equilibrium we can impose $a_1 = a_2$. This allows us to solve for a_1 from (2.14):

$$a_1^{JL} = \sqrt[3]{\frac{L}{2}(1 - B_1 - \frac{L}{4})}.$$

Thus the value of the firm in equilibrium is

$$V^{JL} = \frac{1}{2} - QB - 2\sqrt[3]{\frac{L}{2}(1 - B_1 - \frac{L}{4})}$$

Now we can compare V^{JL0} with $V^{JL\bar{B}}$. To do so, the firm evaluates

$$\begin{aligned} & V^{JL\bar{B}} - V^{JL0} \\ &= -Q\bar{B} + 2\sqrt[3]{\frac{L}{2}} \left(\sqrt[3]{\left(1 - \frac{L}{4}\right)} - \sqrt[3]{\left(1 - \bar{B} - \frac{L}{4}\right)} \right) > 0. \end{aligned}$$

Define L_{JL}^s as the value that solves

$$-Q\bar{B} + 2\sqrt[3]{\frac{L}{2}} \left(\sqrt[3]{\left(1 - \frac{L}{4}\right)} - \sqrt[3]{\left(1 - \bar{B} - \frac{L}{4}\right)} \right) = 0.$$

This allows the statement of the following proposition.

Proposition 10 *Under a joint and non-several liability regime, the firms will have zero*

leverage with a high level of care when $L < L_{JL}^s$. Conversely, the firms will choose full leverage and low care when $L > L_{JL}^s$.

This is similar to proposition 5 for the single tortfeasor. When the regime is joint and non-several negligence, the firm will decide between being non-negligent and one of the two choices under joint and non-several liability.

Proposition 11 *Under a joint and non-several negligence regime, if the firm is negligent it will fully leverage.*

The proof is similar to that in the single firm case.

The firm will choose either to be non-negligent or it will choose the full leverage-low care choice that it picks when the regime is joint and non-several liability. Finally, we can define L_{JL}^c as the value of L that solves

$$\sqrt[3]{L} \left(1 - 2 \sqrt[3]{\frac{(1 - \bar{B} - \frac{L}{4})}{2}} \right) - Q \bar{B} = 0.$$

Again, as shown above, the following results follows.

Proposition 12 *Under a joint and non-several negligence regime the firm will choose to be non-negligent for $L < L_{JL}^c$ and the firm will be negligent choosing full leverage and low care otherwise.*

Finally, $L_{JL}^s < L_{JL}^c$ which leads to the next proposition.

Proposition 13 *Joint and non-several negligence is no worse a regime than joint and non-several liability.*

While the preceding sub-section may have been terse, it was to allow me to introduce the next sub-section where I will discuss the case of joint and several liability. I will discuss the implications of the two regimes in a discussion that follows.

2.9.3 Joint and Several Liability and Negligence

In the previous sub-section, each firm only owed, at best, half the amount of the liability. Here the firms, may owe up to the full amount. In expectation, they can expect to pay $\frac{L}{2}(1 + B_2 + L)$. The value of the firm under a joint and several liability regime as in (2.13) is

$$V^{JSL} = \frac{1}{2} - QB - \frac{\frac{L}{2}(1 + B_2 + L) \left(1 - B - \frac{L}{4}(1 + B_2 + L)\right)}{a_1 a_2} - QB - a_1.$$

Using similar arguments above, the level of care is

$$a_1^{JSL} = \sqrt[3]{\frac{L(1 + B_2 + L)}{2} \left(1 - B_1 - \frac{L}{4}(1 + B_2 + L)\right)},$$

and the value of the firm is

$$V^{JSL} = \frac{1}{2} - QB_1 - 2\sqrt[3]{\frac{L(1 + B_2 + L)}{2} \left(1 - B_1 - \frac{L(1 + B_2 + L)}{4}\right)}.$$

Again, for a Nash equilibrium, we need the firm, if it decides to fully leverage, to prefer the value of the firm when $B_1 = \bar{B}$ and $B_2 = \bar{B}$ to the value of the firm when $B_1 = B_2 = \bar{B}$.

Define L_{JSL}^s as the value that solves

$$-Q\bar{B} + 2\sqrt[3]{\frac{L(1 + \bar{B} + L)}{2} \left(\sqrt[3]{\left(1 - \frac{L(1 + \bar{B} + L)}{4}\right)} - \sqrt[3]{\left(1 - \bar{B} - \frac{L(1 + \bar{B} + L)}{4}\right)}\right)} = 0.$$

In addition, define L_{JSL}^c as the value of L that solves

$$\sqrt[3]{L} \left(1 - 2\sqrt[3]{\frac{(1 + \bar{B} + L)}{2} \left(1 - \bar{B} - \frac{L(1 + \bar{B} + L)}{4}\right)}\right) - Q\bar{B} = 0.$$

Finally, $L_{JL}^s < L_{JL}^c$ which leads to the next set of propositions.

Proposition 14 *Under a joint and several liability regime, the firms will have zero leverage with a high level of care when $L < L_{JSL}^s$. Conversely, the firms will choose full leverage and low care when $L > L_{JSL}^s$.*

Proposition 15 *Under a joint and several negligence regime, if the firm is negligent it will fully leverage.*

Proposition 16 *Under a joint and non-several negligence regime the firm will choose to be non-negligent for $L < L_{JSL}^c$ and the firm will be negligent choosing full leverage and low care otherwise.*

Proposition 17 *Joint and non-several negligence is no worse a regime than joint and non-several liability.*

The more important question is to compare the joint and non-several liability and negligence regimes with their joint and several counterparts. This will allow the determination of which regime to adopt. The reader should intuit that a negligence regime will be the superior one, however, which one is the question. Negligence will do no worse than strict liability, but the question is when the firm decides to be negligent what is the level of care? This will be the topic of the next sub-section.

2.9.4 A Ranking of the Four Regimes According to the Level of Care

What figure 2.5 showed was that as long as leverage was held constant, an increase in the liability led to a higher level of care under strict liability. The issue was that at some point the liability was too high and the firm decided to fully leverage and there will be a dramatic drop in care. As liability increases above that level, the firm will increase its care once again, but not to the pre-zero leverage levels. The case of the negligence regime is similar. The firm is non-negligent until the high liability induces it to switch to a high leverage, low and negligent level of care.

The situation when comparing the four joint regimes is analogous. The firms will also choose to be non-negligent up to some level of liability and then they choose to become negligent. Hence, there are two issues to be addressed. The first is which regime is the first to induce the firms to switch from being non-negligent to negligent? The second is when the firms have decided to become non-negligent which liability regime produces better levels of care even after they have decided to be negligent? To answer these questions, we need to compare L_{JSL}^c with L_{JL}^c and a_1^{JL} with a_1^{JSL} .

Recall that L_{JL}^c is the value of L that solved

$$\sqrt[3]{L} \left(1 - 2 \sqrt[3]{\frac{(1 - \bar{B} - \frac{L}{4})}{2}} \right) - Q \bar{B} = 0.$$

while L_{JSL}^c solved

$$\sqrt[3]{L} \left(1 - 2 \sqrt[3]{\frac{(1 + \bar{B} + L)}{2} \left(1 - \bar{B} - \frac{L(1 + \bar{B} + L)}{4} \right)} \right) - Q \bar{B} = 0. \quad (2.15)$$

Substituting L_{JL}^c into (2.15) yields

$$\begin{aligned} & \sqrt[3]{L_{JL}^c} \left(1 - 2 \sqrt[3]{\frac{(1 + \bar{B} + L_{JL}^c)}{2} \left(1 - \bar{B} - \frac{L_{JL}^c(1 + \bar{B} + L_{JL}^c)}{4} \right)} \right) - Q \bar{B} \\ &= \sqrt[3]{L_{JL}^c} \left(1 - 2 \sqrt[3]{\frac{\frac{(1 - \bar{B} - \frac{L_{JL}^c}{4})}{2} + \frac{1}{2} (L_{JL}^c - \bar{B} (\bar{B} + L_{JL}^c) - \frac{L_{JL}^c}{4} (\bar{B} + L_{JL}^c) (1 + \bar{B} + L_{JL}^c))}{2}} \right) - Q \bar{B}. \end{aligned} \quad (2.16)$$

Let L^* be the L that solves

$$L - \bar{B} (\bar{B} + L) - \frac{L}{4} (\bar{B} + L) (1 + \bar{B} + L) = 0.$$

It is clear that if $L_{JL}^c > L^*$, (2.16) will be positive implying that the firm will prefer to

be negligent under a joint and several negligence regime when $L = L_{JL}^c$. If $L_{JL}^c < L^*$, (2.16) will be negative which means the firm will be non-negligent.

The level of care can be determined as follows. When $L < L_{JL}^c$ both regimes will see the firms taking optimal levels of care, since they both prefer to be non-negligent. When $L > L_{JL}^c$, then it depends on whether $L_{JL}^c < L^*$. If this holds, then the firm prefers to be non-negligent at $L > L_{JL}^c$ under a joint and several negligence regime while it chooses negligence under the joint and non-several negligence regime. Furthermore, when the firm is negligent under the joint and several negligence regime, its level of care is

$$a^{JSL} = \sqrt[3]{\frac{L(1 + \bar{B} + L)}{2} \left(1 - \bar{B} - \frac{L}{4}(1 + \bar{B} + L)\right)},$$

while under a joint and non-several regime it is

$$a^{JL} = \sqrt[3]{\frac{L}{2} \left(1 - \bar{B} - \frac{L}{4}\right)}.$$

It can be shown that $a^{JSL} > a^{JL}$ for the same level of debt. Hence, whenever the firm is negligent, it is preferred that the regime be a joint and several regime. The following proposition follows from the discussion above.

Proposition 18 *When $L_{JL}^c < L^*$, then joint and several negligence is a superior regime with respect to the level of care.*

The joint and several negligence regime induces the optimal level of care for any $L < L_{JSL}^c$. For values of $L > L_{JSL}^c$ the firm, negligent as it may be, will still take a level of care higher than it would have taken had the regime been joint and non-several. This can be seen in Figure 2.7.

[Insert Figure 2.7 here]

The interesting case is when $L_{JL}^c > L^*$. In that case, the firm is non-negligent for a larger range of L under a joint and non-several negligence regime. The firm will choose

to be negligent under the joint and several negligence regime when $L > L_{JSL}^c$, but as figure 2.7 shows, $L_{JSL}^c < L_{JL}^c$. The thing to note, though, is that for $L \in (L_{JSL}^c, L_{JL}^c)$, the firm is exercising less than optimal care under joint and several negligence and less than the care exercised under joint and non-several negligence. For values of $L > L_{JL}^c$, however, the firm exercises more care in the joint and several negligence than the joint and non-several negligence regime. This is because the firm is fully leveraged in both situations and is negligent. Due to the higher liability, however, that it expects to pay under the joint and several regime, the firm will exercise a higher level of care than if it only owed half the liability.

Proposition 19 *When $L_{JL}^c > L^*$, then the following holds*

- (i) When $L < L_{JSL}^c$, the firm is non-negligent under both regimes.*
- (ii) Joint and non-several negligence is superior regime with respect to level of care that the firm takes when $L \in (L_{JSL}^c, L_{JL}^c)$.*
- (iii) Joint and several negligence is the superior regime with respect to level of care that the firm takes when $L > L_{JL}^c$.*

Figure 2.8 shows this proposition. For low levels of the liability both negligence regimes will yield the socially optimal outcome. For higher levels of the liability, joint and several negligence is superior since it induces a higher level of care even though the firm is negligent. In the middle range of liability, the joint and non-several negligence regime is better. This is because the liability is low enough that the firms prefer to take the optimal care. The expected bankruptcy costs are higher than the liability avoided, as it is still relatively low. When the liability rises, the firms switch to being negligent. Since they are only paying up to half the liability each, they prefer to take much less care than if they were potentially liable for the entire amount. Hence, the joint and several liability regime is superior for the high values of L but joint and non-several negligence is superior for intermediate values.

2.9.5 Discussion

The previous section has ranked the various legal regimes according to the level of care they induce. The rankings were conditional on exogenous variables such as L and Q . This is similar to Kornhauser and Revesz's (1990) rankings, but where they conditioned on the solvency of the firm. The main lesson is that negligence, be it joint and several or joint and non-several always dominates strict liability. This is consistent with Landes' (1990) comment. Two extensions to this model could be made.

The first is that the socially optimal level of care was defined independently of the each other's level of care. In other words, if firm two was negligent, firm one would still be required to take care equal to $\sqrt[3]{L}$. Note that if firm two were highly leveraged and taking very low care, would a court not require firm one to take extra care above $\sqrt[3]{L}$? Landes (1990) contends that this is the case. If this were true, then one could define the socially optimal level of care for firm one conditional on firm two's care level. In this case, the socially optimal level of care for firm one would be $\sqrt{\frac{L}{a_2}}$. As firm two's care decreases, the level of care required from firm one would increase. This complicates the model further and requires some more analysis.

Another extension is to allow $1 - B - L < 0$.²⁵ This would allow the level of care for the fully leveraged firm to increase for some level of L and then start decreasing. The result would be that the clarity with which I ranked the various regimes would disappear. Again this requires more analysis.

I do believe, though, that the results presented are general enough to give some insight into the issues. Negligence is still shown to dominate strict liability. Joint and several negligence seems to be the better regime for most of the values of L , but with some exceptions. I suspect that if the extensions were solved, the results would be no different qualitatively.

²⁵But not $1 - B - \frac{L}{2} < 0$.

2.10 Summary and Conclusions

This study takes the literature on torts and bankruptcy one step further. The previous papers on the subject had treated the solvency of a firm as exogenous and then conditioned the efficiency of the various legal regimes on the level of solvency. In this paper, the only exogenous factors are the level of liability and the bankruptcy costs. The paper can rank the various legal regimes conditional only on these two exogenous factors. Solvency is now endogenized. This is done by modelling the capital structure of the firm as well the level of care.

The chapter gives a brief background on the law of torts, followed by a brief look at the bankruptcy code. When a firm causes harm to victims, this does not mean that the victims will be able to receive compensation. This is because the firms can declare bankruptcy and avoid paying the litigants. One way to increase the successful avoidance of payouts to the litigants is through the use of debt in the capital structure. Firms that may face litigation have an incentive to add debt to their capital structure above and beyond what the normal dictates of finance would call for. Because of this, the firm will never take the socially optimal level of care under a strict liability regime.

The paper introduces a parametrized model that makes more concrete statements possible. Under a strict liability regime, the firm will choose to have no debt and take a high level of care for certain levels of the liability. As the liability increases, the firm will choose to fully leverage and lower its care. A negligence regime will see the firm taking optimal care for more values of the liability before it eventually fully leverages and becomes negligent by taking low care.

For a single tortfeasor, the paper showed that negligence is a superior regime to strict liability. A firm is more likely to take the socially optimal level of care under negligence. As long as the cost of taking the socially optimal level of care is low, the firm will remain non-negligent. Even when it decides to be negligent, it will take that level of care as when the regime was strict liability. Hence, the firm never does any worse in a negligence regime than strict liability.

When the subject is joint torts the rankings are not as simple. The negligence standards are shown to be superior to their strict liability counterparts. Under a joint and several negligence regime, the firms will take optimal levels of care while not borrowing for some values of liability until the liability becomes too high. At that stage, the firms decide to fully leverage and take less care. Joint and non-several negligence will induce similar behavior. At what level of liability each negligence regime induces the switch from non-negligence to negligence varies depends on among other things the bankruptcy costs. It may be that joint and several negligence dominates joint and non-several negligence for all levels of liability. On the other hand, there may be some ranges of liability where the converse is true.

The advantage of the paper is that provides the reader with rankings that are conditioned on the range of possible damages. It moves away from conditioning the results on the solvency of the firm and towards conditioning on other exogenous variables.

The main caveat to this paper is that it does not take activity levels into account. Many of the results may change if that were to happen. To do that, though, the revenues of the firm would have to affect the liability and hence would have to be endogenous. This is work for future research.

The final note is that this paper can give us some insight into why some states have abolished joint and several torts. While Landes and Posner (1987) contend that this is because these states do not value efficiency as much as states that did not abolish joint and several liability, there may be other reasons. These states could be ones where firms were choosing less care and more leverage as a means to escape the increasing liabilities that the firms were facing. It must be said, though, that the paper did find that for most ranges of the liability, joint and several negligence was the superior regime. My conjecture is that as states moved in general from a negligence regime to a strict liability regime regardless of the number of tortfeasors, they encountered problems with the joint and several liability regimes that allow for sub-optimal care. Instead of reverting to a negligence standard they abolished joint and several liability to minimize the impact.

Chapter 3

A Positive Theory of Regulatory Finance

3.1 Introduction

This chapter brings together two seemingly unrelated topics: regulation and capital structure, but which are fundamentally linked. The choice of regulation affects the capital structure and vice versa. A regulator who cares more about the profits of the regulated firm will exhibit a different price allowed and a different capital structure than a regulator who cares more about the welfare of the consumers. Hence, by observing the combination of prices and capital structure that regulated firms have, we can infer the type of regulator in that environment. The type of regulator will allow us to predict various events such as the pace of deregulation.

The subject of regulation has long been studied, as has the topic of capital structure, but relatively little has been written on the capital structure of regulated firms. Most of what has been written is normative as is the case for most of the topics in regulatory finance, in that it prescribes what should be the capital structure for a regulated firm as opposed to describing how the capital structure is determined.

The capital structure of a regulated firm is affected by conditions that non-regulated

firms are exposed to in addition to the decisions made by regulators, such as the allowed rate of return and the capital structure itself. The chapter will contribute on two fronts. The first is to provide a positive theory of capital structure for regulated utilities.¹ The second is to show how the factors affecting the regulated firms and their capital structure can be used to predict the pace of deregulation that has been sweeping the various industries. The electricity industry in the U.S. will be the focus of the study when discussing examples or empirical evidence.

A brief introduction to the topic of regulation in general and regulatory finance in particular will be presented. A model of how the prices and capital structure are set will be established. Regulation will be modelled as the outcome of a regulator who places some weight on consumers' welfare and some weight on producers' welfare. The price and debt equity ratio will be shown to be increasing with the weight the regulator places on firms' profits. The observed prices and capital structures of the various electricity utilities will be used to infer these weights. Finally these weights will be used to predict the choice of regulations in a state and whether the state will deregulate or not.

The outline of the paper is as follows: The next section will introduce the reader to the basics of regulation in general, and regulatory finance in particular. Section three will conduct a brief literature survey. Section four will discuss the model that will be used in section five to carry out the various estimations. The chapter will then conclude.

3.2 The Basics of Regulation

Economic regulation is any restriction on the economic activity of firms imposed by the government.² These restrictions can be imposed on the prices charged, quantities provided or any other activities such as quality, entry or exit. In the U.S., the various

¹By positive, I mean to distinguish it from the numerous normative studies that have proposed methods by which regulators should determine the allowed rates of return for a particular firm and what capital structure should result from these decisions. See Gordon (1974), Phillips (1988) and Thompson (1991).

²See Viscucci et al. (1997; p. 307).

levels of government have been allowed to engage in such regulations through a series of court decisions.³

Empowered by these court decisions, a wave of legislative activity at the state and federal level ensued. In the 1907-1930 period, most of the states created public utility commissions to regulate various industries such as electricity, water, gas, telecommunications and transportation.⁴ The federal government regulated many industries that operated across different states. This continued until the 1970s, when a wave of deregulation began. Transportation such as airlines and trucking, natural gas, telecommunications and various other industries were deregulated. The latest industry to undergo major restructuring, if not outright deregulation, is electricity which is the focus of this paper.⁵

Regulation goes through three stages: legislation, implementation and then deregulation.⁶ The legislative stage sees the setting up of an agency, usually called a public utility commission (PUC), that will carry out the regulations, set out the agency's mandate and empower it to take the necessary actions required to achieve the mandate spelled out in the legislation. These PUCs' characteristics vary by state. The commissioners of these PUCs can be elected by the public, as in Alabama, appointed by the governor directly, as in Nevada, or appointed subject to approval by the state senate.⁷

The PUC will regulate, among other things, the price that the firms under its jurisdiction are allowed to charge the consumers. This price is meant to be both fair to the consumers and the firm. Before proceeding to discuss the nature of these regulated prices, a brief discussion of what prompts the existence of regulation in the first place is needed. To do this, we need to discuss the nature of competition in the market.

One of the concerns regulators have with the structure of the market is the presence

³*Munn v. Illinois* (1877) established that a state could regulate monopolies. *Nebbia v. New York* (1934) gave states the authority to regulate any industry as long as there was a public interest to be served by regulation. Viscucci et al. (1997; pp. 311-12) and Phillips (1988; pp. 75-116) give more details.

⁴Viscucci et al. (1997; p. 314 & p. 324) and Phillips (1988; pp. 121-147).

⁵Fox-Penner (1997) is a good source for this issue.

⁶Viscucci et al. (1997; pp. 317-22).

⁷Phillips (1988; pp. 126-27). Other aspects include the term of office and the size of the staff.

of monopolies, and more importantly natural monopolies. Monopolies have been treated either through anti-trust or regulatory legislation. A monopoly is considered socially undesirable since it allows the firm to charge a price above marginal cost which creates a dead weight loss. Monopolies, in general however, should not be a concern, since as long as there is free entry, competition will eliminate such social imperfections. It is when only one firm can be sustained in the market, otherwise known as a natural monopoly, that there is reason for alarm. An industry is characterized as being a natural monopoly when the production of a particular good or service by a single firm minimizes costs.⁸ The market is only big enough for one firm. Declining marginal costs or declining long run average costs may be one of the factors leading to this. If the industry requires huge fixed costs to serve any level of output, then only one firm might be profitable in such a market. In the electricity industry for example, this was true in the past. Electricity plants required massive investments in plant and equipment and hence, in order to recoup the costs a firm would want to charge prices above marginal cost, usually fuel, which was quite low compared to the fixed costs. The average electric utility today has \$2.7 billion worth of capital invested, which is not a small amount.⁹

Natural monopolies are problematic for both consumers and firms. Consumers are ill-served because once the firm has monopolized the market, it will no longer charge a price equal to the marginal cost associated with the cost minimizing output. Rather, it will charge a price above marginal cost and produce less than the socially optimal output. For firms, the problem is one of deciding who serves the market? Suppose initially there are two firms in the market. If one expands the output to take advantage of the declining costs, it will be able to undercut its competitor, drive it out of business and serve the whole market. There exists an integer problem. Only one can be in the market at one time and there is no room for mutual existence. This may cause concern for an existing firm that has a monopoly in the market, as another firm might be able to take advantage

⁸Viscucci (1995, p. 351).

