ARE FLORIDA PHYSICIANS SUBSTITUTING BANKRUPTCY PROTECTION FOR PRIVATE MALPRACTICE INSURANCE?

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The members of the Committee appointed to examine the thesis of NICHOLAS GEOFFREY CRAIN find it satisfactory and recommend that it be accepted.

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Chair

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Abstract

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This paper proposes a model to explain the incentives which motivate a significant number of Florida physicians to practice medicine without malpractice insurance. The model demonstrates that, through the discharge of tort related debt, bankruptcy can serve as a form of insurance for physicians. Bankruptcy provides an upper boundary for the actual payment made on malpractice claims. The bankruptcy boundary reduces the expectation of loss in a given period because claims above the bankruptcy threshold are partially discharged. The premium rates on insurance include the full value of these claims, thus the expected loss increases with the purchase of insurance. Using a state contingent insurance model, the paper demonstrates that the decrease in expected claim value from forgoing insurance will motivate physicians to underinsure or practice "bare".

An empirical analysis of data available on Florida malpractice claims does not show significant results to support the hypothesis that expected claim value is reduced by

practicing uninsured. However, examination of the distribution of claims by specialty suggests that physicians who specialize in fields where very high value claims are more likely have greater incentives to practice uninsured. This is consistent with the notion that they are practicing uninsured so that bankruptcy will serve as an upper boundary to their loss.

The paper further suggests that the use of bankruptcy as a substitute for private malpractice insurance by some physicians can improve efficiency. Others have argued that the medical liability system is an inefficient method of insuring patients against iatrogenic injury. The bankruptcy result allows patients and physicians to contract around the potentially inefficient liability standards. This should improve efficiency, so long as patients are well informed.

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CHAPTER 1

INTRODUCTION

There is increasing anecdotal evidence in the popular press and in medical trade journals that physicians are opting to practice without medical malpractice insurance. This trend is particularly evident in the state of Florida. The percentage of uninsured physicians in Florida ranges from 1% to over 30% depending on the medical specialty. The incentives which are motivating these physicians to forgo insurance are not well understood. Often the high cost of insurance premiums is cited as the reason physicians forgo insurance. However, if insurance premiums are actuarially fair, the high premiums reflect the substantial risk of loss. Physicians who decided to forgo insurance would seem to be taking an extremely high risk. Traditional insurance models would suggest that a risk averse physician facing high risks would fully insure.

This paper proposes that physicians in Florida who forgo medical malpractice insurance are doing so because the expected value of loss in a given time period is reduced by forgoing insurance. The difference in expected loss occurs because malpractice claims which exceed the assets held by an uninsured physician can be disposed of in bankruptcy. As it functions to limit the risk of a very large claim, bankruptcy can be thought of as a substitute for private malpractice insurance.

CHAPTER 2

LITERATURE REVIEW

The medical malpractice "crisis" periods observed in the mid-1970s, mid-1980s and early-2000s, encouraged a significant amount of research attempting to explain the phenomena involved in the medical malpractice insurance market. Most of the literature relevant to the insurance choice of physicians can be divided into three broad categories:

1. Analysis of large rate increases during the "crisis" periods.
2. Analysis of tort processes and claim resolution.
3. Analysis of the economic efficiency of the malpractice system.

Much of this work has significant implications for the incentives of physicians to seek insurance, and the likely social and economic outcomes resulting from high numbers of uninsured physicians. There has been little work specifically examining the incentives for physicians to practice without insurance. Largely this literature is confined

to general theories on insurance and risk-averse behavior, and medical industry articles offering anecdotal evidence of increasing number of bare physicians.

There has also been significant amount of research done by both economists and law scholars relating to the function of bankruptcy as a form of insurance. This work is primarily concerned with the structure of optimal bankruptcy policy and the relationship of bankruptcy with forms of social insurance. Many of the concepts developed in this research are applicable to medical malpractice bankruptcy, which, as this paper proposes, may serve as a substitute for private malpractice insurance.

Analysis of Rate Increases

The debate over malpractice premium increases is one of the principal concerns of physician organizations and one of the main issues in the national discussion of medical malpractice. Often the debate centers on whether the premium increases represent some form of market failure, such as lack of competition or adverse selection. The debate about market failure is important because some legal scholars have proposed that allowing the use of bankruptcy as insurance is a justifiable policy when private insurance markets fail (Feibelman 2005). The literature on rate increases is also important because it provides evidence that the premiums offered to physicians are close to actuarially fair. This contradicts the notion in many of the trade and popular press articles which suggest that physicians are forgoing insurance because the premiums are too high.

Malpractice insurance premiums follow a pattern of rising very quickly, sometimes greater the 60% per year, following periods of remaining relatively constant (Danzon, Epstein and Johnson 2004). This pattern is frustrating for physicians who are limited in their ability to rapidly pass on the increased cost of insurance to patients. There are many theories which attempt to explain why rates follow this pattern. One widely cited reason is the desire of insurance companies to make up for investment income lost during times of poor financial performance (Page 2002). In the book *Medical Malpractice*, Danzon (1983) evaluates most of the competing theories regarding rate increases as they apply to the 1970s and 1980s crises. She demonstrates that steady increases in claim frequency and severity directly contributed to the need for insurers to raise premiums. The increase in claim severity and frequency are both attributed to large changes in social attitudes toward litigation and pro-plaintiff changes in tort law. The collective bargaining of group medical associations preserves competition in the malpractice insurance market preventing underwriters from "making up" for investment losses. She also finds that during the 1970's, premiums prior to the "crisis" were often written at a premium to loss ratio less than 1.00. This suggests that premium rates prior to the increase were actually more favorable to the physician than actuarially fair insurance.

The Chandra, Nundy and Seabury (2005) study of the National Practitioner Data Bank is focused on trends in malpractice claim payments rather than insurance premiums. While the data of claim severity is skewed toward a small number of high

value claims, they dispel the widely held belief that the growth in payments is largely associated with these high value claims. In fact, the mean payment grew faster then the mean of the top 10 payments from 1991 to 2003. They also find that the growth in payments is consistent with the overall growth in national health care spending. The implication is that the increase in malpractice claim payments since 1993 reflects the cost of fixing the injuries caused by negligence rather then social or legal trends. While this may conflict with the analysis by Prof. Danzon, it reinforces the notion that there is no market failure in the medical malpractice market.

This literature is evidence that the premiums set by insurance companies are neither actuarially unfair, nor do they involve exorbitant loads. In Florida where uninsured physicians are far more prevalent then in any other state, premium-to-loss ratios are the 13th most favorable to physicians in the nation. Policies continue to often be written at a premium-to-loss ratio which is nearly actuarially fair for physicians (Florida Office of Insurance Regulation 2005). The level of premiums and the rate of premium increase are insufficient to explain the large number of uninsured physicians. This supports the notion that another mechanism such as bankruptcy is acting as a substitute for private malpractice insurance.

Analysis of Tort Process and Claim Resolution

Most state legislatures have debated or enacted different tort reforms to cope with the medical malpractice "crisis." One of the most popular measures of tort reforms

is a cap on non-pecuniary losses (Studdert, Mello and Brennan 2004). The effectiveness of these caps is a subject of debate, but the majority of studies on tort reform demonstrate that caps do effectively limit medical malpractice payments (Studdert, Mellow and Brennan 2004). The literature regarding tort reform caps is important because it follows the same logic as this paper regarding claim limits. The two most important findings are that as limits are placed on jury outcomes, settlement amounts are reduced and the frequency of claims decline.

If caps are effective at limiting jury verdicts, it is important that they function to limit settlement amounts as well. One unique aspect of the medical malpractice system is the method in which claims are resolved. Across states the majority of paid claims are settled out of court, yet most jury verdicts are in favor of the plaintiff. 96% of claims against insured physicians were settled out of court between 1993 and 2001 (Chandra, Nundy and Seabury 2005). Seig (2000) uses a bargaining model to explain most of the data observed in medical malpractice settlement and jury award data from insured physicians in Florida. Using this model to simulate the effect of capping jury awards, he concludes that a cap on jury awards would result in a significant reduction in settlement payments and a slight reduction in frequency of claims. This finding might be expanded to support the notion that if bankruptcy acts as a limit to the physician's losses from a jury verdict, there will be a corresponding reduction to the expected value of settling out of court.