⁹See Table 3.1 which will be introduced later.

of a newer technology and drive the incumbent out. Hence, both consumers and firms may call for regulation. The consumers want low prices and the firms want the assurance that no entrant will take away their market after they had invested in the large start-up costs. This discussion can help answer the question: why does regulation exist?

There are various theories explaining the existence of regulation. The first states that regulation exists to serve the consumers who can be harmed by the presence of natural monopolies. This theory is difficult to defend in light of the fact that many industries that are highly competitive are also regulated, such as the taxi industry in most cities.¹⁰ Another theory is known as the capture theory. This states that regulation benefits the firms regulated. Firms would like a stable environment and lobby the government to grant them a monopoly and guarantee them revenues through regulated prices. Proponents of this theory point to the fact that it was the firms that called for regulation, and that the prices allowed did not change once regulation took place.¹¹ Nonetheless, this theory is also hard to defend. Many regulations are clearly not endorsed by the firms. Furthermore, this theory does not explain why we see deregulation.

An economic approach to explaining regulation was proposed by Stigler (1971) and formalized by Peltzman (1976). The regulated price is the result of a regulator satisfying both consumers and producers, but not necessarily to the same degree. A regulator will have a utility function that is increasing in the profits allowed to the firm and decreasing in the price charged to the consumer. The regulator will have some weighting in mind between these two parties. A regulator that is more favorable to consumers will lower the price allowed to the firm, while the one who favors the firms will award a higher price. At regulatory hearings we see both lobbyists for the firm and consumers appearing trying to argue for higher prices for the firm or lower prices to the consumers.¹² Since the regulator will try to keep both parties satisfied, it will neither set the price at the competitive level

¹⁰See Visucui et al. (1997; p. 326). Other industries such as plumbing, electricians, and hairstyling can hardly be characterized as monopolistic.

¹¹Stigler and Friedland (1972).

¹²Note (1981) and Vietor (1989; pp. 104-174).

nor at the monopoly level. Different regulators will have varying preferences concerning which party they favor, which is why some investment banking research firms, such as *Duff and Phelps*, will characterize regulators as being harsh to firms while others will be classified as favorable.

It should be noted that there are three classes of customers: residential, commercial and industrial. While residential customers may vent their anger at high prices by not re-electing the politicians who appointed the commissioners, they are usually a dispersed group who may not exert as much power. It is the industrial customers, however, who may exert some power over the commissions. Threats of relocation in addition to usual regulatory lobbying are just two ways that these customers can exert some influence over the rates allowed.

3.2.1 The Process of Regulation: Costs and Regulatory Finance

The price allowed to a regulated firm, ideally, is supposed to reflect the marginal cost plus some portion of the fixed cost that is meant to reflect a fair rate of return on the investment. This will keep consumer welfare as high as possible with the constraint that the firm's shareholders are adequately compensated. A fair rate of return is meant to allow shareholders to receive what they would have received in an alternate but comparable endeavour.

The regulator will usually set a test period where they will observe the demand for electricity and the costs associated with the firm.¹³ The regulator will then allow the firm to charge a price so that

$$pQ = C + rB,$$

where p is the price allowed, Q is the quantity of units sold, C is the total marginal costs of the firm, r is the fair rate of return and B is the rate base of the firm. From this equation, it is clear that there are three variables that need to be determined by the

¹³Phillips (1988).

regulator: the costs, the rate base and the rate of return.

Operating costs comprise a large component of the total revenues of the firms, as on average they account for 75% of the total revenues.¹⁴ These costs will include expenditures on fuel, wages, depreciation, taxes, operations and maintenance. The regulator will supervise these costs to make sure they are reasonable. The commission may disallow a particular component of the costs when calculating the prices allowed or prohibit the expenditure outright if it is deemed as an imprudent expenditure.¹⁵ For example, it may reject excessive salaries to management. The courts have allowed the commissions to engage in such supervision of costs.¹⁶

Depreciation affects the costs and the rate base. On one hand, the depreciation is recouped in the cost column, but it also reduces the value of the rate base. It also affects the taxes. Some regulators will allow the firm to use straight line depreciation when calculating the costs and the rate base, but will allow them to use accelerated depreciation when calculating taxes.¹⁷

The regulator can also influence the choice of fuel used by the firm. It may require the firm to use a cleaner coal in order to meet some environmental standards. In addition, it may guarantee the debt issued by a firm when constructing a nuclear plant. Fuel expenditures account for a large portion of the operating costs, and is a very important component in the ratemaking process.¹⁸

When calculating the rate base and what costs to allow, some regulators will allow and others will disallow the inclusion of construction work in progress (CWIP). CWIP reflects a rate base that has not arrived yet, but one that requires current financing. Hence, a regulator may allow its inclusion in order to give the firm adequate incentives to make the necessary investments.¹⁹

¹⁴Table 3.1.

¹⁵Zycher (1988).

¹⁶Phillips (1988; p. 234).

¹⁷Phillips (1988; pp. 257-76).

¹⁸Vietor (1989; pp. 104-174).

¹⁹Phillips (1988; pp. 339-40).

There is no uniform way of calculating the rate base. The book value of capital is one such method, adjusting for depreciation, CWIP and any disallowed costs, while the book value of the firm is another. The two coincide for the most part. The courts have taken a positive approach to the issue of the rate base by instructing the commissions to use whatever methods arrives at a fair outcome.²⁰ I will assume that the rate base is equal to the book value of the firm when discussing the rest of the issues.

The final point, and the focus of this paper, is the allowed rate of return. There are several factors that the regulator will take into account when deciding the allowed rate of return. The courts have directed the commissions to award a fair rate of return, a return that will compensate the owners for investing in this project, and one that would leave them no worse off than had they invested in comparable projects. This is known as the cost of capital approach. The cost of capital for a project is the rate of return required to keep investors indifferent between investing in the current project and all other projects that have comparable risks and characteristics.

In order to determine the cost of capital of a firm, the regulator needs to determine the capital structure and the cost of the various components in the capital structure.²¹ Suppose that the firm's capital is K which is composed of debt D and equity E . Then the cost of capital to the firm is

$$r_K K = r_D D + r_E E,$$

where r_K is the cost of capital, r_D is the after tax cost of debt, and r_E is the cost of equity. The pre-tax cost of debt is the interest rate charged on the debt. Most debt contracts have specified interest payments at specified time periods, and most regulators will take these as the given cost of debt. The cost of equity is not as straightforward. Since equityholders are residual claimants on the revenues of the firm, and since there is no pre-specified payment for shareholders, the regulator requires more guidance when

²⁰Ibid.

²¹Ibid.

determining the cost of capital. The regulator could act opportunistically and award no or very little return to the shareholder, since the capital is already paid up. This, in addition to being contrary to the spirit of court decisions, would keep future investors from investing in future projects. Hence, the challenge is to find a rate of return that will treat current and future investors fairly. There are various methods for determining the return to equity. Such methods have occupied the majority of studies in regulatory finance.²² I will not discuss these methods as the reader is referred to the various references on this subject.

What is important, though, is to understand the relationship between the cost of capital and the capital structure. In the absence of any special characteristics of debt, such as the tax deductibility of interest payments, the Modigliani-Miller (1958) theorem tells us that the cost of capital is independent of the capital structure. When the tax code allows firms to deduct the interest payments from their taxable income, however, then a subsidy for debt is created. The cost of capital decreases in debt. Most firms will therefore issue a positive amount of debt when financing their projects. As the amount of debt in the capital structure increases, though, the possibility of bankruptcy increases. Given that bankruptcy usually entails costs that are borne by the creditors, this will begin to push up the cost of debt and therefore the cost of capital. The cost of capital is initially declining in the amount of debt due to the tax advantages debt offers and then begins to increase as concerns over bankruptcy and, more importantly, bankruptcy costs begin to dominate the tax benefits.²³ Hence there is an optimal level of debt that minimizes the cost of capital. The regulators are cognizant of this fact and will also strive to achieve an optimal capital structure when setting the allowed rate of return.²⁴

Phillips (1988, p. 221) reports that forty four states and the District of Columbia

²²Thompson (1991).

²³Debt offers other advantages that are discussed in Harris and Raviv (1991). It is not necessary to appeal to the tax code to justify why the cost of capital declines, at least initially, in the amount of debt. Rather the tax benefits can be interpreted literally or as a metaphor for all other benefits that debt has to offer.

²⁴Patterson (1983) and Copeland and Weston (1993) provide empirical evidence of the tax benefits of leverage.

control the issuance of securities by public utilities. He points to the fact that in 1950s and 1960s the concern among regulatory commissions was that the firms had too little debt.²⁵ Many commissions will ignore the actual capital structure and create a target structure if they decide that the firm could achieve savings by issuing more debt. Commissions that issue such target structures will lower the allowed rate of return on equity if they feel that the firm has too much equity.²⁶ This will have the effect of forcing the firms towards a more optimal capital structure. The courts have supported the commissions in their creation of target structures, as exemplified by the Alabama Supreme Court's decision to allow the state regulators to set the rates of the local phone company based on a higher debt equity ratio than the firm proposed.²⁷ In the United States, while regulators may set a target capital structure, also known as the deemed capital structure, the firms, in most states, are still free to set whatever structure they want. In Canada, many of the regulators set deemed structures and require the firms to follow them. The difference, though, is academic, as it is in the interest of the firm to set its capital structure equal to the deemed structure in order to earn the proper cost of capital.

I surveyed the decisions made by regulators. Consulting *Major Rate Case Decisions 1985-1996*,²⁸ I ascertained the following: forty nine states and the District of Columbia have a regulatory framework where regulated utilities periodically submit a request for, among other things, a rate of return on equity, and a desired level of equity as a percentage of total capitalization. These regulated utilities included electric, gas and telephone companies; of these firms, 72% requested a higher level of common equity in their capital structure than was granted. The average request for these firms was 42.9%, while the regulators granted an average of 41.9%. Meanwhile, the other 28% of the firms requested a lower level of common equity than was granted, with an average request of 44.4% and

²⁵p. 223.

²⁶See Phillips (1988, pp. 371-73) for numerous examples of commissions that rejected proposed capital structures and set the prices based on what they deemed an efficient level.

²⁷See Phillips (1988, pp. 371). The decision was *Alabama v. Southern Bell Teleph. & Teleg. Co.*, 47 PUR3d 65, 67 (1962).

²⁸Regulatory Research Associates Inc.

an average granting of 45.2%. Yet, in both the cases, the allowed rate of return on equity requested was always higher than the return on equity granted, and the difference was on average 1%. The firms requesting a higher equity ratio than granted requested, on average, a return on equity of 13.9% and were granted 12.8%, while the other firms requested 13.9% and receiving 12.9%. The reader should notice that most firms are requesting a level of equity higher than granted, and I will discuss this later.

The regulators operate in a zone of reasonableness awarding different rates of return on equity even when two firms in two different states are faced with similar economic conditions. During the 1960s, regulators in general were quite generous in awarding rates of return to the shareholders. This caused many utilities to increase their debt ratios in their capital structure. In the 1970s, however, as economic conditions worsened for the utilities with higher fuel costs and higher interest rates, the commissioners were not able to pass on the increased costs to the consumers as the 1970s were not generous to the incomes of consumers either! Hence, regulators began to think about restructuring the way they regulated the utilities. At least three observations became apparent to the regulators. The first was what is known as the Averch-Johnson effect.²⁹ This states that if a regulator awards a utility a return on capital that is higher than the true cost, the firm will over-invest in capital. The second was that this over-investment was usually done with debt and hence many firms were financially vulnerable when the economic conditions worsened.³⁰ The third effect was that firms were not taking any measures to increase their technical efficiency. If firms are guaranteed rates of returns over and above their costs, then what incentive would a firm have to search for cost savings, either through prudent management or better technologies?³¹ The 1980s and 1990s saw a new trend in regulation first with incentive regulations and then finally restructuring and outright deregulation.

²⁹Averch and Johnson (1962).

³⁰Although if firms were all equity financed, they would require higher rates of return than if there was some debt in the capital structure.

³¹Viscucci et al. (1997; pp. 386-87).

3.2.2 Incentive Regulations and Deregulation

Many states decided that the traditional rate of return regulation in its basic form was not able to best serve the consumers. Hence, some PUCs decided to introduce various incentive regulations. These were meant to create incentives for firms to search for cost saving measures in the hope that some of these savings may be passed on to the consumers. These regulations can be broken into four broad categories: demand side management incentives, generating performance incentives, fuel cost incentives and corporate performance incentives.³²

Demand side management incentives came in states that mandated that the utilities pursue policies that reduce consumption of electricity. This was motivated by conservation concerns and a desire for the transformation of utilities from providers of kilowatts to providers of energy services. Any reduction in sales, however, would result in a reduction in revenues for the utilities, which creates a disincentive for the utility from pursuing any such demand side management policies. Hence, many regulators came up with various methods to compensate the utilities for lost sales in order to keep the incentives for demand side management. Among these are revenue decoupling which allows utilities to recover their lost revenues the next year by re-adjusting the rates.

Generating performance incentives were meant to encourage utilities to use pursue the most efficient generating technology. For example, any reduction in fuel usage would be rewarded, while the opposite would be penalized. Fuel cost incentives are similar to generation incentives, except that they refer specifically to fuel efficiency.

Corporate performance incentives take into account the entire corporate performance. The two common methods of this were revenue sharing, where the company kept any savings it achieved through productivity improvements, and price caps where the price is capped at some level that allows the firm to keep any savings from productivity for a certain time period.

³²See Edison Electric Institute's publication *Types of Incentive Regulations: A Primer for the Electric Utility Industry, 1997*.

It is not clear whether these regulations are beneficial to consumers, firms or both. They all seem to benefit the firm, except perhaps the fuel cost incentives. The price caps, for example, allow the firms to keep costs down without having the savings taken away. So while some notion of efficiency may be achieved, the consumer may not see the benefits.³³

While these incentive regulations may push the regulated utilities towards more efficient operations, questions about the need for regulation in the first place emerged in the 1980s.³⁴ The view that electricity generation was a natural monopoly no longer became an acceptable model of the industry. This was due to the technological advances in turbine technology, especially gas fired turbines. As Balzhiser (1996) points out, the minimum efficient scale for electricity generation has dropped from 1000 megawatts to 400 megawatts for gas turbines and 10 megawatts for aero-derivative gas turbine. Many industrial users generate their own electricity as a by-product of their industrial activity, which allows them to sell their excess electricity to the utilities and others. In addition, new generators can be built and put into action even quicker than existing excess capacity can be utilized. These factors have led to many moves towards a complete restructuring of the electricity industry if not outright deregulation. The federal government in 1992 passed the Energy Policy Act (EPACT) calling for the open access to the interstate transmission lines for wholesale competition. The states have followed suit and almost all the states have begun to look into the issue of restructuring. California has taken the lead on this issue and full scale competition has started in January 1998. Some states have called for competition in the industrial customer base with the promise of retail competition for residential customers later.³⁵

There are several issues associated with deregulation. The first is that many of the

³³See Enholm and Malko (1995).

³⁴Smith (1988).

³⁵Much of this information can be found at the Energy Informations Administration's website <http://www.eia.doe.gov>. For a discussion of the issues see *The Changing Structure of the Electric Power Industry: An Update (1996)*, Energy Information Administration - U.S. Department of Energy and *The Restructuring of the Electric Power Industry (1999)*, published by the EIA a division of the U.S. Department of Energy.

existing generation facilities are outdated and less efficient than new entrants. The existing utilities are concerned that if full scale competition were to take place, their existing facilities would be obsolete without having recouped their investment. These plants, the utilities will argue, were built with the promise that they would be granted a monopoly in order to recoup their investment over a certain time period. Since deregulation will take away their opportunity for recoupment, the assets become "stranded." Many states have found various ways to deal with these stranded assets. Some states have required customers switching to cheaper providers to pay back their full share of the stranded assets, while other states have only allowed partial recoupment.³⁶

One of the conditions for a successful operation of a deregulated electricity market is that there exist a proper transmission network in effect. Before, the deregulation movement, most utilities were vertically integrated owning all of generation, transmission and distribution facilities. It is clear that while generation may no longer be a natural monopoly, transmission is still problematic. Hence, the federal government, in essence, has required functional separation of transmission from generation by requiring all utilities to allow access to their transmission grids for anyone who wishes to wheel electricity to another customer in another state. The states have been requiring similar measures but within the state. One strategy for an existing utility to maintain its market power is to keep its transmission capacity lower than what would be required for a fully competitive market to operate. Hence, even if a former customer wishes to purchase from another generator, it may not be able to receive anything due to limited transmission.³⁷ This may explain why the states that have deregulated have not seen the full benefits yet.³⁸

Finally, it should be remembered that deregulation is a political decision, and the politicians making such decisions are influenced by the same factors that influenced the

³⁶See Rossi (1998).

³⁷This idea comes from a conversation with Frank Wolak.

³⁸See Borenstein et al (1999a, 199b) and Joskow (1999). Utility executives have been hinting at their resistance to deregulation through such measures for years. See Jurewitz (1988).

regulators. We should expect, as a result, to see states that are more pro-consumer taking the initiative and deregulating the electricity industry more quickly than states that are less pro-consumer. It stands to reason that firms in the states that have been generous to the shareholders will do their best in slowing down the pace of reform, and furthermore, will be more successful than their counterparts in the other states. In addition, we may expect firms in pro-consumer states to keep their transmission capacity lower than what full scale competition would call for.

The next part will give the reader an idea about the state of deregulation at the present.

3.2.3 The Status of Deregulation

There are two drivers in the push toward deregulation: the United States federal government and the various states. The federal government can only influence the pace of deregulation as long as the firms generating electricity transmit across state lines. When this does not happen, then it is up to the individual states to take action. California is one such state that has taken the initiative with the most comprehensive plan to date. I will provide some information on the role of the federal government followed by a discussion of California's plan.

The Federal Government's Role

There are about 3000 utilities throughout the United States, but only about 700 generate power.³⁹ The large utilities generate and transmit electricity across high-voltage transmission lines that they own. There are two markets for electricity: wholesale and retail. The wholesale market is that where electricity is purchased for the purpose of resale. This represents approximately half of all electricity generated, with the rest distributed

³⁹The information here is taken from "The Restructuring of the Electric Power Industry - A Capsule of Issues and Events", a US Department of Energy online publication. http://www.eia.doe.gov/cneaf/electricity/chg_str/booklet/electbooklet.html

locally directly from generation. The wholesale market allows utilities to meet excess demand at peak times and when unexpected demand arrives. In the future, it will also allow customers to purchase electricity from cheaper sources when it becomes available.

The retail market is the market that represents the ultimate consumers. The retail consumers are divided into three major categories: residential, commercial and industrial. The residential customers purchase electricity for heating both for their space and water, air conditioning, lighting, refrigeration, cooking and other applications. Commercial consumers include "nonmanufacturing business establishments, such as hotels, motels, restaurants, wholesale businesses, retail stores, and health, social, and educational institutions."⁴⁰ The industrial sector represents such activities as manufacturing, construction and mining. The industrial customers pay on average less per kilowatt hour than the other two. This reflects their flexibility to locate their operations to other states and hence they receive more competitive prices. The residential customers are the least elastic in their demand for electricity and hence face the highest prices per unit of electricity.

As mentioned earlier, several technological factors have contributed towards the move to deregulation. In addition, the federal government has issued several orders which forced wholesale competition when electricity crosses state lines. This was done by opening interstate transmission lines to non-utilities through a series of measures. Among these was the requirement that all public utilities that own or control transmission facilities used in the transmission of electricity across states separate the transmission from their generating functions. Furthermore, the transmission tariffs need to be public and non-discriminatory. All existing and potential users of the transmission facilities will be given equal access to the transmission, with full disclosure to all such users.

These measures were enacted by the executive branch of the U.S. government. There are also over twenty bills pending in the Senate and House of Representatives calling for deregulation on a larger scale.

⁴⁰Ibid p. 5.

The States: The California Model

Various states have taken the initiative in deregulating their electricity industry. The leader in this aspect has been California.⁴¹ This has been due to the high prices that California consumers of all sectors were paying. So much so that businesses were cancelling plans to construct plants in California. In 1993, the California Public Utilities Commission issued a warning that businesses could not flourish under the prevailing electricity rates. A new set of rules were proposed, and in 1996 Bill 1890, a law to restructure the electric industry, was signed by Governor Pete Wilson.

The purpose of the law was to dismantle California's electric monopolies. This was in order to lower the rates to consumers of all types. In addition, other issues such as the maintenance of reliable and efficient power, renewable energy and other aims were incorporated into the bill.

Full competition was to start on March 31, 1998, and the bill required an immediate 10 per cent cut in rates for residential and small businesses. Industrial customers would receive rate cuts which were larger but graduated over time.

Competition was to be done through the creation of a new market structure. The market would be broken into the generators, an oversight board, an Independent System Operator and a power exchange.

The existing utilities which had a monopoly status over different regions will be forced to compete for the electricity market. Over eighty per cent of the electricity in California was provided by three investor owned public utilities: Pacific Gas and Electric, Southern California Edison and San Diego Gas & Electric. They were regulated utilities and were granted the exclusive right to service roughly one third of California each. The new system will force these firms to functionally separate into three main components: generation, transmission and distribution. While vertical integration may have had its

⁴¹Much of this information can be obtained from the California Public Utilities Commission website: http://www.cpuc.ca.gov/electric_restructuring/er_home_page.htm and the California Energy Commission: <http://www.energy.ca.gov/restructuring/>

benefits in the past, it lead to the natural monopoly situation that was discussed earlier. The natural monopoly, in this case, is in the transmission. Therefore, the firms will be allowed to compete in the first and third component while the second will remain regulated.

On the retail side customers will be able to shop around and buy electricity from the cheapest provider, not just their local utility. The customers may decide to sign long term contracts that give stability and reliability of service and delivery. On the other hand, they may opt for short term or instantaneous contracts that take advantage of cheap prices but may sacrifice reliability. The generators can sell directly to these customers with whom they have negotiated sales contracts. They can also sell electricity into a general pool, which will explained below. The large customers and distribution utilities will draw from the pool without concern about who originated the generation. These distributors may also contract with smaller customers and so on and so forth. While existing utilities will supply the market at the present, there is nothing to prevent construction of new plant to serve the market. Industrial customers who generate their own electricity may also sell their excess supply into the pool or directly. The aim is to allow full competition to take place so that customers will ultimately receive the cheapest rates that reflect the marginal costs of generation.

The regulator will be there to ensure that no one firm or group of firms dominates the market and chokes off future competition through control of transmission. Hence, the law established an Independent System Operator (ISO) to oversee the operation of the transmission system. All existing transmission, regardless of who owns it, is treated as a separate entity that is regulated by the ISO. The ISO will ensure open and non-discriminatory access to the transmission grid to all generators who wish to supply customers. The aim is to make sure that no one blocks, restricts or constricts access to the grid. This will be the key in ensuring that the new market works. The ISO will not be allowed to have any financial interest in any of the generating units, as it is very important that the ISO maintain independence. The ISO is also subject to federal

regulation since many of the transmission lines are used for interstate commerce.

Finally the pool that was mentioned earlier will be established and called the Power Exchange (PX). The PX is essentially a centralized spot and future market for electricity in California. The market works as an auction. Price information is continuously displayed for all to see. Demand for electricity will come in on an hourly basis, and the PX solicits bids to supply the demand requests. The lowest bid will be awarded the contract unless there are capacity constraints, in which case the next lowest bid will receive the next batch and so on. Small consumers will be insulated from these dealings as they will have signed fixed price contracts, while other customers may be contracting directly with the generators. The PX, however, serves as a method for customers to calibrate and evaluate the quality of their contracts. Again, there is federal oversight on the exchange.

An Oversight Board is appointed to ensure that the new system is working. There are five members, three of whom are appointed by the governor while two are appointed by the legislature. The Board then appoints a governing board for both the ISO and the PX. It must be noted that the ISO and PX are not for profit corporations and not government agencies. The governing boards are comprised of individuals from diverse backgrounds. These include those involved in the business of generation, transmission, distribution, buying, selling and using of electricity. In addition, there will be appointments from public interest groups and individuals not directly involved in the electricity market. This is meant to ensure that no one group dominates the governance and the rule making of the new market.

The reader may be asking if there are any costs involved in the transition from the regulated monopoly phase to a fully competitive stage. The answer is yes. As mentioned earlier, there are various costs involved in the transition. The biggest of these are the so called stranded assets costs. These are costs incurred by the utilities under the premise and promise that they would be able to recoup them through the regulated and guaranteed prices in the future. When the market moves to a competitive system, however, the utilities are left with assets whose expenses they may never be able to

recoup. This amounts to a deregulatory taking.⁴² In order to avoid court challenges and also to be fair to the firms, the regulators will allow the firms to recoup the costs of their stranded assets. Any customer who decides to purchase cheaper electricity from a supplier other than their existing provider, between March 31, 1998 and December 31 2001, will be required to pay their portion of the assets that are stranded. For example, if a large industrial customer constituted one tenth of a utility's sales, then if the customer wishes to purchase cheaper electricity, it will be required to pay one tenth of those assets that are deemed stranded. Residential customers who wish to bypass their municipal suppliers will also be assessed an exit fee.

In addition, rates will be frozen at the 1996 levels minus the ten per cent immediate cut for residential customers. The difference between market prices and the frozen rates will be put into a fund that will be used to pay for these assets. This will stay until 2002. Hence for four years, on paper there will be cheaper prices, but in reality they will be frozen at the 1996 rates. The positive aspect of this is that, while rate decreases are foregone for four years, the stranded assets will be paid off. The market will be fully functional in four years. If stranded asset recovery were to be done on pay as you exit basis until all assets were paid off, then it was estimated that the market would not shake off its regulatory past for at least fifteen years. This method also eliminates the possibility that the entrenched interests act strategically by charging large exit fees as a barrier to exit and hence entry.

Between 1998 and 2002 the three investor-owned utilities will receive accelerated payment for their stranded assets. The total dollar figure for these assets are not known, but it could be up to \$30 billion. The California Public Utilities Commission is currently looking into the exact dollar figure. There are several ways to calculate these costs and it is not obvious which formula has been picked.

In principle calculating what should be deemed stranded is simple. The devil is in the details. Conceptually, the firm should look at the value of its assets before the

⁴²See Sidak and Spulber (1997).

restructuring and subtract it from the value post restructuring. This is the value of the stranded assets. When deciding for a particular customer, the firm needs to take the revenue that a customer would have given the firm, subtract the value of the dedicated assets to that customer from an alternate use, and multiply the difference by the length of the contract (with discounting of course!) The problem is how to measure these values. In fact, they are the same problems discussed earlier when determining the rate base. Should it be the market value, book value with straight line depreciation, book value with accelerated depreciation, some mixture of these or others. The federal authorities have been advising the states on the costs and benefits of these different approaches and it will be a while before these are all decided.

The States: Other States

Other states have also taken the initiative to deregulate. In fact, in Table 3.8, I have listed the states by their level of reform. A 5 denotes complete move toward deregulation, while a 1 denotes no action, and the rest denote some degree of action.

Various states have taken action to restructure their industry. Spurred by high prices in the state and by industrial customer's decisions to move to cheaper states, these states have either enacted comprehensive legislation or have the issue pending in their legislatures. Some of the problems facing the states is the question of who should benefit immediately. In California, the residential customers were given immediate rate cuts with businesses having to wait four years. In some other states, industrial customers are being given the rate cuts with residential customers coming later. This has caused some political wrangling in the legislatures, as one can expect.

It must be noted that the utilities themselves have been bracing themselves for such action. Many have been cutting their costs in anticipation of the new market structure. Mergers and consolidations have been sweeping the industry. Soon, the issues will no longer be pure regulatory issues, as anti-trust authorities will begin to be drawn into the fray. Firms may be investigated for abusing their dominant position or even outright

price fixing in the new and emerging markets.

3.3 A Review of the Literature

Regulated firms have higher debt levels than equivalent non-regulated firms.⁴³ One theory that explains the large leverage of regulated firms is the static trade-off theory, or the debt capacity model. This posits that companies would like to leverage infinitely due to the tax advantages that debt offers, but are constrained by expected bankruptcy costs, and hence companies that have lower expected bankruptcy costs will have a higher debt level. Since regulated firms' prices allow them to recover costs, including a rate of return on their investment, this substantially reduces the chances of bankruptcy, which reduces the expected bankruptcy costs, and hence regulated firms should have a higher debt level than their unregulated counterparts.⁴⁴

While traditional finance theories can explain the large leverage of regulated firms by pointing to regulator-guaranteed revenues, what they do not explain is how such revenues are determined, and it is here that the various theories of regulation come into play. There is a tension between the regulated utilities and the commissions, who presumably represent the consumers. On one hand, the firms are receiving a stream of revenues that ensure a level of certainty in the firm's revenues, which plays a role in explaining the large debt in their capital structure. On the other hand, regulators, responding to consumers' concerns over high prices, may keep prices low, disallow certain costs, impose various incentive regulations and finally deregulate the market.

Stigler's (1971) theory of regulation provides an insight into the process of price

⁴³Hyman et al. (1987) found that the Bell Regional holding companies were highly leveraged even after controlling for risk. The average debt ratio of the BHCs, whose beta was .63, was 40%, while, industries that had a beta of .60-.99 had an average debt ratio of 28%.

⁴⁴There are other theories such as the pecking order theories of Myers and Majluf (1984) and agency theories of capital structure such as Jensen and Meckling (1976). See Harris and Raviv (1991) for a good survey of these theories. In addition, Titman and Wessels (1988) provide a good empirical study of the subject.

setting.⁴⁵ The regulated price is the result of a regulator satisfying both consumers and producers, but not necessarily to the same degree. A regulator that is more favorable to consumers will lower the price allowed to the firm, while the one who favors the firms will award a higher price. We should find that regulatory environments not favorable to producers will have low prices and, as a corollary, low debt equity ratios. Firms in these environments, therefore, may search for ways to raise costs in order to raise the prices allowed, including the cost of capital.

A firm facing an unfavorable regulator, one could argue, might increase its debt equity ratio, which would increase the chances of bankruptcy and expected bankruptcy costs, and thereby force the regulator to grant a higher price. In fact, this is what Spiegel and Spulber (1994; 1997) and Spiegel (1994; 1996) argue. Since the regulators allow the firms to recover costs including interest charges, higher debt equity ratios, which have higher expected bankruptcy costs embedded in the interest charges, will allow the firm to charge consumers a higher price. Furthermore, they argue, a higher debt level will be used by firms in regulatory environments that are not favorable to the firms as a tool to keep the regulators from lowering the price. These articles imply that debt will be set by the firm above the efficient level, which is zero. This is because debt in their models has no advantage other than being a strategic device to raise the cost of capital.

Dasgupta and Nanda (1993) offer a similar theory, and moreover, they offer some empirical evidence showing that the debt equity ratios are higher in harsh regulatory environments. This, they claim, is evidence that firms use debt as a tool to counter harsh regulators, where the term harsh refers to regulators who are unfavorable to the shareholders. They regress the debt equity ratios of electric utilities on, among other variables, a dummy variable that indicates whether the state that the firm is in has a harsh regulator. The data is provided by the investment banking consulting company *Duff and Phelps*. Controlling for the other variables, they find that the debt equity ratios are higher in those states that are categorized as harsh.

⁴⁵Peltzman (1976) formalized Stigler's contribution.

The articles by Spiegel and Spulber and Dasgupta and Nanda represent the literature on the positive theory capital structure determination in regulatory finance. Taggart (1985) is another positive piece. It lacks a formal model, but does a good job at surveying the theories and testing them.

These models are good at describing the debt financing of nuclear plants. Traditionally, these plants have been financed using debt either with the approval of the regulators or without. Due to the massive construction costs associated with these plants, some states allowed the firms to issue state backed bonds. These gave a guarantee by the state on the firms' behalf. In other states, the firms issued the debt first, and then came to the regulators asking for recovery. The regulators in these case were reluctant to disallow the debt lest they bankrupt the firms. The models above, however, are not accurate in describing the rest, and the majority, of cases.

The literature mentioned suffers from two flaws. The first, which is institutional in nature, is that they do not recognize that the capital structure of public utilities is determined by the regulator and not by the firm. Hence, at best the models describe the desired level of debt by the firms, rather than the debt level realized. The second flaw is that by ignoring the benefits of debt, most notably tax savings, Spiegel and Spulber's model imply that a higher debt equity ratio automatically means a higher cost to the firm and hence a higher price for the consumers, when it is precisely because of the tax savings from debt that firms would want to lower their debt equity ratio as much as possible even if the regulator did not determine the capital structure.⁴⁶ Any positive theory of capital structure, therefore, should be institutionally correct and account for the full cost of capital. The reader should recall from the section on regulatory finance above that regulator sets the capital structure, either explicitly or through the deemed capital structure mechanism. In addition, 72% of the utilities requested equity levels higher than granted. This suggests that the models in the literature are missing the key

⁴⁶There are other benefits that debt offers, as Harris and Raviv (1991) discuss. Hence, the cost of capital would fall with a positive amount of debt, even if there were no tax savings associated with debt.

elements of regulatory environments.

I will discuss some of the empirical literature after I have introduced the model and discussed the theoretical implications.

3.4 The Models

This section presents two models. The first is a model of regulatory finance which is the institutionally accurate model. In it the regulator sets the price and the capital structure. I will present this model below and it will be the model of choice when empirical results will be discussed. Another model is presented, where the firm chooses a capital structure first and then the regulator sets the price. This model responds to the models of Spiegel and Spulber (1994) and shows that even if the firm could set its capital structure, it would not act as they predict.

3.4.1 The Players and their Payoffs

There are three players: the consumers, the firm and the regulator. The consumers inelastically demand one unit of electricity at price p , and have consumer surplus $V - p$, where V is the consumers' value of consuming the unit of output.

The firm will produce this unit of electricity if it invests K units of capital, which it can finance by debt D' or equity $E = K - D'$. At the end of the period, debt D' requires a gross interest payment of $D \equiv (1 + i)D'$.

The firm faces variable costs C and a cost shock c with probability $\hat{\theta}$. This cost shock has a mean $\hat{\theta} c$ and a variance of $\sigma^2 = (1 - \hat{\theta}) \hat{\theta} c^2$. This uncertainty might or might not be real. The important thing, though, is that there is a risk perceived by the regulator. Empirically, we do not observe firms leveraged above 50% of the capital structure which implies that regulators do perceive some cost shock risks for the firm.

If the cost shock occurs, the firm will not be able to cover its debt obligations if

$p - C - D < c$. The probability of bankruptcy is

$$\theta(p, D | \hat{\theta}) = \left\{ \begin{array}{l} \hat{\theta} \text{ if } p - C - D < c \\ 0 \text{ otherwise} \end{array} \right\}.$$

When the firm goes bankrupt, it faces bankruptcy costs

$$T(\cdot) = \left\{ \begin{array}{l} T(D - p + C + c) \text{ if } D - p + C + c > 0 \\ 0 \text{ otherwise} \end{array} \right\},$$

where $T' > 0$ and $T'' > 0$.

The corporate tax rate is τ , and so the expected return on equity is

$$E = (1 - \theta)(1 - \tau)(p - C - D).$$

The expected return on debt is

$$(1 - \theta)D + \theta(p - C - c - T(\cdot)),$$

where the risk adjusted interest rate i is determined in the capital market according to⁴⁷

$$(1 - \theta)(1 + i)D' + \theta(p - C - c - T(\cdot)) = D'$$

The value of the firm F is equal to the sum of the returns on debt and equity, and so the payoff to the firm is equal to

$$F(p, D) = (1 - \theta)(1 - \tau)(p - C - D) + (1 - \theta)D + \theta(p - C - c - T(\cdot)). \quad (3.1)$$

The regulator has a utility function which is an average of the consumer' surplus and

⁴⁷I am assuming that the risk free rate is equal to zero.

the firm's profits. The payoff to the regulator is

$$(V - p)^\gamma (F)^{1-\gamma}, \quad (3.2)$$

where $\gamma \in [0, 1]$ represents the consumers' bargaining power.⁴⁸ To simplify the analysis, I will assume that $\gamma < \frac{1}{1+\tau(1-\theta)}$.⁴⁹

3.4.2 Model I: The Regulator Sets the Price and Capital Structure

When the regulator picks both the price and capital structure, the model is a one period model with only the regulator making any choices. The regulator's payoff is given by (3.2), and so the regulator will

$$\max_{\{p, D\}} (V - p)^\gamma (F)^{1-\gamma}$$

subject to $F - D \geq (1 + \text{cost of equity}) \times E$. I shall assume that this constraint is non-binding. Let the resulting price and debt be $\{p^*, D^*\}$.

Since the consumers' demand for the unit of output is perfectly inelastic, there are no efficiency issues with respect to the pricing decision as far as the consumers are concerned. An increase in price raises the overall social surplus as it is a pure transfer from the consumers to the firm, while it lowers the expected bankruptcy costs. Furthermore, the regulator will want to set the capital structure efficiently, in order to keep the social surplus as high as possible. The regulator choice of price is constrained by the consumers' bargaining power.

I can now present some propositions whose proofs, unless otherwise stated, are in Appendix D.

⁴⁸Alternatively, it reflects the weight the regulator places on consumer welfare.

⁴⁹This is meant to keep the regulator from being too pro-consumer. Spiegel and Spulber (1997) have a similar condition, while one can imply such a condition in Dasgupta and Nanda (1993).

Proposition 20 *The resulting price and debt $\{p^*, D^*\}$ are implied by*

$$p = \frac{V \left\{ (1 - \gamma) (1 - \tau(1 - \theta)) - \theta(1 - \gamma) \frac{dT}{dp} \right\} + \gamma \{ \theta(T(\cdot) + c) + C(1 - \tau(1 - \theta)) - \tau(1 - \theta)D \}}{1 - \tau(1 - \theta) - \theta(1 - \gamma) \frac{dT}{dp}} \quad (3.3)$$

$$\theta \frac{dT}{dD} = (1 - \theta)\tau \quad (3.4)$$

To understand the price allowed, consider the following. If $\gamma = 0$, then $p_0 = V$. If the firm had all the bargaining power, the regulator would let the firm charge the full V . If $\gamma = 1$, then $p_1 = C + D + \frac{\theta(T(\cdot)+c)-D}{1-\tau(1-\theta)}$. This says that if the consumers had all the bargaining power, the regulator would allow the firm to charge its cost which consists of the operating costs C plus the cost of debt. The cost of debt consists of the interest payments plus the a risk premium, which is composed of the expected costs shock plus the bankruptcy costs minus the gross interest payments that are not paid in the bankrupt states, all of which are discounted by the tax savings. In general, the price is a convex combination of V and the operating costs plus the cost of capital, and is a number between p_0 and p_1 . Realistically, the price will also be bounded below by the cost of equity, and hence the price will be a number between the full cost of capital and the full consumer value. The firm will receive a surplus in excess of the cost of capital.

Another way to understand the price is as follows. The regulator can award a price that is either correlated with the costs or correlated with consumers' value. A regulator that awards prices more correlated with costs is a pro-consumer regulator since not much is left for economic profits. A regulator that awards prices more correlated with the consumers value is allowing the firm more economic profits. As an empirical matter, we can look to see if the revenues are correlated with costs to determine the level of harshness of a regulator.

The debt level is picked optimally by the regulator so that the marginal tax savings from debt are equal to the expected marginal bankruptcy costs. This is seen in (3.4),

where the left hand side is the expected bankruptcy costs, while the right hand side is the tax rate in those non-bankrupt states, representing the expected tax savings from the interest payment deductions. This suggests that the price and capital structure are set independently. A separation theorem analogy is in effect. The regulator aims for efficiency when setting the capital structure, using the price as the transfer mechanism between the consumers and the firm. The regulator, in some cases, may be constrained by being required to voice some basis for awarding the return on equity. Hence, while the efficient capital structure may involve a low equity ratio with a high return on equity, say 400 basis points above the true cost of equity, the regulator may opt for a higher equity ratio and a lower return on equity. This is not captured in my model, but is worth noting.

Proposition 21 *The probability of bankruptcy is always positive.*

Since debt always reduces the cost of capital due to the tax deduction, the regulator will want the firm to carry as much debt as possible, only constrained by the expected bankruptcy costs. Since, the tax savings are always positive, this implies that the expected bankruptcy costs will be positive implying that the probability of bankruptcy will always be positive. At a zero debt, there are tax benefits but no bankruptcy costs and so the regulator will always has an incentive to add some debt to the capital structure.

Proposition 22 *The price is increasing in cost, the cost shock, the cost uncertainty and decreasing in the consumers' bargaining power, or*

$$\frac{dp}{dC} > 0, \frac{dp}{dc} > 0, \frac{dp}{d\sigma} > 0 \text{ and } \frac{dp}{d\gamma} < 0.$$

The regulator will allow the firm to recover some of the costs to keep the firm from bankruptcy and also to lower expected bankruptcy costs. Reducing bankruptcy costs is why the regulator will increase the price when the cost shock increases which also leads to the variance increasing. Recall that there are no efficiency distortions from raising the

price on the consumers' part, and reducing the expected bankruptcy costs reduces the distortions to the firm. As the bargaining power of the consumers increases, the regulator will lower the price in order to increase the surplus available to consumers.

Proposition 23 *The debt equity ratio is decreasing in cost, the cost shock, the cost uncertainty and the consumers' bargaining power, or*

$$\frac{dD}{dC} < 0, \frac{dD}{dc} < 0, \frac{dD}{d\sigma} < 0 \text{ and } \frac{dD}{d\gamma} < 0.$$

Since increases in costs will cause the regulators to increase the price, but not by the full amount of the cost increase, the regulator will reduce the debt level in order to lower the chances of bankruptcy and the expected bankruptcy costs. Similarly, an increase in the cost shock and the variance in the cost shock will lower the debt level as to lower expected bankruptcy costs. This reduction in debt is meant to preserve efficiency in the capital structure. Finally, when the consumers have a higher bargaining power, this will lower the price allowed and hence lower the debt equity ratio. Pro-consumer jurisdictions demand that consumers not be responsible for expensive bailouts of bankrupt firms, and this concern also lowers the debt equity ratio in order to lower expected bankruptcy costs. We should expect to observe, therefore, that pro-consumer jurisdictions will have firms with low allowed prices and low debt equity ratios.

Dasgupta and Nanda (1993), the reader is reminded, found that firms in harsh jurisdictions had higher debt equity ratios. This seems to contradict the results of the last paragraph. In order to resolve this two issues need to be investigated. First, I will re-examine the models in the existing literature by presenting a model similar to Spiegel and Spulber (1997) that takes into account the full cost of capital. Second, I will provide an explanation of the term 'harsh.'