There is further evidence that limits on the expected value of claims reduces frequency of claims. Farber and White (1991) find that plaintiff's lawyers play a large part in screening potential malpractice claims. Plaintiff's lawyers accept cases based on the expected value of the contingency fee. The attorney should only accept those cases where the expected value of the claim is larger then the costs of pursuing the case, which are significant. Faber and White's model would suggest that there might be an additional incentive to forgo insurance – a reduction in claim frequency as a result of reducing the incentive for plaintiff's lawyers to pursue claims with a low probability of success, but high severity. This paper will not consider the reduction in claim frequency that may occur from practicing without insurance. Including the possible reduction in claim frequency in the proposed model would significantly complicate the analysis. Intuitively the reduction in frequency should serve as a similar incentive to the reduced expected claim value included in the model. Faber and White (1991) also found that their sample of settlement amounts was highly skewed toward the higher settlements. The model developed in this paper will demonstrate that bankruptcy can function to limit this relatively small number of high value claims which have a significant effect on expected claim value.

Uninsured Physicians

There has been little academic study devoted to the increase in physicians practicing medicine without insurance. The analysis of a growing trend is largely

confined to the popular press and medical trade journals (Tort Crisis Gamble 2004; Glabman 2003; Keaveney 2004; Silberman 2004). These articles attribute the growth in uninsured physicians to escalating premiums and a perception among physicians and attorneys that uninsured physicians are less likely to get sued.

The presence of high premiums alone is insufficient to explain the growth in the number uninsured physicians. The model of risk and insurance suggested by Arrow (1971) and summarized by Binger and Hoffman (1998) suggests that, if the insurance is close to being actuarially fair, a risk averse individual is unlikely to forgo insurance. Premiums which are simply too high, but at a near unitary premium-to-loss ratio, must reflect the risk associated with practicing medicine. The physician would be expected to exit the medical business rather then participate while uninsured.

This analysis of risk averse individuals assumes that the physician who does not purchase malpractice insurance fully confronts the risk of a claim. However, missing from this analysis is the concept of bankruptcy. If the claim is sufficiently high, the physician might be able to transfer some of the risk to the injured patient in the form of debt discharged in bankruptcy. The unique, high rates of uninsured physicians in Florida can perhaps be explained by considering the attractiveness of bankruptcy as an alternative form of insurance.

Bankruptcy a Substitute for Insurance

It is common for bankruptcy to be viewed by scholars as a form of social insurance against adverse events such as unemployment or extreme medical costs (Fiebelman 2005). The rational for this treatment of bankruptcy nearly always includes the notion that debtors pay for this "insurance" in the form of higher interest payments associated with unsecured debt (Hynes 2004). This body of work acknowledges that no such payment for the transfer of risk exists when debts are generated by torts, such as medical malpractice judgments. Intentional torts, those arising from willful and malicious conduct, are specifically prohibited from being discharged in bankruptcy (Brown 2001). To strengthen this concept laws have been proposed to prevent the discharge of debt resulting specifically from securities fraud torts. Otherwise, debts resulting from torts get little attention, as it is likely this type of debt in relevant to only a small portion of bankruptcy proceedings. In *Kawaauhua v. Gieger* the Supreme Court unanimously ruled that cases of medical malpractice, where no malicious act was involved, are dischargeable in bankruptcy (Brown 2001). This allows uninsured physicians to use bankruptcy as an alternative form of malpractice insurance.

Despite the costs involved, bankruptcy is particularly attractive to individuals who have significant exempt assets and a prospect of high future income (Fiebleman 2005). The malpractice insurance market in Florida represents a unique case for considering the use of bankruptcy as a substitute for insurance because Florida physicians meet both of the conditions outlined above. Florida is one of the most generous states in

providing asset exemptions during bankruptcy. It is one of seven states which include a homestead exemption, allowing debtors to exempt from seizure any equity in their home (Hynes 2004). In addition, physician malpractice claims are common enough that one or more valid claims do little to harm the prospect of a high future income.

The bankruptcy reform laws which went into effect in 2005 may reduce, but not eliminate, this incentive by preventing many physicians from filing for Chapter 7 bankruptcy. One of the principal reforms includes a means test by which debtors who earn above the median income must file for Chapter 13 versus Chapter 7 bankruptcy (DeLaurell and Rouse 2006). Chapter 7 bankruptcies protect all future income, essentially offering the debtor a fresh start and discharging most of the prior debt. Chapter 13 bankruptcies require the debtor to set up a court approved payment plan which pays off some debt over a three to five year period (Hynes 2004). By preventing many physicians from filing for Ch 7 bankruptcy the 2005 bankruptcy reform may somewhat reduce the amount of debt which can be discharged in bankruptcy. Chapter 13 bankruptcies favor the payment of secured debtors (medical malpractice torts are unsecured) and still results in significant amounts of discharged debt (Hynes 2004). The higher costs to the plaintiff of attempting to collect on debt in Chapter 13 bankruptcy may also serve as a credible threat, reducing the settlement demand of plaintiffs following the bargaining models discussed previously (Seig 2000). Although the ability to use bankruptcy to shield future income from tort related debt may be reduced by bankruptcy

reform, the model proposed in this paper will still be valid under the new bankruptcy laws

If the relevant data becomes available future research might exploit this change in bankruptcy law in analysis of time series data. It may be useful to examine the change in rates of uninsured physicians due to an exogenous change in the attractiveness of bankruptcy as an alternative form of insurance. As the change in law is relatively recent, that empirical analysis is beyond the scope of this paper.

Economic Efficiency of the Malpractice System.

The medical malpractice liability system is often criticized as an inefficient system for insuring the patient against iatrogenic injury. The operation of uninsured physicians, while not the optimal medical care contract, may increase efficiency given the current liability rules of the malpractice system.

The cost of the liability claim process is very high compared to a direct accident insurance (Shapiro 1991) or a no-fault system such as worker's compensation (Danzon 1983). Kesseler and McClellan (1996) provide evidence that liability rules result in defensive medicine and increased expenditures on medical care, with no benefit to the patient. Uninsured physicians face perhaps more incentives to practice defensive medicine, because they are not insured against the cost of bad outcomes. If there is an increase in defensive medicine it must be weighed against the added incentive to avoid negligence.

The value of the current liability system lies in the incentive it gives physicians to prevent negligence. However, this incentive is diminished by protection provided by the liability insurance system (Danzon 1983). Although this paper argues that through bankruptcy the uninsured physician faces a lower expected claim value, this does not necessarily reduce the incentive to provide quality care. The incentive to offer good care is likely higher for the uninsured physician. Insured physicians are subject to moral hazard immediately as their insurance coverage covers them against all claims up to a certain limit. As will be demonstrated in the model, uninsured physicians are insured only after the value of the claim exceeds a reasonable high bankruptcy threshold. Uninsured physician thus ought to have a marginal incentive to provide good care.

Shapiro (1991) suggests that the liability system is also inefficient, forcing patients to accept over-insurance. The liability and tort rules allow for full compensation. This provides complete insurance to the patient as far as the system is accurate in adjudicating liability. The cost of this complete insurance is passed on through physician's fees. A patient who might not purchase complete insurance under a first party insurance scheme is forced to do so under a liability scheme.

CHAPTER 3

THEORETICAL MODEL

The Effect of Bankruptcy and Insurance on Expected Value of a Claim

The following model describes how, in a given time period, the purchase of private malpractice insurance can raise the expectation of loss from malpractice. This result will later be incorporated into a state-contingent model of the insurance decision to demonstrate why the optimal choice for a physician will be to underinsure, or operate without insurance.

The ability to have claims discharged in Chapter 7 or Chapter 13 bankruptcy is the key motivating mechanism in the relationship between insurance coverage and expected loss. When claims are high enough to place a physician into bankruptcy, the amount of the claim in excess of the physician's assets is likely to be discharged by the bankruptcy court. In the event of a jury verdict, the actual amount paid by the physician is likely to be less than the verdict. In the event of a settlement, the parties will both have incentives to settle below this bankruptcy threshold. In this way bankruptcy acts as an upper bound to the value of a claim against an uninsured physician.

Consider the effect of bankruptcy on the distribution of potential claims faced by insured physicians. The inherent value of each positive claim is an exogenous random variable (c). Figure 3.1 depicts the distribution of claims (with a payment > $0) for which the final disposition was recorded between July1, 2004, and September 30, 2006.

A Weibull distribution is fit over the observations. Figure 3.2 lists the characteristics of the distribution fit.

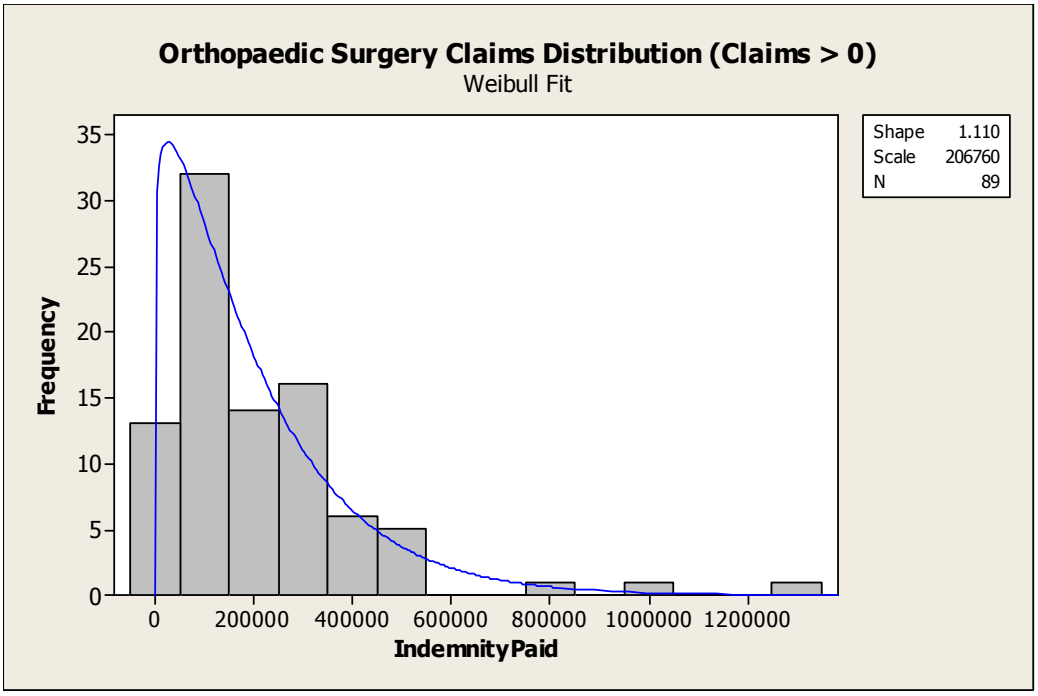

Figure 3. 1: Histogram of Claims in Orthopedic Surgery (0$ Claims Excluded)

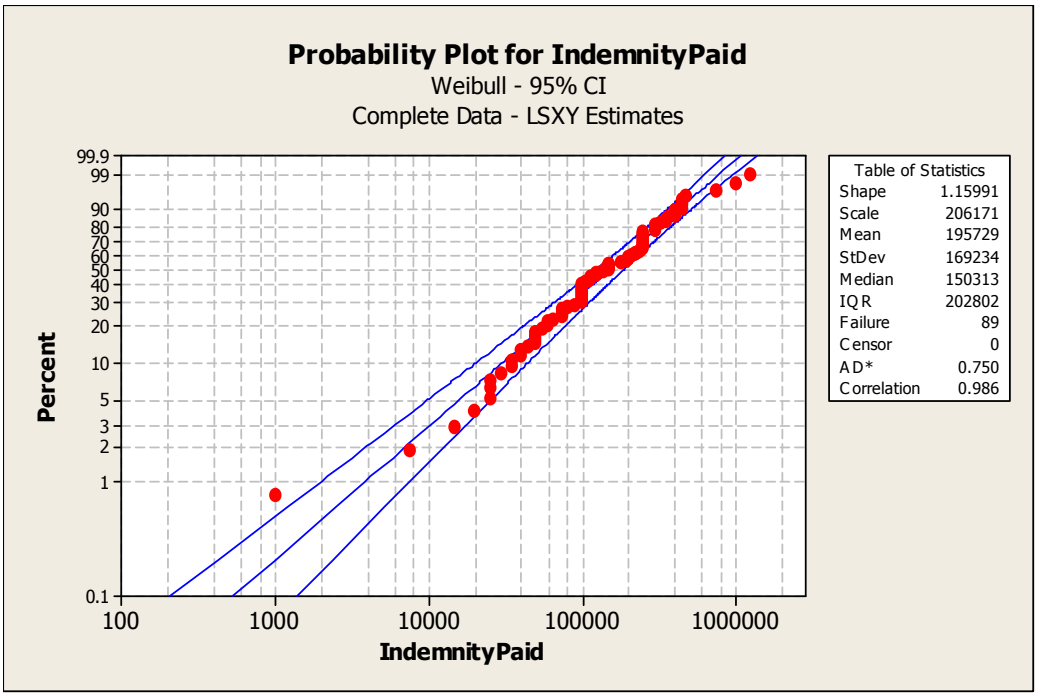

Figure 3.2: Probability Plot of Weibull Distribution fit to Orthopedic Surgery Claims

Assume that when a physician is fully insured, all claims will be paid in full. Figure 3.3 shows the Weibull distribution estimated above for orthopedic surgeons. The expected value of a valid claim to a physician holding insurance with no coverage limit is given in Equation (3.1) by the familiar form for expected value.

$$E\left[c_{\text{fully insured}}\right] = \int_0^\infty c \cdot P_C(c) \cdot dc \tag{3.1}$$

The continuous random variable (c) is distributed over the probability mass function $P_c(c)$.

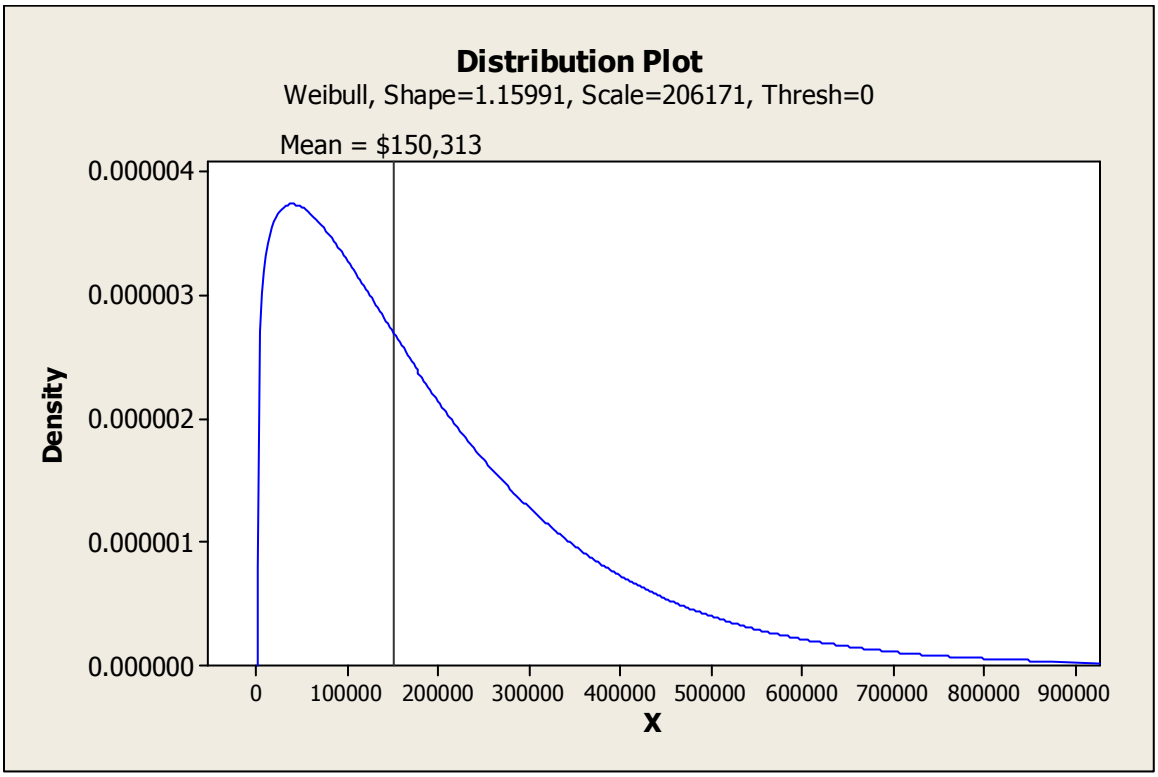

Figure 3.3: Estimate Distribution of Claims Against Orthopedic Surgeons

Physicians who do not carry insurance face a different distribution of claims because they are able to discharge some debt in bankruptcy. Let C_{max} be the sum of a physician's assets, minus the liabilities the physician owes creditors other than the plaintiff. In the event of a jury verdict or settlement larger than C_{max}, a physician will declare bankruptcy. The amount of the claim above C_{max} is discharged by the bankruptcy court, limiting the damage to the physician to C_{max}. Figure 3.4 depicts the Weibull distribution estimated for orthopedic surgeons with an upper bound, C_{max}. In the event of a claim with a value over C_{max}, the actual payment would be limited to C_{max} with the remaining debt being discharged. The expected value for claims with an upper bound created by bankruptcy is given in Equation (3.2).