3.4.3 Model II: The Firm Sets the Capital Structure

Having presented an institutionally accurate model, I want to revisit the model proposed by Spiegel and Spulber (1994; 1997). Recall that I had characterized these models as models of the desired level of debt - models that describe the debt equity ratio that a firm would set if it believed that the regulator would base the price allowed on this desired level of debt. What is of interest, however, is if the correct cost of capital were taken into account, firms would not necessarily request a high level of debt as proposed by Spiegel and Spulber, but rather they most likely would request a lower level of debt. Spiegel and Spulber's results, as will be shown below, are a special case of a general result. I will redo their model but take the full cost of capital into account.

In this model the firm sets the capital structure. There are two periods. In the first period, the firm will choose a capital structure, while in the second period the regulator will set the price. In the second period, the regulator, whose payoff is given by (3.2), will

$$\max_{\{p\}} (V - p)^\gamma (F)^{1-\gamma}.$$

The regulator's pricing strategy $p^*(D)$ is a function of the capital structure set by the firm in the first period.

In the first period, the firm, whose payoff is given by (3.1), will set its capital structure to

$$\max_{\{D\}} (1 - \theta) (1 - \tau) (p - C - D) + (1 - \theta) D + \theta (p - C - c - T(\cdot)).$$

In equilibrium the firm will correctly anticipate the regulator's pricing strategy, and hence the equilibrium strategy of the firm D^* is chosen to maximize $F(p^*(D), D)$. The equilibrium strategies $(p^*(D), D^*)$ constitute a subgame perfect equilibrium of the two stage game.

The regulator's pricing strategy is given by using the expression in (3.3)

$$p^*(D) = \frac{V \left\{ (1 - \gamma) (1 - \tau(1 - \theta)) - \theta(1 - \gamma) \frac{dT}{dp} \right\} + \gamma \{ \theta(T(\cdot) + c) + C(1 - \tau(1 - \theta)) - \tau(1 - \theta)D \}}{1 - \tau(1 - \theta) - \theta(1 - \gamma) \frac{dT}{dp}} \quad (3.5)$$

The firm substitutes (3.5) into (3.1) and will choose $D^* = \arg \max_{\{D\}} F$, where

$$F(p^*(D), D) = (1 - \theta) (1 - \tau) (p^*(D) - C - D) \quad (3.6)$$

$$+ (1 - \theta) D + \theta (p^*(D) - C - c - T(\cdot)). \quad (3.7)$$

The debt level D^* will be determined by the condition⁵⁰

$$\theta \frac{dT}{dD} - \frac{dp^*}{dD} \left((1 - \theta)(1 - \tau) + \theta \left(1 + \frac{dT}{dD} \right) \right) = (1 - \theta)\tau. \quad (3.8)$$

The reader should compare (3.8) with (3.4). Note that the difference is the second term in the right hand side of (3.8). The firm will set the debt level so that the expected bankruptcy costs are equal to the tax savings from debt plus the increase in the value of the firm from the effect of an extra unit of debt on the price the regulator sets. In order to understand whether the firm will set the debt level higher or lower than that which the regulator would set, we need to know the sign of $\frac{dp}{dD}$. The appendix gives the exact expression of $\frac{dp}{dD}$, but the sign can be seen as follows: $\frac{dp}{dD} |_{D \rightarrow 0} < 0$ and $\frac{dp}{dD} |_{D \rightarrow \infty} > 0$. When debt is very small, the regulator will lower the price allowed as debt increases due to the tax savings. When the debt level gets high, the bankruptcy costs begin to outweigh the tax savings and hence, the price allowed rises. Therefore, $\frac{dp}{dD}$ is negative initially and then becomes positive, which implies that the firm may or may not want to

⁵⁰This is seen by differentiating (3.6) with respect to D and setting equal to zero yields the first order condition

$$(1 - \theta)(1 - \tau) \left(\frac{dp^*}{dD} - 1 \right) + (1 - \theta) + \theta \left(\frac{dp^*}{dD} - \frac{dT}{dD} \left(1 - \frac{dp^*}{dD} \right) \right) = 0$$

which results in (3.8).

set its debt level higher or lower than that which the regulator would set. The theoretical results of Spiegel and Spulber (1994, 1997), which have the firm setting their debt above the efficient level, are a special case of this general result.

The firm may wish to set the debt equity ratio higher than or lower than the efficient level. What determines its desired level of debt is the sign of $\frac{dp}{dD}$. Consider if the firm had a high level of existing debt, in which case $\frac{dp}{dD}$ is more likely to be positive due to rising expected bankruptcy costs. The firm would be more likely to request a higher debt equity ratio. If on the other hand, the firm has a low debt equity ratio, $\frac{dp}{dD}$ will be negative and so it would request a lower debt equity ratio. Since 72% of the firms requested a debt equity ratio lower than that granted, this suggests that the models in the existing literature describe the desired behavior of 28% of the firms.

When a state regulator is characterized as harsh, this means that the regulator is not granting the firm its desired price nor its desired debt equity ratio. Furthermore, at low levels of debt, $\frac{\partial^2 p}{\partial D \partial \gamma} |_{D=0} < 0$, which implies that the more the regulator is pro-consumer, the more the firm would desire an even lower debt equity ratio. The harsher the regulator, the more debt the firm has relative to what it would want. In other words, the term harsh is synonymous with a regulator that grants a higher debt equity ratio than desired by the firm, which explains the empirical results of Dasgupta and Nanda.

3.4.4 Regulatory Reform and Investment Incentives

Bargaining power, as seen above, is key to determining both the price allowed and the capital structure of the regulated firm. States in which the consumers have the dominant bargaining power are states where we should expect more and more innovations in lowering the costs facing the consumers. Such states in the past have implemented alternative pricing strategies such as the various incentive regulation pricing mechanisms. Recently, however, many states are taking bolder steps as several states have either introduced full scale competition in the electricity market or introduced legislation to open

the retail electricity market to competition.⁵¹ An interesting question, therefore, is can we use a measure of bargaining power observed in past pricing decisions to infer current movements towards deregulation? This will be the main focus of the empirical section.

Firms in these new deregulated environments would have their prices set competitively and their capital structures would also have to adjust. The firms would now see their prices converge toward marginal cost rather than the weighted average of cost and consumer value that they were accustomed to. Furthermore, the debt equity ratios that these firms are carrying will not be suitable for the new environment. Hence, we can anticipate that many firms will not be looking forward to such deregulation. Firms that are in states with less pro-consumer regulators will be more likely to exert their already large influence in slowing the pace of reform. Firms in states with more pro-consumer regulators who are already accustomed to low prices and lower debt equity ratios will relatively have relatively less to fear from competition. They may, however, try to hamper the deregulatory process by not keeping their transmission capacity at an optimal level, as discussed in the introduction. This indicates an interaction between investment decisions and the capital structure of the firm. Since firms in pro-consumer states will have lower debt equity ratios, they will also be firms that will have lower investments in their transmission systems. The interaction here between capital structure and investment is conducted via the consumers' bargaining power.⁵²

We should observe that states with pro-consumer regulators will be quicker to reform their industry, while the other states will be slower. I will provide more discussion below in the empirical section.

⁵¹Much of this information can be found at the Energy Information Administration's website <http://www.eia.doe.gov>.

⁵²Brealey and Myers (1988) illustrate similar principles with respect to the interaction between finance and investment.

3.5 Empirical Implications

In this section, I will review some of the empirical literature regarding the capital structure of a regulated firm, while I will introduce my empirical results in the rest of the section.

3.5.1 Some Literature

Little has been written on the role of regulatory preferences in determining how the capital structure is set. The article by Dasgupta and Nanda (1993) is one of the few where they explicitly regressed the debt equity ratio of public utilities on the ranking of regulator by their harshness. In it they found that the harsher the regulator, the higher the debt equity ratio. As discussed earlier, there are several problems with this. The first, is that the term "harshness of regulator" is subjective as it was based on information compiled by an investment banking research group and is simply an ordinal ranking of regulators. The second is that harshness may be a reference to the fact that firms may be desiring, as model 2 above shows, a higher equity ratio and hence when they receive a higher debt ratio they feel that they have been treated harshly.

Taggart (1985) also attempts to see if regulation impacts capital structure. He looks at the debt equity ratios of utilities before and after they were regulated in the 1920s. He found that prices rose and so did debt, although in some situations he found that prices rose and debt fell. These, without a formal model, can support various stories. This can support the model presented here. It can also support Speigel and Spulber's model, and hence, while the results are interesting they do not support one side or another.

Hagerman and Ratchford (1978) find that the longer the term a commissioner serves, the higher the rate of return to a utility. Navarro (1982) also confirms this, but in addition finds that elected commissioners and lower paid commissioners will be more pro-consumer.

3.5.2 The Empirical Results

The purpose of this section is twofold. The first is to provide confirmation for some of the results presented above. The second is to estimate the bargaining power of the consumers using the pricing equation in (3.3). The estimates of bargaining power can be used to infer other aspects of the regulatory environments including the pace of regulatory reform. This is an important contribution of the paper, as it allows the use of estimates of an unobservable parameter.

The discussion so far has presented several assertions. Firms that have large bargaining power will have higher revenues and higher debt levels; high debt will be positively correlated with low costs and low variances in cost, while prices will be positively correlated with high costs and high variances; and states in which the consumers have higher bargaining power will be states that will be most likely to move towards deregulation.

To investigate these issues, several data sources were consulted. Data for the years 1984 - 1996 were taken from the annual *Financial Statistics of Major US Investor-Owned Electric Utilities*.⁵³ The data contain the income statements and balance sheets of the various investor owned utilities across the various states. There are over 200 investor owned utilities that provide about 80% of the electricity in the U.S. market, while the rest is provided by publicly owned firms. Nebraska is the only state with no privately owned electric utility.

Table 3.1 provides some summary statistics for the various firms during the time period. It should be noted that the average debt ratio⁵⁴ is 48%, the average price of electricity is 6.6 cent per Kilowatt-hour, and that the average size of a firm is \$2.7 billion in physical capital, with average operating costs around \$1 billion.

⁵³Energy Information Administration - U.S. Department of Energy.

⁵⁴Debt ratio = $\frac{\text{Debt}}{\text{Debt} + \text{Equity}}$.

3.5.3 The Cost and Uncertainty

While the proposition that costs and uncertainty lower the debt equity ratio and raise the price allowed is not too controversial, it is, nonetheless, instructional to investigate it. In order to see the impact of costs and uncertainty, the following equation is estimated:

$$\log\left(\frac{Debt}{Equity}\right) = \sum_{i \in \{States\}} \alpha_i S_i + \beta_1 \log\left(\frac{Capital}{Output}\right) + \beta_2 \log\left(\frac{OP.Cost}{Output}\right) + \beta_3 Var + \beta_4 Growth \quad (3.9)$$

where *OP.Cost* is the operating costs which includes the cost of fuel, taxes, salaries and operating and maintenance expenses, *Capital* is the book value of the plant, and *Var* is defined as the variance in the growth of operating costs. S_i is a dummy variable that takes value 1 for a particular state and zero otherwise. *Output* is the electricity production of the firm measured in MWHours. *Growth* is the average growth of the gross state product.

The S_i dummy is meant to capture the fixed effects for the various states. These fixed effects which will be represented by the α_i are meant to capture the idiosyncratic nature of the various regulatory environments across states including the relative bargaining power of firms with consumers. The $\frac{Capital}{Output}$ variable is a measure of average fixed costs, while $\frac{OP.Cost}{Output}$ is a measure of average variable costs. The results are presented in Tables 3.2a.

We should expect that the measures of variable costs have a negative coefficient in the regression, as this was evident from the model. The fixed cost variable is slightly more complicated. On one hand, the fixed cost per output reflects how expensive the generating facility is relative to sales. In the event of bankruptcy, creditors will not receive as many sales from a plant that has a high fixed cost per output than another plant with a smaller ratio. Hence, fixed costs per output may be a proxy for bankruptcy costs, and we should expect a negative coefficient. On the other hand, many facilities are

built to meet maximum capacity, while electricity is wheeled in from other generators. They are kept as spare plants for backup purposes. Such electricity may command a premium in the time of need from other generators. Therefore, a plant with a lot of capital per output may have a high value since there is the option of generating extra output that the accounting does not reflect. This may mean that the bankruptcy costs are not as high and the coefficient might be positive.

Table 3.2a shows that the debt equity ratio is negatively related to both types of costs, the variance in costs and the interest rate, while the growth of the economy is insignificant. This confirms the basic intuition of the theory. One interesting question is does the type of fuel influence the debt equity ratio? This question comes up because, in the past nuclear stations were funded with state backed bonds which implies that the risk would be borne by the taxpayers and not the firm. To see this, the following regression was run:

$$\begin{aligned} \log\left(\frac{Debt}{Equity}\right) = & \sum_{i \in \{States\}} \alpha_i S_i + \beta_1 \log\left(\frac{Capital}{Output}\right) + \beta_2 \log\left(\frac{OtherOP.Cost}{Output}\right) \quad (3.10) \\ & + \beta_3 Var + \beta_8 \log\left(\frac{Nuclear}{Output}\right) + \beta_9 \log\left(\frac{Steam}{Output}\right) \\ & + \beta_{10} \log\left(\frac{Hydro}{Output}\right) + \beta_{11} \log\left(\frac{Other}{Output}\right) + \beta_{12} Growth \end{aligned}$$

The variables, *Nuclear*, *Steam*, *Hydro*, and *Other* refer to expenditures on nuclear, steam, hydro or other fuels respectively. *OtherOP.Cost* are operating costs other than fuel.

The results are in Tables 3.2b. All the coefficients have the negative signs except the nuclear fuel variable. This suggests that nuclear plants with the Spiegel and Spulber (1994) model in mind, or were built with some taxpayer backing in mind.⁵⁵ I re-estimated (3.9), by omitting all firms that had expenditures on nuclear fuel in excess of 30% of the

⁵⁵See "Bonneville to pay most of \$55 million in bond settlement", Wall Street Journal. Jan. 27, 1995 p. B5. These and other stories suggest that there was some implicit backing of nuclear plans by taxpayers.

total fuel expenditures. The results are in table 3.2c, and the results do not change from those in table 3.2a.

Another issue with the estimation is the presence of multicollinearity. This is due to the division of all the variables in the equation by the Output variable. To investigate this, I measured the correlation matrix of all the variables involved. The $\frac{Capital}{Output}$ variable was highly correlated with many of the variables. Hence, I re-estimated (3.10) without the $\log(\frac{Capital}{Output})$ variable. The results are in Table 3.2d. Again, only nuclear fuel has a positive impact on the debt equity ratio and the other results have not changed.

One of the problems associated with panel data is that while there may be twelve years of observations for the fifty states, the data may in fact be repeating the observations across the states twelve times. This is due to the stability of the regulatory regimes governing the capital structure. To correct for this, I ran the regression in (3.10), with and without the $\log(\frac{Capital}{Output})$ variable, as a cross section for each year. I have summarized the results in Table 3.2e and 2f. It lists the number of times a variable was significantly positive or negative. The log of other costs was significant and negative eight times when the fixed costs were included and eleven times when it was omitted.⁵⁶ Nuclear fuel was positive seven times when fixed costs were included and six times when they were omitted. Steam fuel was significant and negative five times in the first case and four times in the second. Fixed costs were negative and significant five times, and positive once. Hence even when the regressions were run on cross sections only, the signs were as expected whenever they were significant.

The results shed some light on what factors are important for the determination of capital structure. In some years, regulators are concerned about certain types of costs. It is obvious that variable costs excluding fuel costs are the most important issue every year. This is consistent with the model. When we decompose the fuel costs by type, then two things emerge. The first is that they also have a negative effect on the debt equity ratio, except for nuclear fuel. Steam fuel is the most common form of fuel and so

⁵⁶Recall that the number of time periods is twelve.

it is not surprising that it is the one that has the impact most of the years. Nuclear fuel impacts the debt equity structure positively and especially after 1988. This may indicate the maturing of previously issued bonds that financed these plants, as there have been no new nuclear plants since the early 1980s. The results also suggest that fixed costs are viewed negatively by the market when determining the debt equity ratio. This means that the role for peak servicing is limited and that capital intensive plants per output are not viewed as technically efficient. Finally, the issue of uncertainty seems to not have any effect on the debt equity ratio. This may indicate that the market does not view the cost shocks as a real threat. The coefficient for the variance of costs were negative but insignificant, so there is evidence of weak concern over costs shocks.

I should note that the empirical literature on capital structure is not unanimous. The results of Bradley, Jarrell and Kim (1984) would have suggested that we should find a positive coefficient on the cost variable, while Long and Malitz (1985) would have suggested otherwise. More details on these issues can be found in Titman and Wessels (1988).

This section has shown that the observable variables behave consistently with the predictions of the model. The unobservable variable, consumers' bargaining power, will be discussed in the next section.

3.5.4 Bargaining Power

Estimation

The object of this section is to show that the simplest models can uncover the underlying bargaining power parameter in each state. We have seen that there is a correspondence between the capital structure and the prices allowed to a regulated firm. The main interaction between these two variables is through the bargaining power parameter γ as shown in (3.3). As stated above, the idea of (3.3) is that prices are either correlated with costs or with consumers' value. One way to do this could be taking simple correlations between the prices and the cost per unit. This may not reveal the whole story, though,

due to non-linearity of (3.3). Hence a better way is to directly estimate γ . I will present various methods of estimating this parameter.⁵⁷

Consider (3.3) which was the price allowed by the regulator in model I. Some modifications are required before proceeding to the estimation. The first, is to replace occurrences of gross interest payments D with net interest payments iD' . This is because the model was a one period model, whereas the data is year to year. The second modification is to specify the bankruptcy function. Let $T(\cdot) = T \times D'$ where D' is the total debt outstanding. It seems reasonable to assume that if the firm were to go bankrupt, the bankruptcy costs would be proportional to the entire debt outstanding. This allows (3.3) to be rewritten as

$$p = V \{1 - \gamma\} + \gamma \left(\frac{\{\theta T D' + \theta c - iD'\}}{1 - \tau(1 - \theta)} + C + iD' \right). \quad (3.11)$$

In the model there was one unit of output. Therefore, (3.11) can be interpreted in per unit terms. Debt, interest payments, price, costs are all in per unit terms. Hence, $p = \frac{\text{Total Revenue}}{\text{Output}}$, $D' = \frac{\text{Total debt}}{\text{Output}}$, $C = \frac{\text{Total Operating Costs}}{\text{Output}}$, and $iD' = \frac{\text{Interest Payments}}{\text{Output}}$, where output is measured in KwH. Since, I am only interested in the parameter γ , (3.11) can be simplified further. One simplification is

$$p = V \{1 - \gamma\} + \gamma \{\Gamma_1 D' + \Gamma_2 + \{CQ + iD'\} - \Gamma_3 iD'\} \quad (3.12)$$

where Γ^i , $i = 1..3$ are metaparameters derived by simplifying the expressions in (3.11).⁵⁸ The right hand side of (3.12) is the average price received by the firm which a convex combination of V and $\{\Gamma_1 D' + \Gamma_2 + \{CQ + iD'\} - \Gamma_3 iD'\}$, where V is the consumer value or total consumer surplus available (at price zero.)

⁵⁷The methods here are similar to Ross (1984; 1985) where he attempted to recover regulator's preferences.

⁵⁸ $\Gamma_1 = \frac{\theta T}{1 - \tau(1 - \theta)}$, $\Gamma_2 = \frac{\theta c}{1 - \tau(1 - \theta)}$ and $\Gamma_3 = \frac{1}{1 - \tau(1 - \theta)}$.

Equation (3.12) has two constants V and Γ_2 which will cause some identification problems in the estimation. One way to overcome this is to specify V . V can be thought to be correlated with the gross state product per capita of the state. In addition, it can also be correlated with the number of commercial customers in the state, or more accurately the proportion of commercial customers to the total number of customers. Commercial customers are more inelastic demanders of electricity than industrial customers, and hence have the most surplus extractable.⁵⁹

Hence (3.12) can be re-written as

$$p = \left\{ \alpha \frac{GNP}{POP} + \beta \frac{\text{Number of commercial customers}}{\text{Total number of customers}} \right\} \{1 - \gamma\} + \gamma \{ \Gamma_1 D + \Gamma_2 + \{CQ + iD'\} - \Gamma_3 iD' \} \quad (3.13)$$

where GNP is the gross state product of the state and POP is the population of the state. This allows for the identification of γ and the other parameters.

The next step is to estimate (3.13) for every state. The estimates were obtained with a non-linear regression estimated individually for each state. These estimates are in Table 3.3, and are labelled γ_1 .

Another method is re-estimate (3.13) with the number of industrial customers instead of the number of commercial customers. Industrial customers have a lot of willingness to pay, since they operate large industrial projects, but they also have a lot of flexibility in the long run, since they can always relocate to an adjacent state. Nonetheless, it is interesting to see if there is a change in estimates. The estimates are in Table 3.3 and labelled γ_2 .

Another approach is to redo model I with Q units demanded inelastically as opposed

⁵⁹There is anecdotal evidence to this effect, such as the fact that industrial plants can decide where to locate as opposed to a business in a state. In addition I ran the following regression $\log(\text{quantity}) = \alpha + \beta \log(\text{price})$ for both industrial and commercial customers. β is a point estimate of the own price elasticity of demand. I do not report the results, as they are only suggestive, but the β for industrial customers was significant and negative, while that for the commercial customers was insignificant and close to zero.

to 1 unit. The resulting equation after re-doing the optimization is

$$pQ = V \{1 - \gamma\} + \gamma \left(\frac{\{\theta T D' + \theta c - i D'\}}{1 - \tau(1 - \theta)} + CQ + i D' \right),$$

except that all variables are in aggregate. pQ is the firm's total revenues, D' is total debt, CQ is total operating costs, and $i D' =$ total interest payments. V can be thought as being correlated with the gross state product and total population. Hence the equation can be estimated as follows:

$$pQ = \{\alpha GNP + \beta POP\} \{1 - \gamma\} + \gamma \{\Gamma_1 D + \Gamma_2 + \{CQ + i D'\} - \Gamma_3 i D'\}.$$

The equation is estimated state by state and the results are in Table 3.3 labelled γ_3 .