$$(3.2) \qquad E[c_{\text{uninsured}}] = \int_0^{C_{\max}} c \cdot P_C(c) \cdot dc + C_{\max} \cdot \int_{C_{\max}}^{\infty} P_C(c) \cdot dc$$

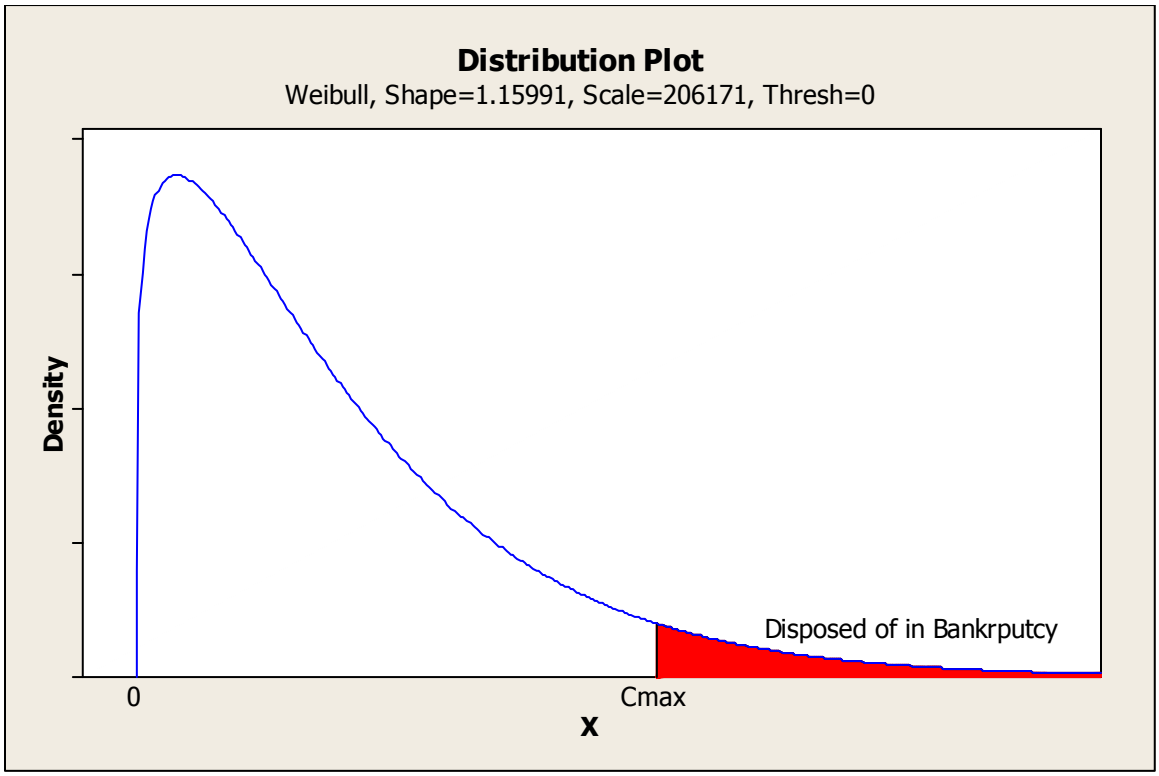

Figure 3.4: Distribution of Claims Limited by Bankruptcy

Subtracting Equation (3.2) from Equation (3.1) gives:

$$(3.3) \qquad E[c_{\text{fully insured}}] - E[c_{\text{uninsured}}] = \int_0^{\infty} c \cdot P_C(c) \cdot dc - \left[\int_0^{C_{\max}} c \cdot P_C(c) \cdot dc + C_{\max} \cdot \int_{C_{\max}}^{\infty} P_C(c) \cdot dc \right]$$

The increase in expected value of a claim resulting from the decision to purchase full insurance is given by Equation (3.4).

$$(3.4) \qquad E\left[c_{\text{fully insured}}\right] - E\left[c_{\text{uninsured}}\right] = \int_{C_{\max}}^{\infty} [c - C_{\max}] P_C(c) \cdot dc$$

In Equation (3.4) it is evident that as C_{max} increases the bounds of integration shrinks as does the value of the term [c-C_{max}]. This is consistent with the intuition that a physician with more wealth is less capable of using bankruptcy to reduce the value of claims. It is also evident from Equation (3.4) that as the amount of the claim distribution that falls above C_{max} increases, the reduction in expected claim value will also increase. This would suggest that, all other things being equal, a physician in a specialty with a higher risk of large claims has more to gain from forgoing insurance.

This comparison between fully insured and uninsured physicians doesn't reflect the coverage limits typically included in physician malpractice policies. Physicians holding limited coverage policies also face higher expected claim values than uninsured physicians. In coverage limited policies the insurance company will pay the claim up to the coverage limit. The remaining portion of the claim is the responsibility of the physician. In this model the coverage limit is purchased by the physician prior to the relevant time period. It is depicted by a parameter I_{limit}. The purchase of a limited coverage insurance policy shifts the bankruptcy level outward from C_{max} to C_{max} + I_{limit}. The shift in bankruptcy limit is depicted in Figure 3.5.

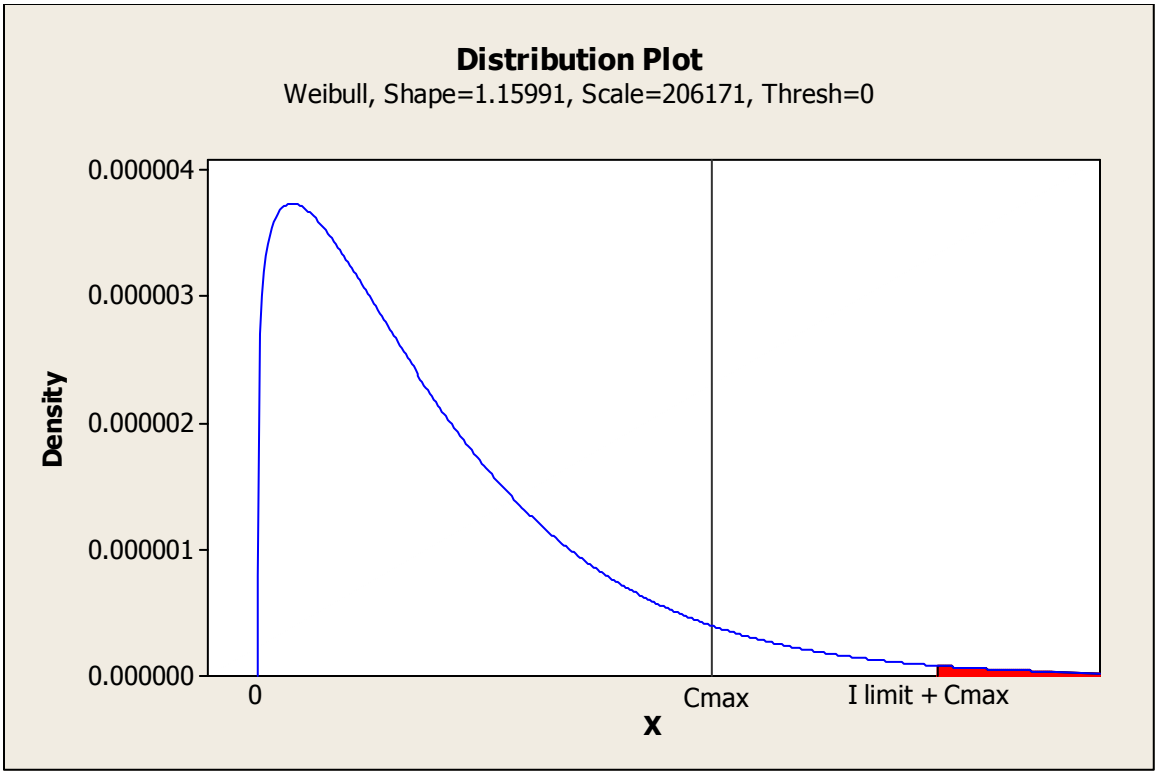

Figure 3.5: Bankruptcy Limit on Distribution of Claims With Limited Coverage

The expected value of a claim for a physician with limited coverage insurance is given by Equation (3.5).

$$(3.5) \qquad E\left[c_{\text{partial}}\right] = \int_{0}^{C_{\max}+I_{\lim it}} c \cdot P_C(c) \cdot dc + (C_{\max} + I_{\lim it}) \cdot \int_{C_{\max}+I_{\lim it}}^{\infty} P_C(c) \cdot dc$$

From Equation (3.2) and Equation (3.5) we can see that the increase in expected value of a claim from purchasing limited coverage insurance is:

(3.6)
$$E[c_{\text{partial}}] - E[c_{\text{uninsured}}] = \int_0^{C_{\max}+I_{\lim it}} c \cdot P_C(c) \cdot dc + (C_{\max} + I_{\lim it}) \cdot \int_{C_{\max}+I_{\lim it}}^{\infty} P_C(c) \cdot dc$$
$$- \int_0^{C_{\max}} c \cdot P_C(c) \cdot dc - C_{\max} \cdot \int_{C_{\max}}^{\infty} P_C(c) \cdot dc$$

(3.7)
$$E[c_{\text{partial}}] - E[c_{\text{uninsured}}] = I \int_{C_{\max}+I_{\lim it}}^{\infty} P_C(c) \cdot dc + \left[\int_{C\max}^{C\max+I_{\lim it}} (c - C_{\max}) P_C(c) \right] \cdot dc$$

From examination of the bounds of integration on the second term of Equation (3.7) it is evident that the change in expected value from the purchase of any limited coverage insurance is always non-negative.

(3.8)
$$E[c_{\text{partial}}] - E[c_{\text{uninsured}}] \geq 0$$

The marginal increase in expected value of a claim from additional insurance can be expressed using the partial derivatives:

(3.9)

$$\frac{\partial E(c)}{\partial I_{\lim it}} =$$

$$\lim_{i \to 0} \frac{\int_0^{C_{\max}+I_{\lim it}} c \cdot P_C(c) \cdot dc + (C_{\max} + I_{\lim it}) \cdot \int_{C_{\max}+I_{\lim it}}^{\infty} P_C(c) \cdot dc - \int_0^{C_{\max}+I_{\lim it}+i} c \cdot P_C(c) \cdot dc + (C_{\max} + I_{\lim it} + i) \cdot \int_{C_{\max}+I_{\lim it}+i}^{\infty} P_C(c) \cdot dc}{i}$$

$$(3.10)\quad \frac{\partial E(c)}{\partial I_{\lim it}} = \lim_{i \to 0} \frac{\int_{C_{\max}+I_{\lim it}}^{C_{\max}+I_{\lim it}+i} \left(c - C_{\max} - I_{\lim it}\right) \cdot P_C(c) \cdot dc + (i) \cdot \int_{C_{\max}+I_{\lim it}+i}^{\infty} P_C(c) \cdot dc}{i}$$

The calculus in Equation (3.10) that is involved in explicitly evaluating the marginal increase in a claim's expected value is problematic because one of the key terms, (i), is a boundary of integration. However, by proving through induction that any additional purchase of insurance will always increase the expected value of the claim, it follows that the marginal increase will always be positive. Additionally, from Equation (3.10) we can make similar inferences about the marginal change in expected claim value as were observed in Equation (3.4) regarding the total change in expected claim value. The more wealthy a physician is, the smaller the marginal increase in claim value from the purchase of insurance, ceteris paribus.

Equation (3.7) demonstrated that for a physician holding no insurance, the purchase of any limited insurance coverage will increase the expected value of a claim. To show through induction that the marginal change in expected value is always positive, it must also be shown that that for any given level of limited coverage insurance, the purchase of any additional insurance will increase the expected value of a claim. Consider the effect on the expected value of a claim from the purchase of a discrete additional amount of insurance (I_{add}>0).

From Equation (3.5):

(3.11) $$E\left[c_{\text{partial+add}}\right] = \int_{0}^{C_{\max}+I_{\lim it}+I_{add}} c \cdot P_C(c) \cdot dc + (C_{\max} + I_{\lim it} + I_{add}) \cdot \int_{C_{\max}+I_{\lim it}+I_{add}}^{\infty} P_C(c) \cdot dc$$

(3.12) $$E\left[c_{\text{partial+add}}\right] = \int_{0}^{C_{\max}+I_{\lim it}} c \cdot P_C(c) \cdot dc + \int_{C_{\max}+I_{\lim it}}^{C_{\max}+I_{\lim it}+I_{add}} c \cdot P_C(c) \cdot dc + (C_{\max} + I_{\lim it} + I_{add}) \cdot \int_{C_{\max}+I_{\lim it}+I_{add}}^{\infty} P_C(c) \cdot dc$$

Subtracting Equation (3.5) from Equation (3.12):

(3.13) $$E\left[c_{\text{partial+add}}\right] - E\left[c_{partial}\right] = \int_{C_{\max}+I_{\lim it}}^{C_{\max}+I_{\lim it}+I_{add}} \left(c - C_{\max} - I_{\lim it}\right) \cdot P_C(c) \cdot dc + (I_{add}) \cdot \int_{C_{\max}+I_{\lim it}+I_{add}}^{\infty} P_C(c) \cdot dc$$

Careful examination of the bounds of integration on the first term in Equation (3.13), we can conclude that Equation (3.13) is strictly non-negative. Equation (3.14) describes an additional assumption that some portion of the probability distribution of (c) is positive above $C_{max} + I_{limit}$., i.e. there is a positive probability of some claim resulting above the bankruptcy limit.

(3.14) Assume $P_c(c^*) > 0$ for some $c^* > C_{mac} + I_{\lim it}$

Given the result of Equation (3.13) and the assumption of Equation (3.14), the increase in expected value of a claim with the purchase of insurance must be strictly positive.

(3.15) $E\lfloor c_{\text{partial+add}} \rfloor - E\lfloor c_{partial} \rfloor > 0$ for all $I_{\text{limit}} \geq 0$ and all $I_{\text{add}} > 0$

By induction we conclude the marginal change in expected claim value always increases with insurance:

(3.15) $\frac{\partial E(c)}{\partial I} > 0$, for all c > 0

When making insurance decisions, physicians must consider the expected value of a claim and the likelihood that a positive claim will occur. A physician will purchase insurance based upon the expected loss (L), a function of the expected value of a claim, and ρ, the likelihood that a claim will occur:

(3.16) $L = \rho \cdot E(c)$

From Equation (3.15) and Equation (3.16):

(3.17) $\frac{\partial L}{\partial I} = \rho \frac{\partial E(c)}{\partial I} > 0$

This link between expected value of loss and the insurance held by the physician violates the assumption that loss is independent of coverage in actuarially fair insurance. The application of this finding in a state contingent model of the insurance decision will result in underinsured or even uninsured physicians.

Effect of Bankruptcy in a State Contingent Insurance Model

This portion of the model evaluates the effect of the relationship determined in Equation (3.17) on the insurance decision. The model used for analysis of the insurance decision will be a state contingent model with two states defined by whether or not the physician's practice during a fixed time period results in a malpractice claim. The model is largely based on the model developed in Binger and Hoffman (1998). The physician is originally endowed with incomes assigned in State 1 and State 2. He or she may alter the allocations between States 1 and 2 by the purchase of insurance.

Let X be the income resulting from the physician's practice. It is assumed to be constant over the time period.

(3.18) State 1: No Loss. The physician original endowment is $S_1 = X$.

(3.19) State 2: Malpractice Claim. The physicians original endowment is $S_2 = X - L$

Let π be the probability that a claim will arise – the probability of State 2 being the actual state of the world. We then bound π in [0,1].