Equation (3.13) was estimated state by state. Another way to estimate it is to use a non-linear seemingly unrelated regression (non-linear SUR). This is to take advantage of the shocks in the costs of fuel that affect all states as a whole. The estimates are also in Table 3.3 and are labelled γ_4 .

There are nine regional reliability councils that coordinate the planning and operations of generation and transmission between various states. This allows a generator in one state to transmit to an adjacent state in case of a shortage or generation failure. The regional councils are the listed in Table 3.13. Each council consists of a number of states, although some states such as Texas are in a one reliability council. Equation (3.13) was estimated using a non-linear SUR by each of the reliability councils. The results are labelled γ_5 and are in Table 3.3.

While, the value of γ theoretically should be between 0 and 1, the estimates are not all less than one. When the restriction was imposed in the estimation, the restrictions were all binding for all the five different methods used. I report the unconstrained values of γ in Tables 3.3.

It should be noted that debt D is endogenously determined in the model, and hence

some sort of control for endogeneity should be used. To do this non-linear instrumental variable estimation needs to be used. There were many choices of instruments. Among them were the yield on utility company's bonds, rates of return on utility company's stocks, the credit rating of the various firms. These were not used, however, as the data was either sparse or not as rich as the dataset being used. The instrument that was used was the book value of capital. The book value of capital is strongly correlated with debt and not as strongly correlated with price.⁶⁰ Equation (3.13) was re-estimated using the instrumental variable.

The reader should interpret the values of γ in Table 3.3 as the relative value of one states' consumers bargaining power as compared to other states. Hence a higher γ indicates that consumers in that state have a higher relative bargaining power as compared to states with lower γ . There are various reasons why the estimates could be greater than one. One reason is that I used a uniform measure of cost as provided in the uniformly reported income statements. Various states, however, could be using different measures than the ones reported to the federal government. The discussion of the various treatments of CWIP and depreciation earlier should inform the reader of the difficulty in determining which costs were truly used in the commissions' decisions. What is important, though, is that γ reflects the degree to which the prices are correlated with costs as opposed to the consumers valuation of consumption. A state whose prices are more in line with costs are states with pro-consumer regulators, while states where prices are more correlated with measures of value such gross state product per capita are states with pro-firm regulators. Finally, the estimate could be also thought of as the relative bargaining power of consumers as opposed to the absolute bargaining power.

To give some confidence in these estimates, a method of attaching some validity to these estimates is needed. This method will be provided after a brief discussion of market to book ratios.

⁶⁰The correlation between capital and debt was 0.97 and was significant. The correlation between capital and price was close to zero and insignificant.

Verification

A generous regulator will award the firm prices that compensate for the costs plus an allowed rate of return. It is in this allowed rate of return where the scope for generous pricing comes into play. The regulator needs to compensate the firm's shareholders with a rate of return that will induce them to invest in the firm in the first place. If the regulator is generous, then the rate of return awarded will be higher than that which the investors would have required. The effect of this is to raise the market to book ratio of the firm. I will give a brief exposition to the reader on the meaning of market to book ratios.

Market to book ratios are important when considering regulatory finance.⁶¹ A market to book ratio indicates the degree to which the regulator is generous to the firm. To understand this, consider a share that yields a perpetual dividend d . The share will be priced by investors using the Gordon formula

$$E = \frac{d}{k_1}$$

where k_1 is the investors desired rate of return.⁶² This rate of return is what investors will require in order to hold the particular share with all its characteristics which include risk. If the share was completely risk free, the investors would require the risk free rate, and any additional risk will require some compensating risk premium.

Suppose a firm would like to invest in capital which costs K dollars today, and for now, assume that equity is the only method of finance. The firm will need to attract investors to pay K dollars with the promise to pay them a stream of payments that will compensate them with at least their desired rate of return k_1 . If the firm manages to pay in perpetuity a stream of dividends equal to $k_1 K$, then the value of the equity will be $E = K$, which means that market value E of the equity is equal to the book value K . In

⁶¹See Booth (1997) for a detailed discussion.

⁶²I am assuming no growth in the dividends.

the case of a regulated firm, it is up to the regulator to provide the investors with their desired rate of return.

The regulator would like to award the firm a rate of return that reflects this k_1 . While there are several methods proposed in the literature to estimate these rates of return,⁶³ the regulator's choice of allowed rate of return will be, in part, influenced by the relative bargaining power of the firm. Suppose the regulator awards a rate of return $k_2 > k_1$. The value of equity will equal

$$E_2 = \frac{k_2 K}{k_1} > K$$

and so $\frac{E_2}{K} > 1$, or the market to book ratio is greater than one.⁶⁴ Conversely, when the regulator awards the firm a rate of return less than k_1 the market to book ratio will be less than one. Clearly, the addition of debt to the picture will complicate the analysis, but the idea is the same: whenever the allowed rate of return on equity will be higher than that required by investors, the market to book ratio will be greater than one. These ratios are what signal to investors the desirability of investing in that firm.

Returning to the issue of bargaining power, recall the a higher bargaining power for the firm would mean a higher allowed rate of return and hence a high market to book ratio. Hence, we should expect that states with low γ s will have higher market to book ratios.

The firms in the sample are all owned by holding companies. These companies are listed in the various appendices of the *Financial Statistics of Major US Investor-Owned Electric Utilities*.⁶⁵ The market to book ratios were then obtained for these holding companies from the COMPUSTAT database. Table 3.4 lists the average market to book ratio for the states during the entire period. I then found the correlation between the market to book ratio and the various estimates of γ . This was done using the average market to book ratio by state and then by firm. Table 3.5a reports the correlations

⁶³See Thompson (1991) for details on these methods.

⁶⁴Market to book ratios are also proxies for Tobin's Q ratios.

⁶⁵Energy Information Administration - U.S. Department of Energy.

between the various γ s and the average market to book ratio, where the average is by state. Table 3.5b reports the correlations where the averages are by firm. Both sets of correlations are negative and significant at the 5% level. This gives strong support to the various estimates of γ as estimates of the bargaining power of consumers. While all of the correlations are negative, γ_3 has the strongest correlation. This may be because of the use of aggregates in estimation. However, the other estimates are still significantly negatively correlated and that is what we were looking for: a parameter that validates some notion of bargaining power.

This is an important result, as it shows that the method used to estimate γ can yield meaningful estimates that are robust to the type of estimation. This important result allows us to use these estimates in order to understand other issues in the electricity industry. One such issue is the nature of the regulatory environment.

3.5.5 The Regulatory Environment

Incentive Regulation

Are incentive regulations more beneficial to consumers or to firms? To answer this, I classified states according to the existence or absence of the various incentive regulations. Four such incentive regulations are examined: the demand side management (DSM), generating performance (GP), fuel cost incentives (FC) and corporate performance (CP) incentives. These were discussed earlier in the introduction. Table 3.6 lists the states that have these incentives. Each state was assigned a 0 if the incentive regulation was absent and a 1 if it was present.

I estimated the relationship between the presence or absence of the various incentive regulations using the probit procedure. The independent variable was γ , which measures the consumers bargaining power, while the dependent variable was either DSM, GP, FC or CP depending on which regulation was being studied. If these regulations benefit the consumer more than the firm, we should expect the coefficient for γ to be positive. Two measures of γ were used: γ_1 which was the per-output estimate, and γ_3 which was the

aggregate estimate. The results are in Table 3.7. The coefficients are negative for all of the incentive regulations, except the demand side management incentives, suggesting that the regulations, other than the DSM, were implemented by states that were pro-firm. This suggests that these regulations benefitted firms more than consumers. The DSM regulations had mixed results depending on which measure of γ was used. This suggests that consumers may have had a desire for less consumption of electricity due to their conservation concerns.⁶⁶

Deregulation

There have been many gestures made concerning a complete deregulation of the electricity market, and there are several factors behind these moves. Needless to say, consumers' bargaining power is one them. States that are pro-consumer should be the ones pushing for deregulation. These are states that have high γ and hence moderate prices and lower debt equity ratios, and hence are states where the conditions for deregulation are ripe. The debt equity ratios are not as high and so the financial stability of the firms is not at peril. In addition, these firms might be more likely to be more technically efficient due to the lower allowed prices and other various incentive regulations. Conversely, firms in states that had suffered from high prices due to the firms' superior bargaining position will be more able to slow many of the attempts at deregulating the industry. As discussed earlier, firms in states that have built up a large amount of stranded assets will lobby for a slowing of the deregulation. How successful they are depends on their relative bargaining power. Some states such as California, which was one of the first to deregulate, have allowed a full recovery of stranded assets, New Hampshire has not allowed full recovery, and Pennsylvania has rejected any competition transition charge that will allow the recovery of stranded assets.⁶⁷ Interestingly, the value of γ_3 in California is 0.37, in New Hampshire 0.96 and in Pennsylvania 1.09, while the average price in

⁶⁶The probits were conducted with the other measures of γ . The results were robust to the choice of γ , except for the DSM regulation.

⁶⁷Rossi (1998).

California was 9.3 c/KwH, in New Hampshire 4.12 c/KwH and in Pennsylvania 4.06 c/KwH. Finally, the average capital per output in California is 20.7 c/KwH, in New Hampshire is 21.2 c/KwH and in Pennsylvania 16.6 c/KwH. This suggests that various factors are involved. States with high prices will see a push towards deregulation due to the pressure exerted by consumers. California can have deregulation and yet the firms who have the bargaining power are able to recover their stranded assets which are quite high due to the generous regime they have been in. Pennsylvania which has low prices and high consumer bargaining power will push for deregulation with no stranded asset recovery. New Hampshire has low prices, large stranded assets but also high consumer bargaining power, but not as high as Pennsylvania, and hence it has deregulation with limited stranded asset recovery.

Using the information in a recent Energy Information Administration (EIA) publication, I classified the states according to their pace of deregulation into five groups.⁶⁸ I assigned a 5 to states that have enacted legislation for restructuring, a 4 for states that have issued a comprehensive regulatory order, a 3 for states that have legislation or orders pending, a 2 for states that are conducting hearings and a 1 for states that have no activity at all. These are listed in Table 3.8. This classification does not distinguish between states that have allowed full or partial recovery of stranded assets. At the time of this paper, I was unable to construct a full dataset of which states have allowed such recovery schemes. Nonetheless, we can make use of the classifications mentioned. An ordered probit was conducted with the level of reform being the dependant variable. The following variables were used to investigate which states were at which level of deregulation:

1. γ : We should expect states with strong consumer bargaining power to be states pushing for deregulation. Hence we should expect a positive coefficient on γ . γ_1 was used as representative measure of γ .⁶⁹

⁶⁸*The Restructuring of the Electric Power Industry (1999)*, published by the EIA a division of the U.S. Department of Energy.

⁶⁹The results are robust regardless of the choice of γ . Hence, I do not report them all in the paper.

2. The ratio of the firms' revenues to the state GNP. This reflects a measure of the transfer from the consumers to the firms. While, firms may have been able to charge higher prices due to their bargaining position, consumers may become frustrated and vote for politicians who will re-adjust the relative bargaining positions. Hence the higher this share of state income, the bigger the push for deregulation and we should expect a positive coefficient.
3. The state's gross domestic product: This measures the size of the state and gets to the question of whether bigger states take bolder steps.
4. The average debt equity ratio of the firms in a state: This indicates the level of firms' bargaining power and indicates which states where the firm has been extracting large rents from the consumers, and hence these states may see the pressure from consumers to move towards deregulation. Hence, we should expect a positive coefficient.
5. The ratio of the expenditures on the various fuels to the total expenditures on fuel. Four variables were constructed: $\frac{\text{Nuclear Expenditures}}{\text{Total Fuel expenditures}}$, $\frac{\text{Steam Expenditures}}{\text{Total Fuel expenditures}}$, $\frac{\text{Hydro Expenditures}}{\text{Total Fuel expenditures}}$ and $\frac{\text{Other fuel Expenditures}}{\text{Total Fuel expenditures}}$. These variables will indicate which states will deregulate depending on which fuel is used more intensively in that state. I have no intuition on the sign.
6. Capital per output: This measures the ratio of physical capital to output. States that have larger capital per output have larger assets that will be affected by deregulation, and hence have larger stranded assets. These firms will push to slow down deregulation and so the coefficient should be negative.
7. Other operating costs per output: This is a measure of inefficiency (excluding fuel). States with inefficient firms may cause consumers to move their state towards some change, and so the coefficient should be positive.

8. Price: A high price state will also spur consumers to demand some level of deregulation. This should show up as a positive coefficient.

The results are in Table 3.9. They show that all the variables, except price are significant and have the expected sign.⁷⁰ What is interesting, as far the contribution of this paper is concerned, is that γ is a significant predictor of regulatory reform. It says that states where consumers have more bargaining power are states which will take the initiative in deregulating. It also suggests that deregulation is viewed by policymakers as a positive development for consumers.

Other Issues: Transmission Investment and Which State is Pro-Consumer?

Two non-related issues remain. Will firms try to keep their transmission capacity below that which is necessary for a competitive market to operate. To answer this, I would require data on the transmission capacity per output in each state. Since, I do not have this data, I used the expenditures of each firm on transmission maintenance and operations as a proxy for the firms' commitment to transmission. In order to correct for a size effect, I took the ratio of these expenditures to the state's gross domestic product. Finally, I measured the correlation between γ and the average ratio of expenditures on transmission maintenance to gross state product. The results are in Table 3.10, and show that the relationship is negative and significant. This is suggestive at best. It could also be interpreted as harsher states leave less money for expenditures on long term projects such as transmission. If states with larger γ s are the ones deregulating, however, and these states have lower expenditures on transmission, than this may explain why these states, such as California, are not seeing the full benefits of competitive markets.⁷¹ This is quite an important issue for policy makers to take into account when designing new

⁷⁰If I redo the regression, but without γ and price, with $D \times price$, where $D = -1$ for $\gamma < 0.8$, $D = 1$ for $\gamma > 1$ and $D = 0$ otherwise, then this variable is positive and significant. This shows that high price states with consumer power go for deregulation, while high price states with firm bargaining power resist deregulation.

⁷¹See Borenstein et al. (1999a, 1999b).

markets for electricity.

The last question has been the subject of studies in the social choice literature: what determines which state is more pro-consumer or less? Navarro (1982) studied what factors led to harsh regulators. He found that elected commissions were harsher among other things. His study used rankings by investment research companies for the various commissions. It would be interesting to study whether the estimates of γ could also yield such results. I estimated the following regression:

$$\begin{aligned} \gamma = & \beta_1\{\text{number of commissioners}\} + \beta_2\{\text{commissioners term of office}\} \\ & + \beta_3 E_1 + \beta_4 E_2 + \beta_5 E_3 + \beta_6 GNP, \end{aligned}$$

where E_i are dummy variables. $E_1 = 1$ if the commissioners are appointed directly by the governor and 0 otherwise, $E_2 = 1$ if the commissioners are appointed but ratified by the state legislature and zero otherwise, and $E_3 = 1$ if they are elected directly and zero otherwise. The GNP variable reflects the size of the state and the first two variables are evident. The first five variables are reported in Table 3.11 and are taken from Phillips (1988; pp. 126-28).

The results are in Table 3.12. They indicate that the number of commissioners is insignificant, but the term is positively linked to consumer bargaining power. This suggests some degree of independence that allows commissioners to "do the right thing." The commissioners directly elected are the most pro-consumer, which is hardly surprising as there are more consumers than firms. Those commissioners directly appointed are more pro-consumer than those ratified by the legislature, which might suggest some lobbying by the firms at the legislative level. Finally the larger the state, the more pro-firm it is.

3.6 Conclusions

Electricity regulation and deregulation is a very exciting field to study. Much is going on all over the world as we speak, and this study is very timely in its contribution. The

chapter develops a theory of regulatory finance that correctly accounts for the cost of capital as well as the institutional setting. It shows how a regulator who sets both the price and capital structure for a regulated firm will behave. A pro-firm regulator will allow a high price coupled with a higher debt equity ratio, while a pro-consumer regulator will do the opposite. This insight is useful as it allows us to measure the preferences of regulators. This in turn sets the stage for many empirical investigations.

The chapter surveys the basics of regulation, regulatory finance and deregulation. The section defines a natural monopoly and explains why both consumers and firms may want regulation. The economic theory of regulation is introduced. This states that regulators will set a price for the regulated firm keeping the firm as well as the consumers in mind. The survey turns to the topic of regulatory finance. The basics of capital structure are introduced. The cost of capital and hence the price allowed is decreasing in the amount of debt in the capital structure - but up to a point. Finally various incentive regulations and outright deregulation is discussed. A discussion of the California model of deregulation is described with some cautionary words for future design.

The chapter develops a model of regulatory finance. A regulator has to decide upon a price that will be allowed to the regulated firm and a capital structure for the firm. The regulator has to balance the consumers' surplus and the firm's profits, but not necessarily with equal consideration. The unequal consideration is what will lead to different regulators awarding different prices, and hence different rates of return, across the states. Some states will have higher rates of return than others all else being equal. These higher rates of return also lead to higher debt equity ratios. The regulators, who are pro-firm, transfer some of the surplus from the consumers to the firms but do so efficiently. The key in this result, of course, was that the demand for electricity was perfectly inelastic. This assumption which could be relaxed, is actually probably quite realistic. The demand for electricity by the residential and commercial customers is usually a function of pre-existing demand and the discretionary component in their spending is quite limited. Hence, the theoretical results of the paper are quite realistic

too.

The message from this model is that regulators may award high prices but do so efficiently through the capital structure. The other important message is that when prices track costs, this is a sign of a pro-consumer regulator, while when prices are less responsive to costs and more responsive to consumer value the regulator is pro-firm. This allows us to infer the regulators' preferences by observing the prices allowed to the firms. This became evident in the empirical part of the paper which will be summarized below.

The chapter presents a second model that gives some insight into how firms formulate their requests at regulatory hearings. If the firm had a choice in setting its capital structure first and then requesting a rate of return, the firm would choose a higher ratio of equity in its capital structure. Subsequently, it would ask for a higher rate of return on the equity. This is somewhat consistent with two observations. The first is that most firms request a higher equity ratio in their capital structures as well as a higher rate of return than is awarded. The second is that in the study by Nanda and Dasgupta, they found that firms who operated under regulators who were classified as harsh to the firms had higher debt equity ratios. This is however, the perspective of the firms that would have liked a higher equity ratio.

The second model should not be taken as a model of regulatory requests since the model is not rich with any institutional features describing the process of regulatory hearings. Rather it responds to those who suggest that firms would have an incentive to leverage in order to influence prices. If anything, firms would want a higher equity ratio.

An empirical section conducts various empirical exercises based on the theory developed. The data was from various investor owned electric utilities in the United States. It covered the years 1984-1995 and was taken from the income statements and balance sheets of these firms.

The basic predictions of the first model are tested. Debt equity ratios are negatively related to costs and uncertainty. This result is robust to whether costs are aggregated or broken down into their various components. The only exception was with respect to

nuclear fuel. The data showed that firms that had a substantial use of nuclear fuel had a higher debt equity ratio. This suggested some sort of regulatory backing for the funding of nuclear plants. It may also validate Spiegel and Spulber's theory of firms setting higher debt equity ratios when facing an opportunistic regulator.

The next empirical exercise was to estimate the value of the preferences of the regulators towards consumers or γ . This was done by using the pricing equation that was developed from the theory. As stated, when firms are awarded a price based closely on costs, then γ should be high. When prices do not track costs as much, but rather reflect consumer value, then γ is low. By utilizing the data on prices, costs, the capital structure, and variables associated with the value available such the gross state product, I was able to estimate γ for the various states.

There are several advantages to this method. It is the result of theoretically sound model, and the estimation is robust to specification which suggests that it is powerful in making inferences about the regulatory environment. It also lets the data speak rather than relying on subjective rankings conducted by investment research agencies regarding the value of γ . In this aspect the paper is quite innovative.

The paper explains why a firm that has a harsh regulator should expect to see its market to book ratio lower than that of a firm that faces a favorable regulator. The values of γ are shown to be meaningful as they are negatively correlated with the market to book ratios of the regulated firms. This allows the use of these estimates of γ for other empirical endeavors.

One of these endeavors is to investigate the various regulatory environments. The incentive regulations were studied to see if there was a relationship between the harshness of a regulator and which regulations were in place. The pace of deregulation was studied with respect to the consumers bargaining power. The pace of deregulation was shown to be positively related with whether the regulator was pro-consumer. States that had pro-consumer regulators were those that were more likely to deregulate than those with pro-firm regulators. Interestingly, though, those states with pro-consumer regulators

had lower investment in transmission capacity which suggests that such firms might be attempting to thwart the intentions of deregulation

Another political economy application of the paper was to investigate which institutions gave rise to pro-consumer regulators. Characteristics such whether the regulators were elected and the length of their term were shown to have some significance in predicting whether a regulator was pro-consumer.

Other applications of the relationship between the consumers' bargaining power and regulations could be studied. Environmental restrictions on the regulated firms, service requirements and other such non-price regulations could also be investigated.

The study could be refined further. By getting a better understanding of the details of the regulatory institutions in each state, the model could be refined to account for the state specific procedures. If the regulatory hearings themselves were used as the source of data, then many of the estimation problems identified in the paper could be removed.

Deregulation may be the vogue these days, but nonetheless this paper is very relevant. Restructuring is a more appropriate word for what is taking place, as the industry is moving from a completely regulated sector to various deregulated sectors and re-regulated ones. In the electricity industry, generation is being deregulated while transmission remains under supervision. Hence, the issues raised in this paper are quite relevant. Furthermore, bargaining power will be critical in predicting the pace and nature of deregulation. It should be noted that this study can be duplicated for the various industrialized countries that have not yet experienced restructuring in electricity, or for that matter any other regulated industry.

Chapter 4

An Overview of the Thesis

This thesis addresses two different topics within the context of capital structure. The first paper shows that debt can be valuable as a tool for avoiding paying damages to victims of the activities of the firm. These victims who ordinarily could collect from the firm are now not able to collect the full amount, because there are other claimants on the assets of the firm.