As defined in the previous section, let L be the expected value of the loss suffered from a malpractice claim. L will initially be held constant to demonstrate the standard result that the physician will fully insure. Then we will examine the incentives for physicians to underinsure when there is a marginal increase in the expected loss with the purchase of insurance as described in Equation (3.17). The physician may purchase actuarially fair insurance. The amount of coverage purchased by the physician will be denoted by I. Then the physician's income can then be summarized as:

(3.20) State 1: $S_1 = X - \pi I$

(3.21) State 2: $S_2 = X - L + (1-\pi)I$

In Equations (3.20) and (3.21), (π I) can be interpreted as the actuarially fair insurance premium. We assume the following regarding the physician's utility function:

(3.22) $Utility = U(C_x)$
$U'(C_x) > 0$ (Non - satiation)

(3.23) $U''(C_x) < 0$ for $C_x \in (0,\infty)$ (Convexity)

Figure 3.6 depicts a graph of the physician's utility function:

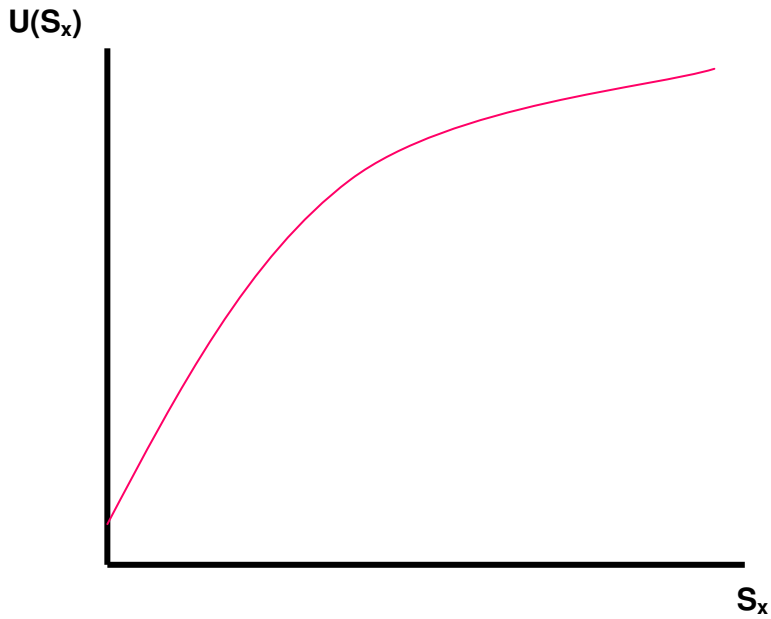

Figure 3.6: A Physician's Utility Function with Regard to Income

We can now define the expected utility function:

(3.24) $EU = (1-\pi)U(S_1) + \pi U(S_2)$

Figure 3.7 depicts the graph of expected utility in the state contingent model. The graph depicts the slope of the indifference curve (-MRS_{12}) to be more negative than the slope of the budget line. It is clear that a higher expected utility can be obtained through the purchase of insurance. This will de demonstrated in the following analysis.

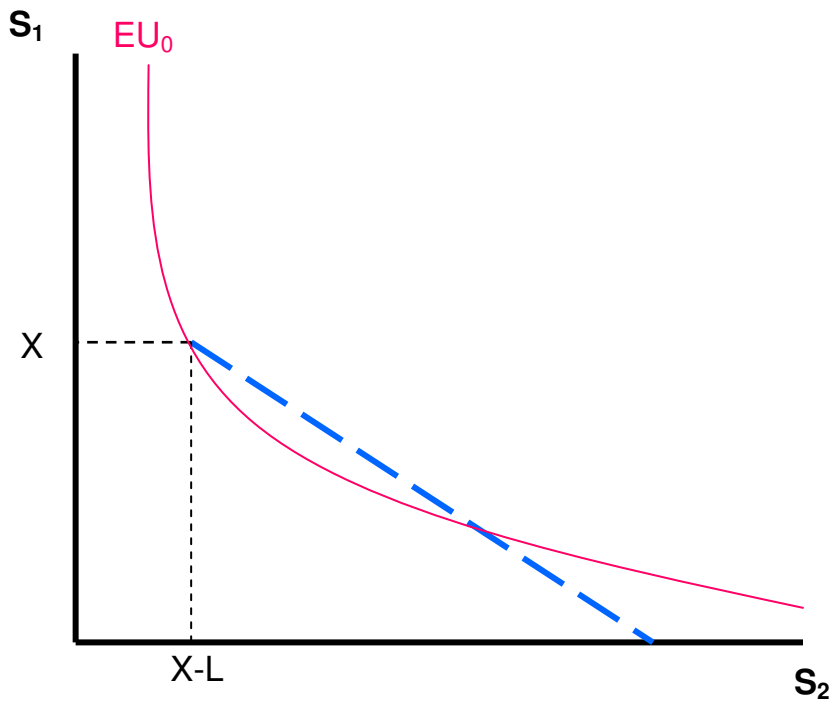

Figure 3.7: State Contingent Expected Utility Indifference Curve with Initial Endowments

To maximize the expected utility, physicians must choose how much insurance to purchase. Choosing how much insurance to purchase is equivalent to choosing the allocation between State 1 (No Loss) and State 2 (Malpractice Payment). The slope of the budget line represents the ratio on which the physician can trade income in State 1 (by paying the insurance premium) to gain additional income in State 2 (insurance payment for loss).

Differentiating Equation (3.20) and (3.21) with regard to insurance yields the following:

(3.25) $\frac{\partial S_1}{\partial I} = -\pi$

(3.26) $\frac{\partial S_2}{\partial I} = 1 - \pi$

Thus the budget line created by the purchase of insurance has an initial endowment of (X, X-L) and a price ratio of:

(3.27) $\frac{\partial S_1}{\partial S_2} = \frac{-\pi}{(1-\pi)}$

This price ratio given in Equation (3.27) can be interpreted as the amount by which income is reduced in State 1 by the purchase of premiums, to raise income in the form of liability coverage in State 2. This price ratio can be used to express the relative price of additional income in each state.

(3.28) $P_{S1} = 1$

(3.29) $P_{S2} = \frac{\pi}{1-\pi}$

The Lagrangian constrained maximization problem can now be created:

$$(3.30)\quad \mathcal{L}_{\max} = (1-\pi)U(S_1) + \pi U(S_2) + \lambda\left[X + \frac{\pi(X-L)}{1-\pi} - S_1 - \frac{\pi S_2}{1-\pi}\right]$$

Evaluating the first order conditions we obtain:

$$(3.31)\quad \frac{\partial \mathcal{L}_{\max}}{\partial S_1} = (1-\pi)U'(S_1) - \lambda = 0$$

$$(3.32)\quad \frac{\partial \mathcal{L}_{\max}}{\partial S_2} = \pi U'(S_2) - \frac{\pi\lambda}{1-\pi} = 0$$

$$(3.33)\quad \frac{\partial \mathcal{L}_{\max}}{\partial \lambda} = X + \frac{\pi(X-L)}{1-\pi} - S_1 - \frac{\pi S_2}{1-\pi} = 0$$

From Equations (3.31) and (3.32) we obtain:

$$(3.34)\quad \frac{(1-\pi)U'(S_1)}{\pi U'(S_2)} = \frac{1-\pi}{\pi}$$

Simplifying Equation (3.34) we find:

(3.35) $U'(S_1) = U'(S_2)$

The assumptions regarding the utility function, Equations (3.22) and (3.23), ensure that the utility function and its derivative are one-to-one functions. S_1 and S_2 must be the same point. The second order conditions which demonstrate that this is a maximizing point are evaluated in Appendix A.

(3.36) $S_1 = S_2$

From Equations (3.36), (3.20) and (3.21).

(3.37) $X - \pi I = X - L + (1 - \pi)I$

From Equation (3.37) it follows that:

(3.38) $I = L$

This demonstrates the familiar result regarding a risk averse individual. Given that the insurance is actuarially fair and the loss is independent of the coverage held, a risk averse individual will fully insure. Figure 3.8 demonstrates this result graphically.

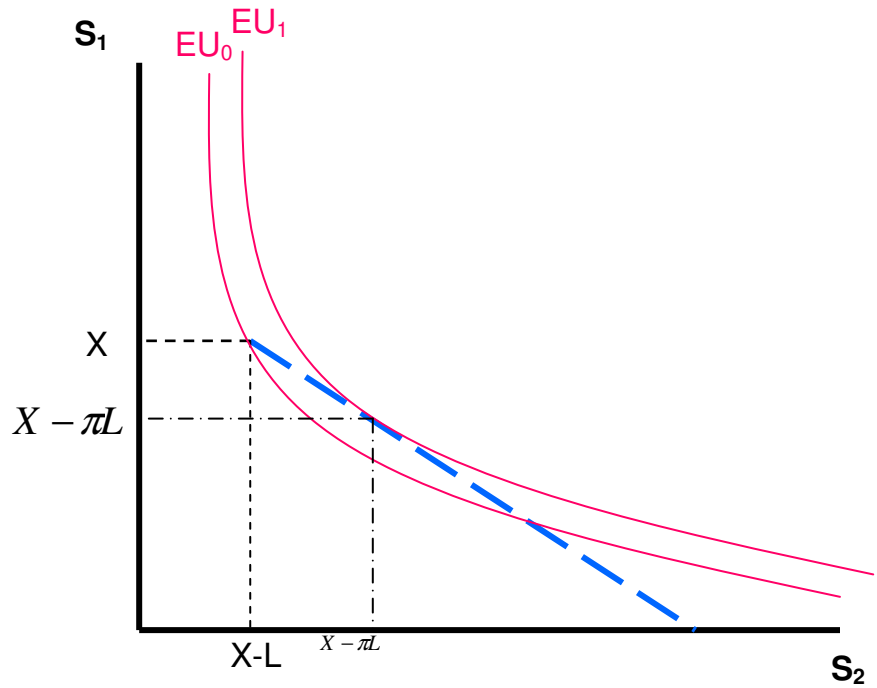

Figure 3.8: Graph of Optimal Insurance Choice with Actuarially Fair Insurance and Exogenous Loss.