This result can be thought of as an application of the various theories of capital structure presented in chapter one. Whereas in the earlier papers interest payments allowed firms to avoid paying taxes, debt allows the firm to avoid paying its litigants. In previous studies, debt is shown to provide incentives to managers to have the best interests of the shareholders. By maximizing the value of the firm, debt in this chapter does the same but by minimizing payments to litigants.

Debt can create wealth and externalities. It creates wealth by transferring assets, that third parties would have claimed, to creditors. It creates externalities by keeping litigants from claiming the damages that are owed to them. Furthermore, it reduces the incentives that the firm has to take adequate care that would minimize the risk of the accidents.

Understanding this allows for the design of efficient liability rules. Negligence is shown to dominate strict liability no matter the number of tortfeasors. This is important to

understand when designing legal rules.

Debt was also used as a tool to efficiently transfer wealth from consumers to firms by a regulator. A regulated firm receiving a high price will receive this price but will also be forced to keep an optimal capital structure. Observing this allows us to make positive inferences about the nature of the regulatory environment. Just as the capital structure of firms in different industries differed due to certain characteristics of those industries, the capital structure of regulated firms will also differ according to the characteristics of the regulator. Knowing this can shed light on which environments will also deregulate.

The thesis has shown that capital structure is very important in understanding the workings of legal and regulatory regimes. The first paper makes normative statements concerning the desirability of leverage while the second provides a positive analysis of capital structure. The size of the pie can indeed be affected by the way we cut it!

Appendix A

Proofs for Torts and Bankruptcy

A.1 Proof of Proposition 1

The social planner will want to maximize the social welfare function given by (2.4) with respect to a and B . The first order conditions respectively are

$$c'(a) = -p'(a)L, \tag{A.1}$$

$$-\{Q'(B)G(B) + Q(B)g(B)\} < 0. \tag{A.2}$$

Let a^* be the solution for (A.1), while it is obvious that $B = 0$ is the optimal B .

A.2 Proof of Proposition 2

The firm will want to maximize the value of the firm given by (2.3) with respect to a and B . The first order conditions are obtained by setting $\frac{\partial V}{\partial a}$ and $\frac{\partial V}{\partial B}$ equal to zero. They are as follows:

$$c'(a) = -p'(a) \left(L(1 - G(B)) + \int_B^{B+L} (x - L - B) g(x) dx \right), \tag{A.3}$$

$$G(B + L) - G(B) = \frac{\{Q'(B)G(B) + Q(B)g(B)\}}{p(a)}. \quad (\text{A.4})$$

The right hand side of (A.3) is the liability that the firm expects to pay. The first component $L(1 - G(B))$ indicates that the firm has to pay L only in those situations when the firm has revenues that exceed B . When the firm has more revenue than $B + L$, it has to pay the full amount L . In those situations where, revenues are greater than B and less than $B + L$, it is able to escape part of the liability which is the second expression in the right hand side of (A.3). Now, since $\int_B^{B+L} (x - L - B) g(x) dx < 0$, the right hand side of (A.3) is less than L . Hence, the a^{SL} that solves (A.3) is suboptimal, or $a^{SL} < a^*$. Note that if $B = 0$, the second part of the right hand side of (A.3) would still be there, implying that a^{SL} is still non-optimal.

The left hand side of (A.4) is the marginal benefit from debt, which is the probability that revenues are between the debt level and debt plus liability level. This is the area where the firm is able to partially escape the liability. Now, the right hand side is the marginal cost of debt, which is the extra bankruptcy cost that the firm takes on when borrowing an extra unit of debt. The solution to (A.4) is $B > 0$, which is sub-optimal.

The second order conditions are assumed to hold. They will be used later when doing comparative statics.

A.3 Proof of Proposition 3

The firm will decide whether to be negligent or not. It needs to compare the value of the firm given by (2.5) with that given by (2.3). When the firm decides to be non-negligent, then $a = a^*$ and $L = 0$. The first order condition for B is the same as (A.2) implying that $B = 0$. Now the firm has to compare

$$\int_0^\infty xg(x)dx - c(a^*) \quad (\text{A.5})$$

with (2.3). If (A.5) is greater than (2.3), the firm will choose to be non-negligent while the converse is true. The firm will stay non-negligent as long as

$$\begin{aligned} & c(a^*) - c(a^{SL}) \\ & \leq p(a^{SL}) \left\{ L(1 - G(B)) + \int_B^{B+L} (x - B - L)g(x)dx \right\} + Q(B)G(B). \end{aligned} \quad (\text{A.6})$$

The condition in (A.6) is quite simple. The left hand side is the extra cost of being non-negligent. The right hand side is the liability that the firm is expected to pay out plus the expected bankruptcy costs. If the extra cost of being non-negligent is less than what it will cost the firm when it is negligent, then the firm would rather stay non-negligent.

A.4 Proof of Proposition 4

We are interested in $\frac{\partial B}{\partial L}$ and $\frac{\partial a}{\partial L}$. Using the envelope theorem, we can see that

$$\begin{bmatrix} V_{BB} & V_{Ba} \\ V_{aB} & V_{aa} \end{bmatrix} \begin{bmatrix} \partial B/\partial L \\ \partial a/\partial L \end{bmatrix} = \begin{bmatrix} -V_{BL} \\ -V_{aL} \end{bmatrix}$$

which implies

$$\frac{\partial B}{\partial L} = \frac{-V_{BL}V_{aa} + V_{aL}V_{Ba}}{|H|}, \quad (\text{A.7})$$

$$\frac{\partial a}{\partial L} = \frac{-V_{BB}V_{aL} + V_{aB}V_{BL}}{|H|}, \quad (\text{A.8})$$

where $|H| = V_{BB}V_{aa} - (V_{Ba})^2 > 0$, the Hessian of the maximization problem is positive as a consequence of the second order conditions, $V_{BB} < 0$, $V_{Ba} = p'\{G(B+L) - G(B)\} < 0$, $V_{aa} < 0$. $V_{BL} = p(a)g(B+L) > 0$, and $V_{aL} = -p'(a)(1 - G(B+L)) > 0$. To evaluate the signs of (A.7) and (A.8), we need to evaluate the sign of the numerators. There are four possible scenarios, and I shall show that three are possible, with one not.

A.4.1 Scenario 1: $\frac{\partial B}{\partial L} < 0, \frac{\partial a}{\partial L} < 0$.

For this to be true, we need

$$-V_{BL}V_{aa} + V_{aL}V_{Ba} < 0$$

$$-V_{BB}V_{aL} + V_{aB}V_{BL} < 0$$

This implies that

$$\frac{V_{aB}}{V_{aa}} > \frac{V_{BL}}{V_{aL}}$$
$$\frac{V_{BL}}{V_{aL}} > \frac{V_{BB}}{V_{aB}}$$

which implies that $\frac{V_{aB}}{V_{aa}} > \frac{V_{BB}}{V_{aB}}$ or $V_{aa}V_{BB} < (V_{aB})^2$ which contradicts the second order condition. This implies that scenario one is not possible.

A.4.2 Scenario 2, 3 & 4:

The three examples presented in the text show that all three cases are possible.

Appendix B

What happens if Creditors are not Senior

If creditors are junior to litigants, then the value of the firm is

$$\begin{aligned}
 V \equiv & p(a) \left\{ \int_{B+L}^{\infty} (x - B - L)g(x)dx + \int_{B+L}^{\infty} Bg(x)dx + \int_L^{B+L} (x - L - Q(B))g(x)dx \right\} \\
 & + (1 - p(a)) \left\{ \int_B^{\infty} (x - B)g(x)dx + \int_B^{\infty} Bg(x)dx + \int_0^B (x - Q(B))g(x)dx \right\} \\
 & - c(a). \tag{B.1}
 \end{aligned}$$

In this case,

$$\frac{\partial V}{\partial B} = -Q'(B) (p(G(B+L) - G(B)) + (1-p)G(B)) - Q(B) (pg(B+L) + (1-p)g(B)) < 0.$$

Hence, no debt will be issued.

Suppose there is a probability π that the firm is senior to the litigants and $(1 - \pi)$ that it is junior to the litigants. In this case, the value of the firm is

$$V = \pi\Theta_1 + (1 - \pi)\Theta_2$$

where Θ_1 is the value of the firm according to (2.4) and Θ_2 is the value of the firm according to (B.1). In this case, the first order condition is

$$\frac{\partial V}{\partial B} = \pi \underbrace{\frac{\partial \Theta_1}{\partial B}}_{=0 \text{ when } B \text{ is solution for (A.4)}} + (1 - \pi) \underbrace{\frac{\partial \Theta_2}{\partial B}}_{-ve}$$

which implies that $B < B$ implied from (A.4). The firm issues a positive amount of debt, but not as much as when the firm was always senior to the litigants. Hence, as long as there is a non-zero probability that the creditors are senior to the litigants, the firm will issue a positive amount of debt and all the results of the paper hold.

Appendix C

Proofs of the Parametrized Models

C.1 Proof of Proposition 5

L^s is defined as the solution of

$$2\sqrt{L} \left(\sqrt{1 - \frac{L}{2}} - \sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) = Q \bar{B}.$$

Note that the left hand side is monotonic in L , as

$$\begin{aligned} & \frac{d \left(\sqrt{L} \left(\sqrt{1 - \frac{L}{2}} - \sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) \right)}{dL} \\ &= \frac{1}{4\sqrt{L}} \left(\sqrt{4 - 2L} - \sqrt{4 - 4\bar{B} - 2L} \right) + \frac{\sqrt{L}}{2} \left(\frac{1}{\sqrt{4 - 4\bar{B} - 2L}} - \frac{1}{\sqrt{4 - 2L}} \right) > 0. \end{aligned}$$

When $L = 0$, then $2\sqrt{L} \left(\sqrt{1 - \frac{L}{2}} - \sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) - Q \bar{B} = -Q \bar{B} < 0$ which implies the firm prefers to be have no leverage. As L increases then either the equality will hold at some level $L = L^s$. If the equality never holds for any of the feasible values of L , then the firm always prefers to be fully leveraged. This would mean that bankruptcy costs

are too high and do not warrant leverage.

C.2 Proof of Proposition 6

When $L < L^s$, the firm has no debt and hence $a = a^{SL0} = \sqrt{L\left(1 - \frac{L}{2}\right)}$. When $L < L^s$, the firm has no debt and hence $a = a^{SL\bar{B}} = \sqrt{L\left(1 - \bar{B} - \frac{L}{2}\right)}$. Now notice that $L\left(1 - \bar{B} - \frac{L}{2}\right) < L\left(1 - \frac{L}{2}\right)$ which implies that $a^{SL\bar{B}} < a^{SL0}$. In addition $\frac{d\left(\sqrt{L\left(1 - \bar{B} - \frac{L}{2}\right)}\right)}{dL} = \frac{(1 - \bar{B} - L)}{2\sqrt{L\left(1 - \bar{B} - \frac{L}{2}\right)}} > 0$ given the assumptions of the model. Note that if $(1 - \bar{B} - L) < 0$ for some values of L then care could go up and then down again.

C.3 Proof of Proposition 7

Suppose not. Then the firm would be taking care less than $a^{SL} < a^*$. If it does not borrow, then $V^0 = \frac{1}{2} - 2\sqrt{L\left(1 - \frac{L}{2}\right)}$. Hence

$$V^0 - V^N > 0$$

which implies that

$$\begin{aligned} 2\sqrt{L\left(1 - \frac{L}{2}\right)} + \sqrt{L} &> 0 \Leftrightarrow \\ \sqrt{L}\left(2\sqrt{\left(1 - \frac{L}{2}\right)} + 1\right) &> 0 \Leftrightarrow \\ 1 - \frac{L}{2} &< \frac{1}{4} \Leftrightarrow \\ L &> \frac{3}{2}, \end{aligned}$$

which is a contradiction since $L < 1$ by assumption. Hence, the firm will not be negligent with zero leverage.

C.4 Proof of Proposition 8

L^c is defined as the solution of

$$\sqrt{L} \left(1 - 2\sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) = Q \bar{B}.$$

Note that the left hand side is monotonic in L , as

$$\begin{aligned} & \frac{d \left(\sqrt{L} \left(1 - 2\sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) \right)}{dL} \\ &= \frac{1}{2\sqrt{L}} \left(1 - \sqrt{(4 - 4\bar{B} - 2L)} \right) + \frac{\sqrt{L}}{\sqrt{(4 - 4\bar{B} - 2L)}} > 0. \end{aligned}$$

When $L = 0$, then $\sqrt{L} \left(1 - 2\sqrt{\left(1 - \bar{B} - \frac{L}{2}\right)} \right) - Q \bar{B} = -Q \bar{B} < 0$ which implies the firm prefers to be non-negligent. As L increases then either the equality will hold at some level $L = L^c$. If the equality never holds for any of the feasible values of L , then the firm always prefers to be non-negligent. This would mean that bankruptcy costs are too high and do not warrant leverage and hence negligence.

C.5 Proof of Proposition 9

When $L < L^c$, then $a = a^* = \sqrt{L} > a^{SL0} > a^{SL\bar{B}}$, and when $L > L^c$, then $a = a^{SL\bar{B}}$. Since the firm under strict liability would have already fully leveraged and hence it takes the same level of care as a firm operating under a strict liability regime.

C.6 Other Proofs

All the proofs of the multiple torts are analogous.

C.7 Proof of Proposition 18 & 19

The key in these proofs is the comparison of L_{JL}^c with L^* . First note that L^* solves

$$\sqrt[3]{L_{JL}^c} \left(1 - 2 \sqrt[3]{\frac{(1 - \bar{B} - \frac{L_{JL}^c}{4})}{2} + \frac{1}{2} \left(L_{JL}^c - \bar{B} (\bar{B} + L_{JL}^c) - \frac{L_{JL}^c}{4} (\bar{B} + L_{JL}^c) (1 + \bar{B} + L_{JL}^c) \right)} \right) - Q \bar{B}$$

$$L - \bar{B} (\bar{B} + L) - \frac{L}{4} (\bar{B} + L) (1 + \bar{B} + L) = 0. \quad (C.1)$$

Note that the left hand side is decreasing in L except for the first term. The left hand side is not monotonic, but it increases in L and then decreases. In fact,

$$\frac{d \left(L - \bar{B} (\bar{B} + L) - \frac{L}{4} (\bar{B} + L) (1 + \bar{B} + L) \right)}{dL}$$

$$= 1 - \frac{5}{4} \bar{B} - \frac{1}{4} \bar{B}^2 - \bar{B} L - \frac{1}{2} L - \frac{3}{4} L^2.$$

Now there will be a value of L that solve $\frac{d(L - \bar{B}(\bar{B} + L) - \frac{L}{4}(\bar{B} + L)(1 + \bar{B} + L))}{dL} = 0$. Call this L' . For all values of $L < L'$ (C.1) is increasing in L . I shall assume that all the values of L_{JL}^c that are used in proposition 18 and 19 are greater than L' . If this were not the case then the comparisons would be more complex, as we would have too many scenarios. By restricting our attention to those $L_{JL}^c > L'$ we can simplify the analysis.

Hence, for values of $L > L'$, (C.1) is decreasing in L . Hence when $L_{JL}^c < L^*$, the left hand side of (C.1) is positive which implies that

$$\sqrt[3]{L_{JL}^c} \left(1 - 2 \sqrt[3]{\frac{(1 - \bar{B} - \frac{L_{JL}^c}{4})}{2} + \frac{1}{2} \left(L_{JL}^c - \bar{B} (\bar{B} + L_{JL}^c) - \frac{L_{JL}^c}{4} (\bar{B} + L_{JL}^c) (1 + \bar{B} + L_{JL}^c) \right)} \right) - Q \bar{B} < 0$$

or that the firm prefers to be non-negligent under a joint and several negligence regime when $L = L_{JL}^c$. The converse is true.

Appendix D

Proofs of the Regulated Finance Paper

D.1 Proof of Proposition 20, 21, 22 & 23

Recall that

$$F = (1 - \theta)(1 - \tau)(p - C - D) + (1 - \theta)D + \theta(p - C - c - T(\cdot)),$$

and let $\mathfrak{S} = (V - p)^\gamma (F)^{1-\gamma}$. Then

$$\mathfrak{S}_p = \frac{A}{V - p} \times \left(\begin{array}{c} -p(1 - \tau(1 - \theta) + \theta(1 - \gamma)T') + \\ V\{1 - (1 - \theta)\tau + \theta(1 - \gamma)T' - \gamma(1 - \tau(1 - \theta))\} + \\ \gamma\{\theta(T + c) + C(1 - \tau(1 - \theta)) - \tau(1 - \theta)D\} \end{array} \right)$$

where $A = \left(\frac{\theta c + \theta T - p + p\tau + C - C\tau - D\tau - \theta p\tau + \theta C\tau + D\theta\tau}{-V + p} \right)^{-\gamma}$.

$$\mathfrak{S}_D = -A(1 - \gamma)(\theta T' - \tau(1 - \theta))$$

Setting $\mathfrak{S}_p = 0$, this yields

$$\begin{aligned} & -p(1 - \tau(1 - \theta) + \theta(1 - \gamma)T') + \\ & V\{1 - (1 - \theta)\tau + \theta(1 - \gamma)T' - \gamma(1 - \tau(1 - \theta))\} + = 0 \\ & \gamma\{\theta(T + c) + C(1 - \tau(1 - \theta)) - \tau(1 - \theta)D\} \end{aligned}$$

which results in (3.3).

Setting $\mathfrak{S}_D = 0$ yields $-\theta T' + \tau(1 - \theta) = 0$ which results in (3.4). If $p - C - D > c$, then $\mathfrak{S}_D > 0$ and hence more debt is borrowed until $\theta > 0$.

Setting $\mathfrak{S}_p = 0$, and $\mathfrak{S}_D = 0$ yield the optimal $\{p^*, D^*\}$ implied in the solutions in (3.3) and (3.4). The second order conditions, evaluated at the optima are

$$\mathfrak{S}_{pp} = \frac{A}{V - p} (-(1 - \tau(1 - \theta) + \theta(1 - \gamma)T') - \theta(1 - \gamma)(V - p)T'' - \theta\gamma T') < 0,$$

$$\mathfrak{S}_{DD} = -A(1 - \gamma)\theta T'' < 0$$

and

$$\mathfrak{S}_{Dp} = A(1 - \gamma)\theta T'' > 0.$$

The second order conditions imply that the determinant of the Hessian

$$|H| = \begin{vmatrix} \mathfrak{S}_{pp} & \mathfrak{S}_{pD} \\ \mathfrak{S}_{pD} & \mathfrak{S}_{DD} \end{vmatrix} = 0$$

D.1.1 The Case of γ

To do comparative statics with respect to γ , we need the following:

$$\mathfrak{S}_{p\gamma} = -(V - C)(1 - \tau(1 - \theta)) + \theta(c + T) - D\tau(1 - \theta) - \theta T'(V - p) < 0,$$

and $\mathfrak{S}_{D\gamma} = 0$, where $\mathfrak{S}_{p\gamma}$ and $\mathfrak{S}_{D\gamma}$ are evaluated at $\{p^*, D^*\}$. Hence,

$$\frac{dp}{d\gamma} = \frac{\begin{vmatrix} -\mathfrak{S}_{p\gamma} & \mathfrak{S}_{pD} \\ 0 & \mathfrak{S}_{DD} \end{vmatrix}}{|H|} < 0$$

and

$$\frac{dD}{d\gamma} = \frac{\begin{vmatrix} \mathfrak{S}_{pp} & -\mathfrak{S}_{p\gamma} \\ \mathfrak{S}_{pD} & 0 \end{vmatrix}}{|H|} < 0.$$

D.1.2 The Case of C

In this case,

$$\mathfrak{S}_{pC} = \frac{A}{V-p} \left(\gamma(1 - (1-\theta)\tau) + \theta(1-\gamma)T''(V-p) \right) > 0,$$

and

$$\mathfrak{S}_{DC} = -(1-\gamma)A\theta T'' < 0,$$

where \mathfrak{S}_{pC} and \mathfrak{S}_{DC} are evaluated at $\{p^*, D^*\}$. Then

$$\begin{aligned} \frac{dp}{dC} &= \text{sign} \frac{\begin{vmatrix} -\mathfrak{S}_{pC} & \mathfrak{S}_{pD} \\ -\mathfrak{S}_{DC} & \mathfrak{S}_{DD} \end{vmatrix}}{|H|} = \text{sign} \begin{vmatrix} -\mathfrak{S}_{pC} & \mathfrak{S}_{pD} \\ -\mathfrak{S}_{DC} & \mathfrak{S}_{DD} \end{vmatrix} \\ &= \text{sign}(-\mathfrak{S}_{pC}\mathfrak{S}_{DD} + \mathfrak{S}_{DC}\mathfrak{S}_{pD}) > 0 \Leftrightarrow \\ \mathfrak{S}_{pC} + \mathfrak{S}_{DC} &> 0 \Leftrightarrow \frac{\mathfrak{S}_{pC}}{-\mathfrak{S}_{DC}} > 1 \Leftrightarrow \end{aligned}$$

$$\begin{aligned} &\frac{\frac{1}{V-p}\gamma(1 - (1-\theta)\tau) + \theta(1-\gamma)T''}{\theta(1-\gamma)T''} \\ &= 1 + \frac{\frac{1}{V-p}\gamma(1 - (1-\theta)\tau)}{\theta(1-\gamma)T''} > 1. \end{aligned}$$