We now consider the case where the expected value of a claim is a function of the amount of insurance held by the physician. As demonstrated in the previous section the marginal change in expected loss with regard to insurance is positive.

(3.39) Expected $Loss = L(I)$

(3.40) $\frac{\partial L}{\partial I} > 0$

The physician's income must reflect this relationship between loss and insurance coverage:

(3.41) Income in State 1: $S_1 = X - \pi I$

(3.42) Income in State 2: $S_2 = X - L(I) + (1-\pi)I$

Re-evaluating the budget line given the new income equations yields:

(3.43) $$\frac{\partial S_1}{\partial I} = -\pi$$

(3.44) $$\frac{\partial S_2}{\partial I} = 1 - \pi - \frac{\partial L}{\partial I}$$

Thus the new budget line created by the purchase of insurance has an initial endowment of (X, X-L) and a slope of:

(3.45) $$\frac{\partial S_1}{\partial S_2} = \frac{-\pi}{(1-\pi) - \partial L / \partial I}$$

Figure (3.9) depicts several versions of the new budget line. Depending on the strength of the relationship between expected claim value and insurance coverage, the physician will underinsure or forgo insurance all together.

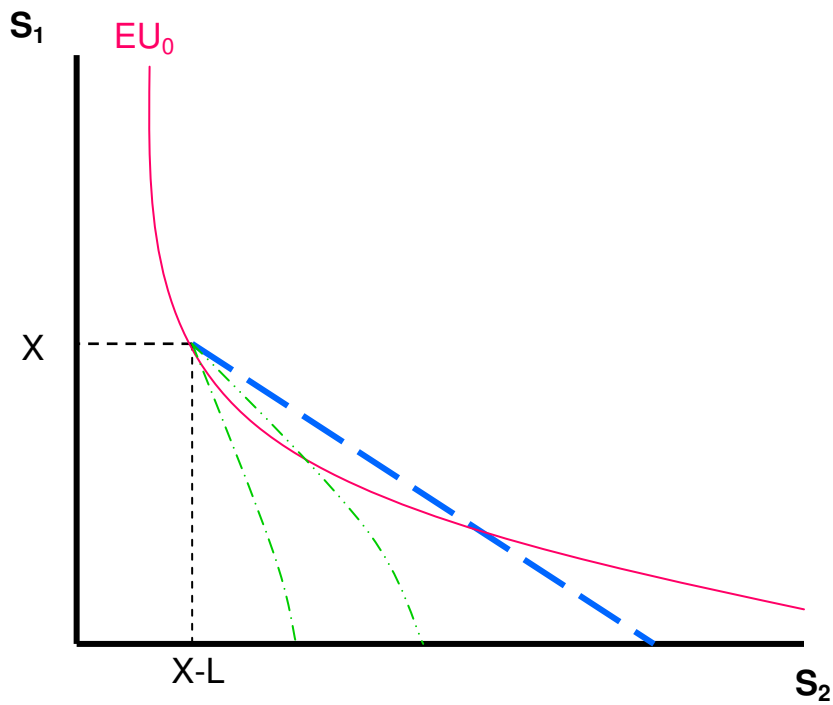

Figure 3.9: State Contingent Expected Utility Indifference Curves with Altered Budget Lines.

Consider the new price relationship between income in State 1 and State 2. Note the price of S_2 is now an increasing function of I.

(3.46) $P_{S1} = 1$

$$(3.47)\quad P_{S2} = \frac{\pi}{1-\pi-\partial L/\partial I}$$

The Lagrangian constrained maximization problem can now be created:

$$(3.48)\quad \mathcal{L}_{\max} = (1-\pi)U(S_1) + \pi U(S_2) + \lambda\left[X + \frac{\pi(X-L)}{1-\pi-\partial L/\partial I} - S_1 - \frac{\pi S_2}{1-\pi-\partial L/\partial I}\right]$$

Evaluating the first order conditions we obtain:

$$(3.49)\quad \frac{\partial \mathcal{L}_{\max}}{\partial S_1} = (1-\pi)U'(S_1) - \lambda = 0$$

$$(3.50)\quad \frac{\partial \mathcal{L}_{\max}}{\partial S_2} = \pi U'(S_2) - \frac{\pi\lambda}{1-\pi-\partial L/\partial I} = 0$$

$$(3.51)\quad \frac{\partial \mathcal{L}_{\max}}{\partial \lambda} = X + \frac{\pi(X-L)}{1-\pi-\partial L/\partial I} - S_1 - \frac{\pi S_2}{1-\pi-\partial L/\partial I} = 0$$

From Equations (3.49) and (3.50) we see:

$$(3.52)\quad \frac{(1-\pi)U'(S_1)}{\pi U'(S_2)} = \frac{1-\pi-\partial L/\partial I}{\pi}$$

Simplifying Eq. (3.52) we obtain:

$$(3.53)\quad U'(S_1) = \left(\frac{1-\pi-\partial L/\partial I}{1-\pi}\right)U'(S_2)$$

Given $\partial L/\partial I > 0$ from Equation (3.40),

$$(3.54)\quad U'(S_1) < U'(S_2)$$

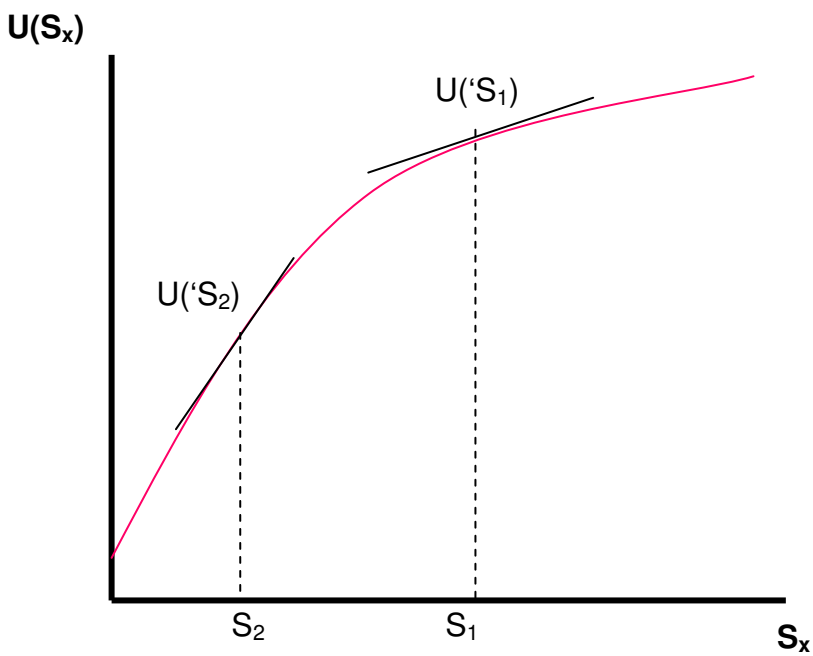

Figure 3.10: Utility Function with Underinsurance

The second order conditions which demonstrate this to be a maximization point are given in Appendix A. From the non-satiation and convexity assumptions regarding the utility function it follows:

(3.55) $S_1 > S_2$

Substituting in for S_1 and S_2 in Equation (3.39) we obtain:

(3.56) $X - \pi I > X - L + (1 - \pi) I$

(3.57) $I < L$

This result suggests that a physician will underinsure. The extent to which a physician will substitute protection in bankruptcy for private insurance is dependent on the strength of the relationship between expected loss and coverage.

CHAPTER 4

EMPERICAL RESULTS

Empirical Approach

The intent of this section is to examine empirical evidence of the relationship between expected loss and insurance hypothesized in the theoretical model. The analysis makes use of two databases kept by the state of Florida to track characteristics of physician practices and medical malpractice claims. The Florida Practitioner Profile Database is updated by physicians as they renew their medical license, nominally every other year. It contains information about a physician's practice, including their specialty and their insurance status. The Florida Professional Claims Reporting System records information on all liability claims brought against Florida physicians and hospitals. This includes the amount of claims, the amount of non-economic damages, whether the physician is insured, the severity of the injury, and the method of disposition (settlement/court verdict).