In addition,

$$\begin{aligned}
\frac{dD}{dC} &= \text{sign} \frac{\begin{vmatrix} \mathfrak{S}_{pp} & -\mathfrak{S}_{pC} \\ \mathfrak{S}_{Dp} & -\mathfrak{S}_{DC} \end{vmatrix}}{|H|} = \text{sign} \begin{vmatrix} \mathfrak{S}_{pp} & -\mathfrak{S}_{pC} \\ \mathfrak{S}_{Dp} & -\mathfrak{S}_{DC} \end{vmatrix} \\
&= \text{sign} (-\mathfrak{S}_{pp}\mathfrak{S}_{DC} + \mathfrak{S}_{pC}\mathfrak{S}_{pD}) < 0 \Leftrightarrow \\
\mathfrak{S}_{pp} + \mathfrak{S}_{pC} &< 0 \Leftrightarrow \frac{\mathfrak{S}_{pC}}{-\mathfrak{S}_{pp}} < 1 \Leftrightarrow \\
&\frac{\gamma A(1 - (1 - \theta)\tau) + \theta(1 - \gamma)A(V - p)T''}{(1 - \tau(1 - \theta))A + \theta(1 - \gamma)(A(V - p)T''' + \theta T')} < 1.
\end{aligned}$$

D.1.3 The Case of c

$$\mathfrak{S}_p = \frac{A}{V - p} \times \left(\begin{array}{c} -p(1 - \tau(1 - \theta) + \theta(1 - \gamma)T') + \\ V\{1 - (1 - \theta)\tau + \theta(1 - \gamma)T' - \gamma(1 - \tau(1 - \theta))\} + \\ \gamma\{\theta(T + c) + C(1 - \tau(1 - \theta)) - \tau(1 - \theta)D\} \end{array} \right)$$

In this case,

$$\mathfrak{S}_{pc} = \frac{A}{V - p} (\gamma(\theta T' + 1) + \theta(1 - \gamma)T''(V - p)) > 0,$$

and

$$\mathfrak{S}_{Dc} = -(1 - \gamma)A\theta T''' < 0,$$

where \mathfrak{S}_{pc} and \mathfrak{S}_{Dc} are evaluated at $\{p^*, D^*\}$. Then

$$\frac{dp}{dc} = \text{sign} \frac{\begin{vmatrix} -\mathfrak{S}_{pc} & \mathfrak{S}_{pD} \\ -\mathfrak{S}_{Dc} & \mathfrak{S}_{DD} \end{vmatrix}}{|H|} = \text{sign} \begin{vmatrix} -\mathfrak{S}_{pc} & \mathfrak{S}_{pD} \\ -\mathfrak{S}_{Dc} & \mathfrak{S}_{DD} \end{vmatrix}$$

$$\begin{aligned}
&= \text{sign}(-\mathfrak{F}_{pc}\mathfrak{F}_{DD} + \mathfrak{F}_{Dc}\mathfrak{F}_{pD}) > 0 \Leftrightarrow \\
\mathfrak{F}_{pc} + \mathfrak{F}_{Dc} > 0 &\Leftrightarrow \frac{\mathfrak{F}_{pc}}{-\mathfrak{F}_{Dc}} > 1 \Leftrightarrow \\
&\frac{\frac{1}{V-p}\gamma(\theta T' + 1) + \theta(1-\gamma)\Gamma''}{\theta(1-\gamma)\Gamma''} > 1.
\end{aligned}$$

In addition,

$$\begin{aligned}
\frac{dD}{dc} &= \text{sign} \frac{\begin{vmatrix} \mathfrak{F}_{pp} & -\mathfrak{F}_{pc} \\ \mathfrak{F}_{Dp} & -\mathfrak{F}_{Dc} \end{vmatrix}}{|H|} = \text{sign} \begin{vmatrix} \mathfrak{F}_{pp} & -\mathfrak{F}_{pc} \\ \mathfrak{F}_{Dp} & -\mathfrak{F}_{Dc} \end{vmatrix} \\
&= \text{sign}(-\mathfrak{F}_{pp}\mathfrak{F}_{Dc} + \mathfrak{F}_{pc}\mathfrak{F}_{pD}) < 0 \Leftrightarrow \\
\mathfrak{F}_{pp} + \mathfrak{F}_{pc} < 0 &\Leftrightarrow \frac{\mathfrak{F}_{pc}}{-\mathfrak{F}_{pp}} < 1 \Leftrightarrow \\
&\frac{(\gamma(\theta T' + 1) + \theta(1-\gamma)\Gamma''(V-p))}{((1-\tau(1-\theta) + \theta(1-\gamma)T') + \theta(1-\gamma)(V-p)T'' + \theta\gamma T')} < 1 \Leftrightarrow \\
\gamma(1 + \tau(1-\theta)) < 1 &\text{ or } \gamma < \frac{1}{1+\tau(1-\theta)}.
\end{aligned}$$

D.2 An Expression for $\frac{dp^*}{dD^*}$

$$\begin{aligned}
&\frac{V \left\{ (1-\gamma)(1-\tau(1-\theta)) - \theta(1-\gamma)\frac{dT}{dp} \right\} +}{\frac{\gamma \{ \theta(T(\cdot) + c) + C(1-\tau(1-\theta)) - \tau(1-\theta)D \}}{1-\tau(1-\theta) - \theta(1-\gamma)\frac{dT}{dp}}} \\
\frac{dp^*}{dD^*} &= \frac{\left(V \left(-\theta(1-\gamma)\frac{\partial^2 T}{\partial p \partial D} \right) + \gamma\theta\frac{dT}{dD} - \gamma\tau(1-\theta) \right) \left(1-\tau(1-\theta) - \theta(1-\gamma)\frac{dT}{dp} \right) - \left(\begin{array}{l} V \left\{ (1-\gamma)(1-\tau(1-\theta)) - \theta(1-\gamma)\frac{dT}{dp} \right\} + \\ \gamma \{ \theta(T(\cdot) + c) + C(1-\tau(1-\theta)) - \tau(1-\theta)D \} \end{array} \right) \left(-\theta(1-\gamma)\frac{\partial^2 T}{\partial p \partial D} \right)}{\left(1-\tau(1-\theta) - \theta(1-\gamma)\frac{dT}{dp} \right)^2}.
\end{aligned}$$

When $D = 0$,

$$\frac{dp^*}{dD^*} = \frac{(-\gamma\tau(1-\theta)V)(1-\tau(1-\theta))}{(1-\tau(1-\theta))^2} < 0.$$

In addition, $\frac{\partial^2 p}{\partial D \partial \gamma} = \frac{(-\tau(1-\theta)V)(1-\tau(1-\theta))}{(1-\tau(1-\theta))^2} < 0$.

When $D \rightarrow \infty$, then

$$\frac{dp^*}{dD^*} \rightarrow \infty.$$

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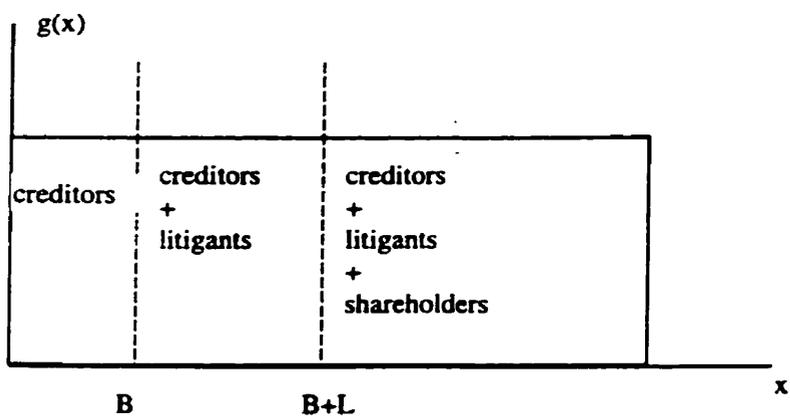


fig2.1: Claims on the assets of the firm

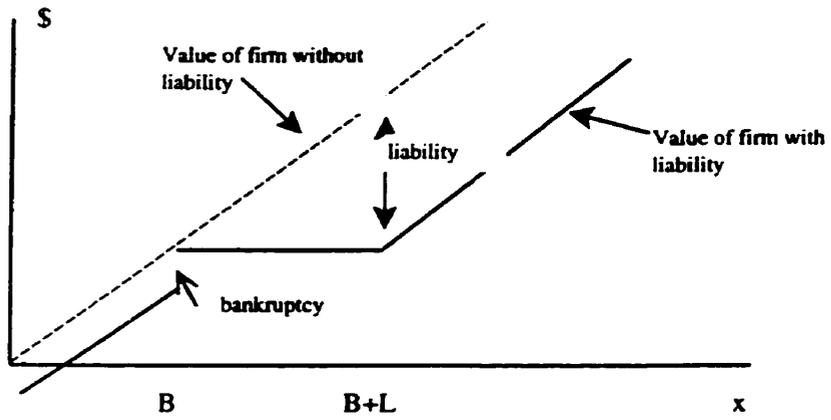


fig 2.2: Value of the firm with and without the liability

Figure 2.3

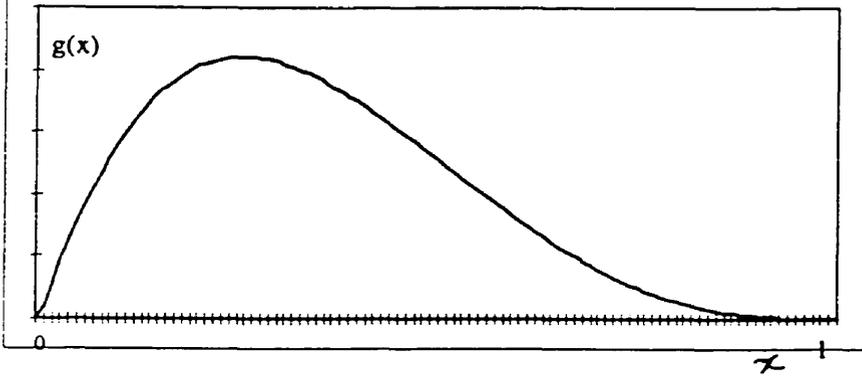
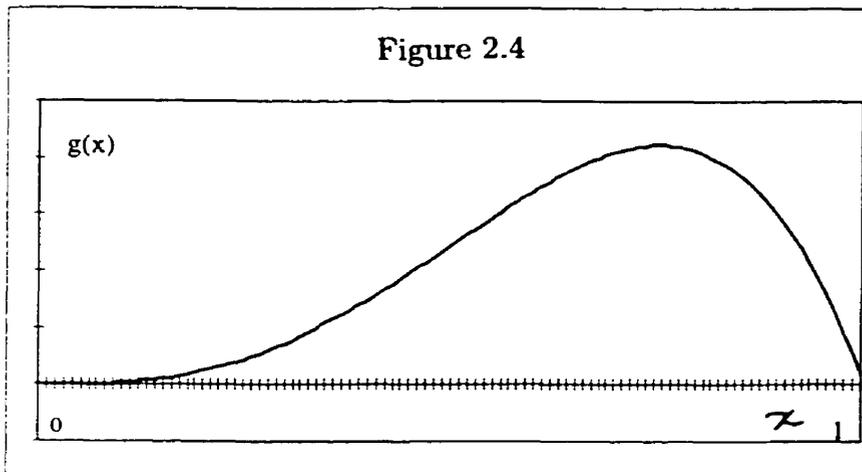


Figure 2.4



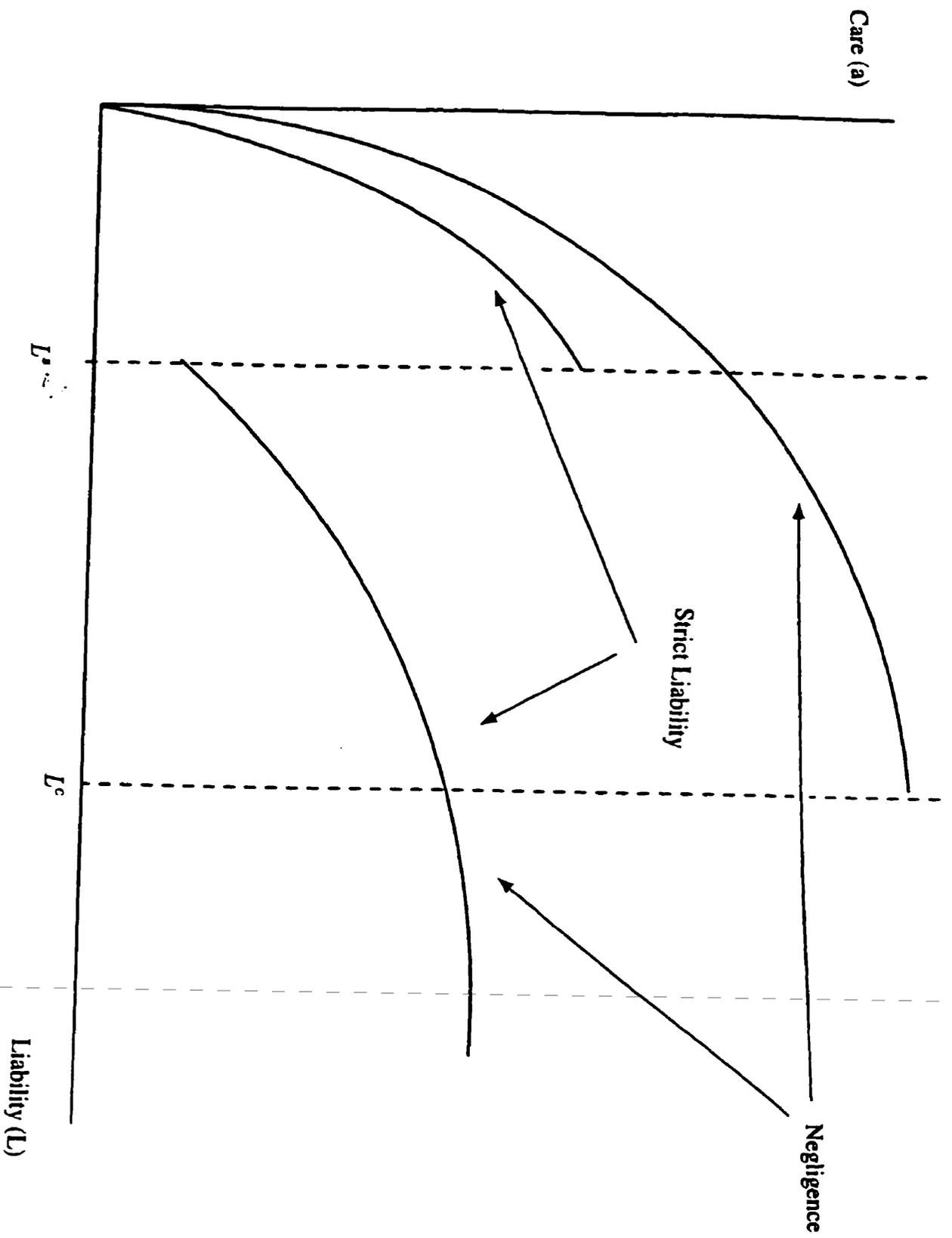


Figure 2.5

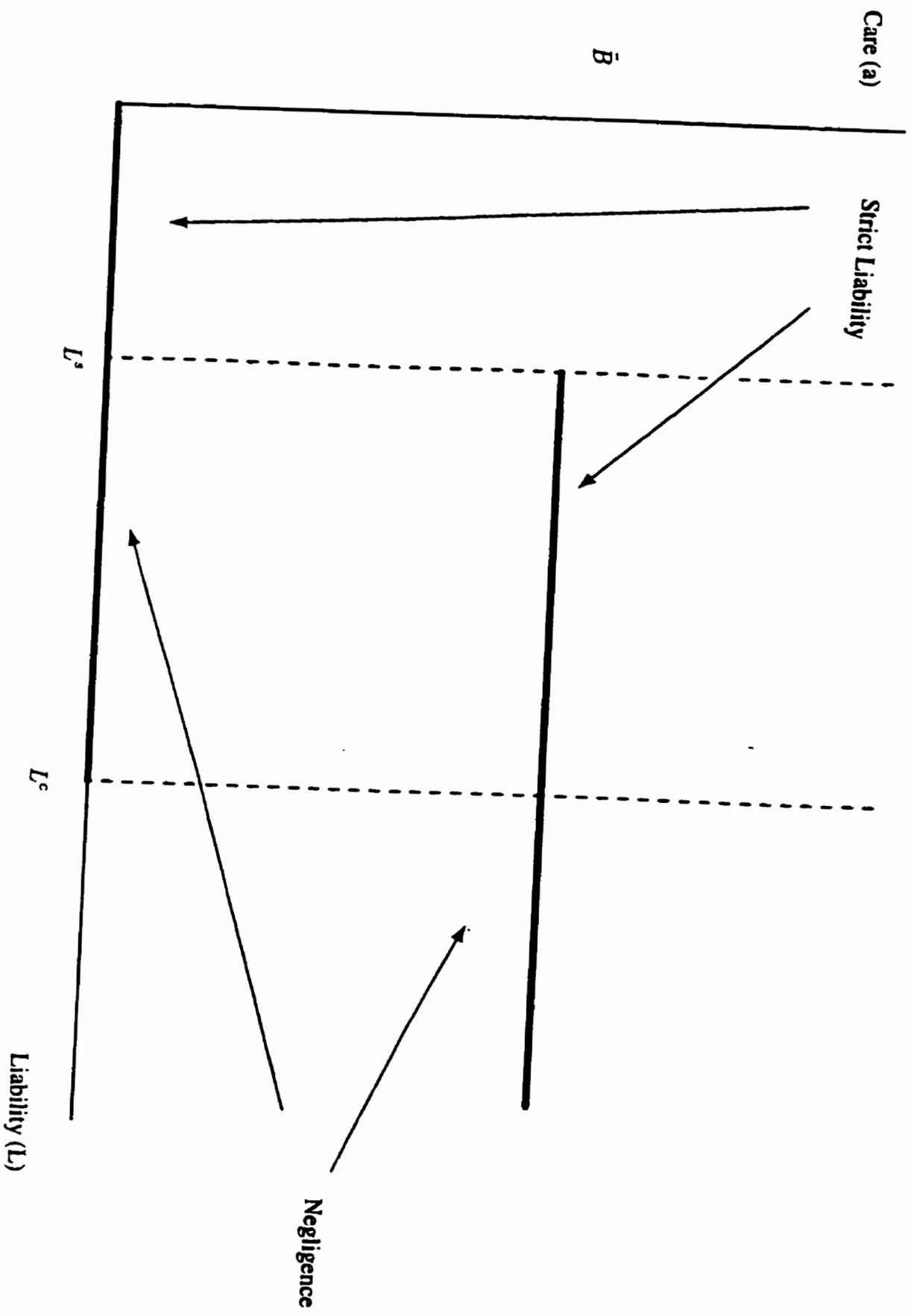


Figure 2.6

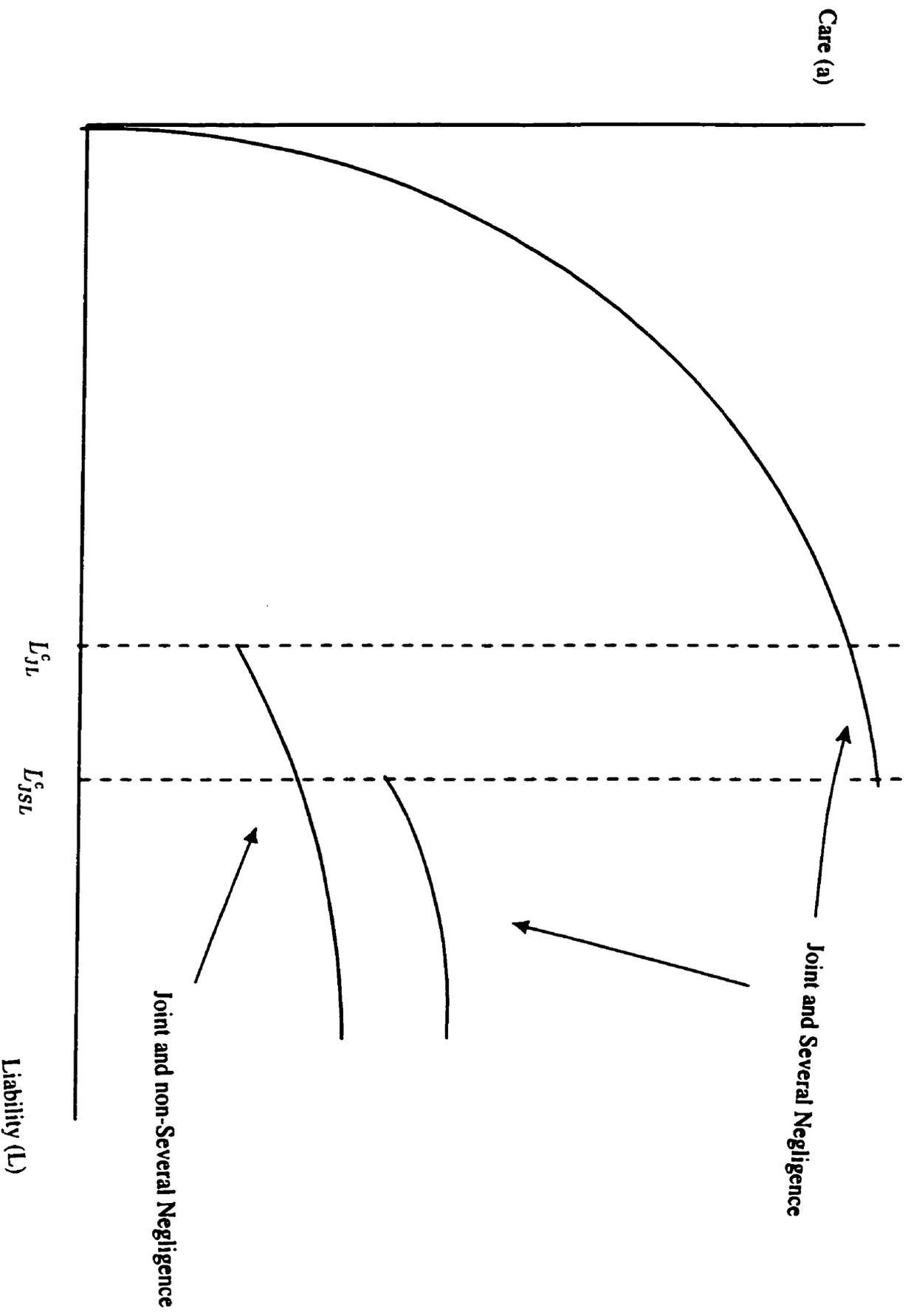


Figure 2.7

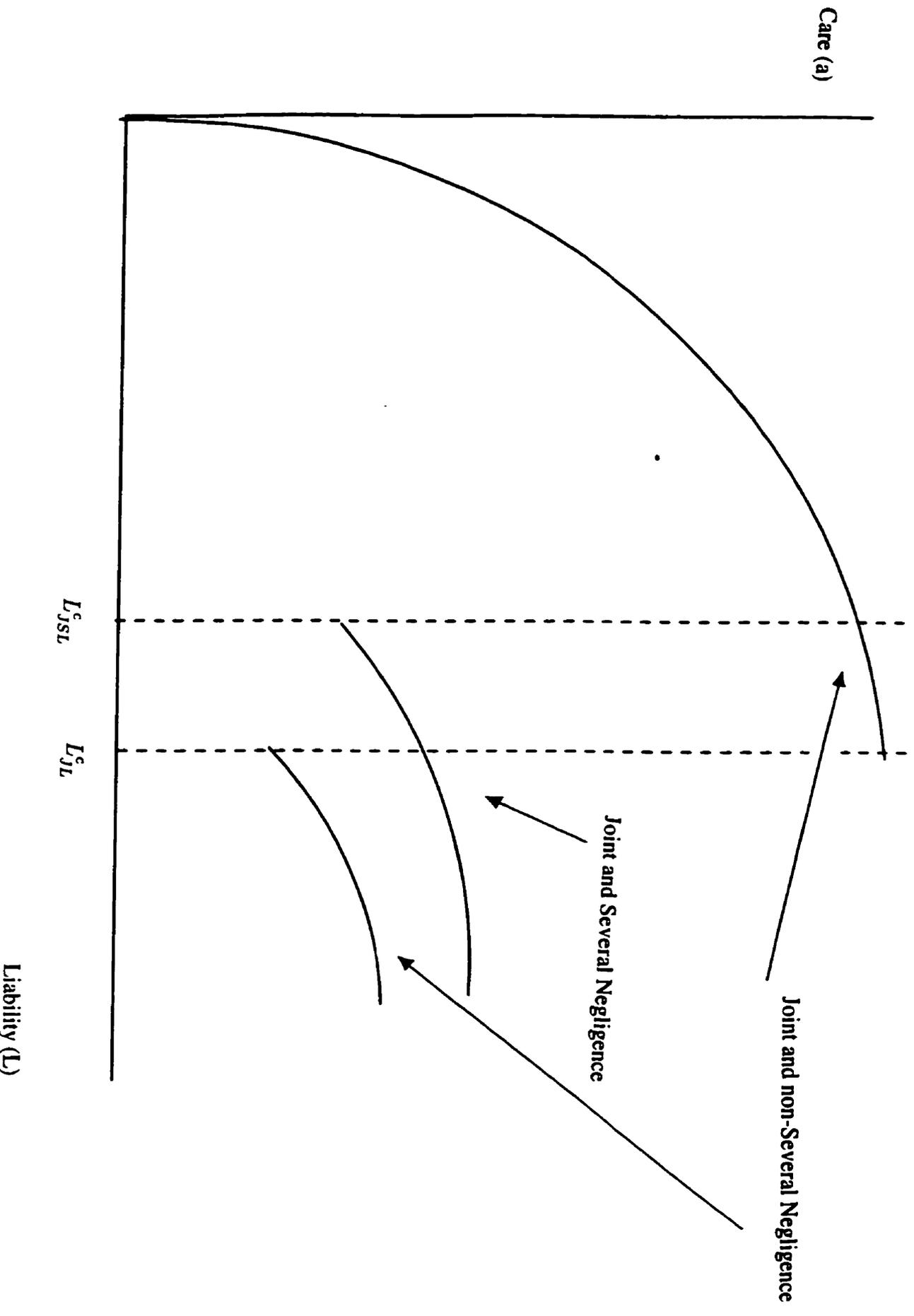


Figure 2.8

Table 3.1: Some Means

Variable	Number	Mean	Std. Dev.	Min.	Max.
EQUITY	1723	1,284,741,494	1,547,302,690	4,935,394	9,505,519,510
DEBT	1715	1,220,766,919	1,498,452,553	5,920,000	8,668,457,351
CAPITAL	1723	2,705,589,230	3,362,108,101	4,541,038	18,755,280,096
EMPLOYEES	1716	3,570	4,068	12	20,326
Output (in MWH)	1723	17,329,220	17,759,199	143,954	91,352,869
SALARY	1714	108,539,906	135,625,929	735,464	956,048,547
STEAM FUEL	1639	217,747,243	240,852,286	-5,442,455	1,819,986,288
NUCLEAR FUEL	820	46,632,582	56,098,511	-32,389	431,476,966
HYDRO FUEL	577	512,678	875,460	-257,833	6,269,331
OTHER FUEL	1462	4,882,805	14,808,655	-1,172,439	288,805,568
TOTAL INCOME TAXES	1722	89,350,003	138,002,476	724,576	1,227,877,910
FED. INCOME TAXES	1708	49,914,115	74,559,359	-132,734,962	850,315,000
OTHER INCOME TAXES	1398	9,742,125	21,368,991	-26,831,999	264,090,000
OPERATING COSTS	1723	1,029,011,184	1,195,488,341	4,495,340	8,550,401,184
NET INTEREST	1723	104,825,931	132,877,518	2,424	798,166,447
REVENUE	1723	1,278,216,881	1,469,267,308	-864,481,814	10,955,219,278
PRICE	1723	6.45	1.89	1.98	15.05
DEBT RATIO (Debt/(Debt+Equity))	1715	0.48	.08	0.13	0.80
Nuclear fuel as % of Total fuel	2,031	0.098	0.203	0.000	1
Steam fuel as % of Total	2,031	0.819	0.292	0.000	1
Hydro fuel as % of Total	2,031	0.043	0.196	0.000	1
Other fuel as % of Total	2,031	0.041	0.144	0.000	1
% of firms using nuclear	2,262	0.387	0.487	0.000	1
% of firms using steam	2,262	0.826	0.379	0.000	1
% of firms using hydro	2,262	0.302	0.459	0.000	1
% of firms using other	2,262	0.691	0.462	0.000	1

Table 3.2a: Dependent variable = Log(Debt/Equity)

Variables	Estimate	t-stat
Log(Capital/Output)	-0.21340	-8.63
Log(Cost/Output)	-0.04583	-4.52
Variance of costs	-0.00000004	-1.63
Growth of state GDP	-3.5717634	-1.26
R ² =0.119236	N=2073	

Table 3.2b: Dependent variable = Log(Debt/Equity)

Variables	Estimate	t-stat
Log(Capital/Output)	-0.029613	-2.71
Log(Hydro/Output)	-0.010573	-4.98
Log(Steam/Output)	-0.006928	-2.87
Log(Nuclear/Output)	0.009508	6.39
Log(Other/Output)	-0.010994	-4.40
Log(Other costs/Output)	-0.199740	-9.19
Variance in costs	-0.000000	-1.07
Growth in state GDP	-4.622591	-1.67
R ² =0.177107	N=2062	

Table 3.2c: Dependent variable = Log(Debt/Equity)

Variables	Estimate	t-stat
Log(Capital/Output)	-0.194317615	-7.62
Log(Cost/Output)	-0.052473387	-5.07
Variance of costs	-0.000000050	-1.59
Growth of state GDP	-3.620334021	-1.21
R ² =0.122201	N=1909	

Table 3.2d: Dependent Variable = Log(Debt/Equity)

Variables	Estimate	t-stat
Log(Hydro/Output)	-0.0094451553	-4.47
Log(Steam/Output)	-0.0079627532	-3.47
Log(Nuclear/Output)	0.0083400018	5.68
Log(Other/Output)	-0.0121200873	-4.85
Log(Other costs/Output)	-0.2099776367	-10.55
Variance in Costs	-0.0000000309	-1.05
R ² = 0.167657	N=2062	

Table 3.2e: Number of significant coefficients for the year by year regressions when Log(Cap./Output) included

Variable	Log (Capital /output)	Log (Hydro/ Output)	Log (Steam/ output)	Log (Nuclear/ Output)	Log (Other/ Output)	Log(Other costs/ Output)	Variance of costs
positive	1			7			
negative	5	1	5		1	8	1

Table 3.2f: Number of significant coefficients for the year by year regressions when Log(Cap./Output) excluded

Variable	Log (Hydro/ Output)	Log (Steam/ output)	Log (Nuclear/ Output)	Log (Other/ Output)	Log(Other costs/ Output)	Variance of costs
positive			6			

negative	1	4		1	11	1
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Table 3.3: Estimates and standard errors of γ by state

1) γ_1

State	Estimate	standard error
AK	1.339282	0.08901
AL	1.157507	0.06253
AZ	1.053027	0.11166
CA	0.635957	0.16869
CO	1.043455	0.03668
CT	0.989550	0.03408
DC	0.999997	4.73317E-006
DE	0.351333	2.64399
FL	0.886488	0.02614
GA	1.002508	0.03838
IA	1.107090	0.03187
ID	1.074470	0.02694
IL	1.117030	0.02602
IN	1.000000	3.33411E-008
KS	0.749080	0.11994
KY	1.053084	0.02549
LA	1.069890	0.04905
MA	1.037975	0.01115
MD	1.118056	0.05173
ME	1.081032	0.0090674
MI	0.943542	0.04503
MN	1.002959	0.01961
MO	1.134866	0.02407
MS	1.065911	0.01215
MT	1.041146	0.02503
NC	0.823179	0.09305
NH	1.103006	0.03385
NJ	1.044087	0.01944
NM	1.076057	0.09506
NV	1.090631	0.04992
NY	1.020479	0.03473
OH	1.220322	0.05218
OK	0.970745	0.08243
OR	0.917036	0.12436
PA	1.046158	0.02126
RI	1.052676	0.02529
SC	1.084436	0.01944
SD	0.926702	0.04612
TN	0.963944	0.03229
TX	1.066634	0.0082938
VA	1.035362	0.01106
VT	1.053689	0.0063853
WA	0.935995	0.10275
WI	1.087109	0.02062

2) γ_2

state	estimate	standard error
AK	1.303466	0.10067
AL	1.161925	0.06154
AZ	1.045463	0.11371
CA	0.678710	0.16210
CO	1.038905	0.03670
CT	0.989159	0.03597
DC	1.000000	1.95312E-007
DE	0.457019	2.84974
FL	0.889600	0.02583
GA	1.035364	0.04073
IA	1.106544	0.03189
ID	1.069632	0.02287
IL	1.118970	0.02612
IN	1.000000	2.04946E-008
KS	0.697635	0.08257
KY	1.057813	0.02503
LA	1.068261	0.04941
MA	1.038276	0.01095
MD	1.076390	0.04763
ME	1.081592	0.0090490
MI	0.948319	0.04539
MN	1.002960	0.01961
MO	1.138360	0.02325
MS	1.066297	0.01213
MT	1.016921	0.02286
NC	0.773583	0.09210
NH	1.102032	0.03368
NJ	1.043472	0.01968
NM	1.075984	0.06716
NV	1.084079	0.04948
NY	1.028575	0.03453
OH	1.219872	0.05233
OK	1.089374	0.06728
OR	0.901027	0.11724
PA	1.046228	0.02128
RI	1.053922	0.02671
SC	1.085583	0.01954
SD	0.956855	0.04282
TN	0.962993	0.03236
TX	1.066786	0.0082820
VA	1.035939	0.01123
VT	1.053597	0.0063380
WA	0.935188	0.10262

3) γ_3

State	Estimate	t-value
AK	0.999994	239,103.17
AL	1	1,240,230.09
AZ	1.545828	8.27
CA	0.37194	3.92
CO	0.952675	8.74
CT	0.999999	1,459,709.78
DC	0.999993	3.57
DE	0.999998	0.82
FL	1.090915	56.94
GA	1.296363	30.85
IA	1	7,452,120.13
ID	0.999995	3.10
IL	1.372973	18.82
IN	1.044849	82.99
KS	0.99193	31.87
KY	1.183232	44.00
LA	1	3,201,167.79
MA	1.011487	141.83
MD	0.99999	7.09
ME	0.973003	39.50
MI	0.917474	24.99
MN	0.977278	50.40
MO	1	69.78
MS	1.113183	6.06
MT	1.437673	15.42
NC	1.168836	62.67
ND	0.566949	0.76
NH	0.965235	11.89
NJ	1.00637	35.13
NM	0.517205	1.89
NV	1.069943	21.45
NY	1.101659	87.99
OH	0.900917	13.11
OK	0.957132	30.81
OR	0.995767	3.48
PA	1.097827	46.19
RI	0.980576	125.28
SC	1.203364	41.90
SD	0.761799	16.94
TN	0.959189	12.23
TX	1.189229	39.71
VA	1.036174	69.08
VT	1.047823	37.79
WA	1.041236	111.55
WI	1.033683	136.61

4) γ_4

State	Estimate	standard error
AK	1.154421	0.0042827
AL	1.106258	0.01424
AZ	1.030412	0.01331
CA	0.608916	0.02040
CO	1.047247	0.0017163
CT	1.067261	0.0033442
DC	1.131220	0.0020193
DE	0.805076	0.05578
FL	0.986735	0.0038596
GA	1.012803	0.0030241
IA	1.104616	0.0046821
ID	1.077651	0.0013224
IL	1.072634	0.0031374
IN	1.065822	0.0032156
KS	0.923828	0.01823
KY	1.072807	0.0023691
LA	1.039281	0.0072230
MA	1.033484	0.0026663
MD	1.029602	0.0057649
ME	1.046045	0.0010798
MI	0.933817	0.0072470
MN	1.003554	0.0015815
MO	1.134876	0.0050728
MS	1.069722	0.0013780
MT	1.040003	0.0015064
NC	0.805878	0.01445
NH	1.100494	0.0029567
NJ	1.044599	0.0026638
NM	1.059749	0.0071599
NV	1.099823	0.0047017
NY	0.982426	0.0055325
OH	1.138337	0.0086164
OK	0.935223	0.0046166
OR	0.669978	0.01574
PA	1.035708	0.0054066
RI	1.004601	0.0021563
SC	1.059941	0.0019291
SD	0.923203	0.0038919
TN	0.952157	0.0029914
TX	1.043134	0.0017595
VA	1.035087	0.0014998
VT	0.976853	0.0018161
WA	1.038968	0.0085270
WI	1.103622	0.0048200

5) γ_5

AK	1.286459	0.10383
AL	1.302745	0.05574
AZ	1.016827	0.10773
CA	0.661245	0.16064
CO	1.024663	0.04481
CT	1.053962	0.04859
DC	1.092513	0.08416
DE	1.158903	2.17510
FL	1.105810	0.03098
ID	1.073392	0.02475
IL	1.057380	0.04516
IN	1.148681	0.03736
KS	0.682093	0.08321
KY	1.060015	0.01775
LA	1.050833	0.04667
MA	1.029700	0.01138
MD	1.034467	0.03609
ME	1.081990	0.0096288
MI	0.954219	0.04596
MN	1.070317	0.04342
MO	1.142981	0.02280
MS	1.064579	0.01441
MT	1.015796	0.01233
NC	0.869099	0.09132
NH	1.101284	0.03617
NJ	1.052620	0.02249
NM	1.046124	0.06997
NV	1.083727	0.05856
NY	1.028702	0.03394
OH	1.224952	0.04548
OK	1.014349	0.04381
OR	0.766021	0.08794
PA	1.040775	0.02114
RI	1.067349	0.02263
SC	1.082109	0.01682
SD	0.939946	0.06081
TN	0.926788	0.07006
TX	1.061786	0.0076005
VA	1.031555	0.01048
VT	1.050882	0.0068081
WA	0.960676	0.09375
WI	1.080038	0.02034

Table 3.4: Average Market to Book Ratios by state

AZ	0.85780
CA	1.406515
CO	1.378588
CT	1.424911
DC	1.489183
DE	1.433797
FL	1.710789
HA	1.408335
IA	1.223798
ID	1.439749
IL	1.096687
IN	1.4087
KS	1.238515
KY	1.470668
LA	1.421079
MA	1.138737
MD	1.253445
ME	0.960893
MI	1.2001
MN	1.775178
MO	1.381161
MT	1.262883
NC	1.623262
ND	1.494359
NH	1.329607
NJ	1.261752
NM	0.835623
NV	1.259839
NY	1.097013
OH	1.206663
OK	1.512693
OR	1.2707
PA	1.228105
SD	1.789803
TX	1.020931
VA	0.924381
VT	1.309058
WA	1.181294
WI	1.627377

Table 3.5a: Results of Correlations by States :

Measure of γ	Correlation	p-value
γ_1	-0.09272	0.0001
γ_2	-0.08193	0.0002
γ_3	-0.4235	0.0001
γ_4	-0.05072	0.0196

Table 3.5b: Results of Correlations by Firms:

Measure of γ	Correlation	p-value
γ_1	-0.09016	0.0001
γ_2	-0.07966	0.0003
γ_3	-0.42522	0.0001
γ_4	-0.04905	0.0242

Table 3.6: Incentive Regulations by State

Incentive Regulation	State
Demand-Side Management Incentives	AZ, CT, CA, CO, FL, HA, IA, IL, IN, KS, MA, ME, MD, MI, MN, MT, NC, ND, NH, NJ, NY, NV, OH, OR, PA, RI, TX, WA, VT
Generating Performance Incentives	AK, CA, CT, DE, FL, GA, LA, MD, MA, MI, NJ, NM, NY, NC, OH, PA, TX, VA
Fuel Cost Incentives	CA, KY, NY, NC, ND, OH, WA; AL, DE, DC, ME, MD, MI, NH, SC, VA
Corporate Performance Incentives	MI, IN, NY, CA

Table 3.7: Results of Probit of the Incentive regulations on γ (Constant omitted from table):

Results for γ_1

Incentive Regulation	Estimate	p-value
GP	-1.42788866	0.0001
FC	-1.26677575	0.0001
DSM	-1.82988807	0.0001
CP	-3.40780609	0.0001

Results for γ_3

Incentive Regulation	Estimate	p-value
GP	-0.92855634	0.0001
FC	-2.13725015	0.0001
DSM	0.2051033	0.2597
CP	-2.2121902	0.0001

Table 3.8: Levels of Reform

5	AZ
5	CA
5	CT
5	DE
5	IL
5	ME
5	MA
5	MT
5	NV
5	NH
5	NJ
5	NM
5	OK
5	PA
5	RI
5	VA
4	MD
4	MI
4	NY
4	VT
3	AK
3	OH
3	SC
3	TX
2	AL
2	CO
2	DC
2	GA
2	HA
2	ID
2	IN
2	IA
2	KS
2	KY
2	LA
2	MN
2	MS
2	MO
2	NC
2	ND
2	OR
2	TN
2	UT
2	WA
2	WV
2	WI
2	WY
1	FL
1	SD

Table 3.9: Results of ordered Probit with the deregulation dummy as dependant variable (Constant omitted):

Variable	Estimate	p-value
γ	1.1093114	0.0001
Total revenue/state GDP	6.1355E-006	0.0001
state GDP	1.5002E-006	0.0001
debt/equity	0.535756	0.0222
Nuclear fuel/Total fuel	-0.00614307	0.1166
Steam fuel/Total fuel	0.0059635	0.3823
Hydro fuel/Total fuel	-0.00203536	0.7182
Other fuel/Total fuel	-0.01495849	0.0207
Log(Capital/output)	-0.0182826	0.5428
Log(Other costs/output)	0.1933402	0.0531
Log(price)	-0.06496108	0.6010

Table 3.10: Correlation between γ and (transmission expenditures)/(state GDP)

Correlation	p-value
-0.2487	0.0001

Table 3.11: Characteristics of State Commissioners

State	Number of commissioners	Term of office	Level of Election
AZ	3	6	3
AK	3	6	2
AL	3	4	3
CA	5	6	2
CO	3	6	2
CT	5	4	2
DC	3	4	2
DE	5	5	2
FL	5	4	2
GA	5	6	3
HA	3	6	2
IA	3	6	2
ID	3	6	2
IL	7	5	2
IN	5	4	2
KS	3	4	2
KY	3	4	2
LA	5	6	3
MA	3	4	1
MD	5	5	2
ME	3	6	2
MI	3	6	2
MN	5	6	2
MO	5	6	2
MS	3	4	3
MT	5	4	3
NC	7	8	2
ND	3	6	3
NH	3	6	1
NJ	3	6	2
NM	3	6	2
NV	5	4	1
NY	6	6	2
OH	5	5	2
OK	3	6	3
OR	3	4	2

Table 3.12: Results of Regression of γ

Variable	Estimate	t-value
Number	-0.001027426	-0.52
Term	0.004708491	2.77
E=1	1.052763982	89.03
E=2	1.027639474	82.94
E=3	1.029527785	79.08
GNP	-0.000000104	-7.00
R ² =0.030568	N=44	

Table 3.13 States by Electricity Reliability Councils

Reliability Council	State
Western Systems Coordinating Council	WA, OR, ID, MT, WY, CA, NV, AZ, NM, CO, UT
Mid-Continent Area Power Pool	ND, SD, NE, IA, MN
Southwest Power Pool	OK, KS, MO, AR, LA
Electric Reliability Council of Texas	TX
Mid-American Interpol Network	WI, IL
East Central Area Coordination Agreement	KY, IN, MI, OH, WV
Mid-Atlantic Area Council	PA, DC, MD, DE, NJ
Northeast power coordinating Council	NY, CT, RI, MA, ME, VT, NH
Southeastern Electric Reliability Council	FL, GA, AL, MS, NC, SC, VA, TN