Linking the two databases together through the physician's medical license number it is possible to observe the value of each claim and whether the physician held insurance. This produced 1915 observations between July 1, 2004, and September 30th, 2006. (These dates were chosen due to a change in the reporting rules for the claims

database that went into effect on July 1, 2004.) Only 23 of the observations represent physicians practicing without insurance.

There are two explanations for the under-representation of uninsured physicians. The most likely explanation is that prior to July 2004, no requirement existed for uninsured physicians to report claims. Previously the statute required the insurance companies, not the physicians, to report claims. A manager of the database project confirms that it is unclear to what extent the new requirement for uninsured physicians to report has been enforced. Another interpretation may be that since uninsured physicians are required to explicitly inform patients about their insurance status prior to care, patients have low expectations of receiving compensation and so fewer claims are filed.

The multiple regression analysis uses information available in the database to control for physician specialty, method of disposition, injury severity and percentage of non-economic loss. All control variables with the exception of non-economic loss are dummy variables. The low number of uninsured observations is especially problematic for drawing strong conclusions about the results. Perhaps, future data will be available with which to make a stronger conclusion regarding the sign and magnitude of the insurance / loss relationship.

Summary of Multiple Regression Results

The results of the multiple ordinary least squares regression are summarized in Table 4.1 and Table 4.2 below. The accompanying plot of residuals follows in Figure 4.1.

Predictor	Coefficient	SE	T-Stat	P-Value
Constant	884574	788384	1.12	0.262
Uninsured Variable	**-40727**	**594713**	**-0.07**	**0.945**
Settlement Dummy	-540893	487992	-1.11	0.268
% Non-Ecomonic	-156711	174914	-0.90	0.370
Severity Dummies Variables				
D-Emot	-13385	838554	-0.02	0.987
D-Temp_Slight	-52579	664293	-0.08	0.937
D-Temp-Minor	-78925	308828	-0.26	0.798
D-Temp_Major	-5770	330338	-0.02	0.986
D-Perm_Minor	-40046	256646	-0.16	0.876
D-Perm_Sig	1191091	285678	4.17	0.000
D-Perm_Major	103972	326671	0.32	0.750
D-Perm_Grave	1787	361525	0.00	0.996
Specialty Dummy Variables				
D-Anes	-114152	731019	-0.16	0.876
D-Pain	-281375	893318	-0.31	0.753
D-DRad	-296559	778776	-0.38	0.703
D-FamP	-132288	699457	-0.19	0.850
D-Surg	-185889	675481	-0.28	0.783
D-CarD	-45000	716854	-0.06	0.950
D-InMed	-166919	660282	-0.25	0.800
D-NeurSur	-195637	828594	-0.24	0.813
D-OBGyn	-177410	668795	-0.27	0.791
D-Oth	-64941	1077091	-0.06	0.952
D-Peds	1877208	715686	2.62	0.009
D-RadDiag	-229884	717916	-0.32	0.749
D-ThorSur	-353901	823649	-0.43	0.668
D-NRN	-274639	936421	-0.29	0.769

Table 4. 1: Coefficient Results: Multiple Regression of Claim Data

Source	DF	SS	MS	F	P
Regression	25	4.47E+14	1.79E+13	2.40	0.00
Residual Error	1084	8.06E+15	7.44E+12		
Total	1109	8.51E+15			

Table 4. 2 Analysis of Variance: Multiple Regression of Claim Data

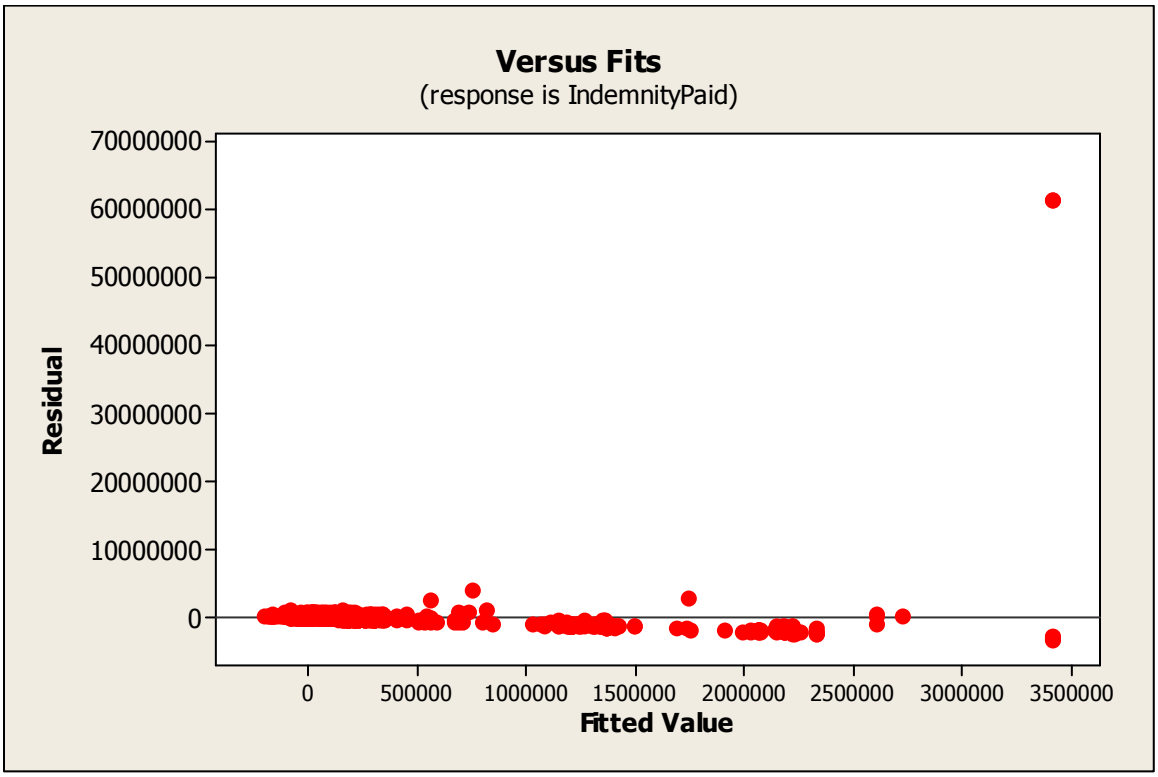

Figure 4.1: Residuals of Multiple Regression Analysis

Several observations are immediately evident from the results. First is the weak, negative coefficient associated with not taking insurance. The negative sign is what we would expect from the theoretical model, but this result is of no real explanatory value given the high standard error. It is also notable that the coefficient associated with settling the case prior to trial is negative. This fits with the idea that physicians stand to gain more from settling out of court compared to a jury verdict. However, the p-value associated with the settlement coefficient is also poor ($p = 0.269$). In both cases we cannot reject the hypothesis that these variables have no effect on claim values.

The large residual that is observed in Figure 4.1 presents an interpretation problem. The residual concerns one observation of a $6,500,000 claim settled by an

insured family practitioner. When deleted as an outlier the regression results change significantly. The coefficient associated with the variable regarding no insurance changes sign, but remains insignificant by any measure. Including this claim in the analysis is justified because it is precisely the type of claim that the bankruptcy strategy from uninsured physicians prevents. Nevertheless, the data available does not lead to any definitive conclusion regarding the validity of the theoretical model introduced in Chapter 3.

A Qualitative Observation

There may be some additional qualitative evidence to suggest that the model proposed in Chapter 3 has some merit despite the poor data available for uninsured physician claims. Table 4.3 lists the percentages of Florida physicians practicing uninsured in several major specialties. This information was determined from the Florida Practitioner Profile Database.

Specialty	Total Licensed	Percent Bare
OBG – OBSTETRICS AND GYNECOLOGY	2039	31.1%
GS – SURGERY	2270	28.5%
ORS - ORTHOPEDIC SURGERY	1226	18.8%
U – UROLOGY	738	12.2%
FP - FAMILY PRACTICE	3129	9.4%
N – NEUROLOGY	592	8.3%
IM - INTERNAL MEDICINE	9280	7.8%
FAMILY PRACTICE	348	6.0%
AN – ANESTHESIOLOGY	2552	6.0%
IM - GERIATRIC MEDICINE	400	5.7%
OPH – OPHTHALMOLOGY	1469	4.2%
PD – PEDIATRICS	3587	3.9%
EM – EMERGENCY MEDICINE	1431	3.8%
RADIOLOGY – DIAGNOSTIC	1319	2.6%

Table 4. 3: Uninsured Physician Rate by Specialty

Figure 4.2 depicts a dotplot of the distribution of claims in four selected specialties in which a significant amount of data exists.

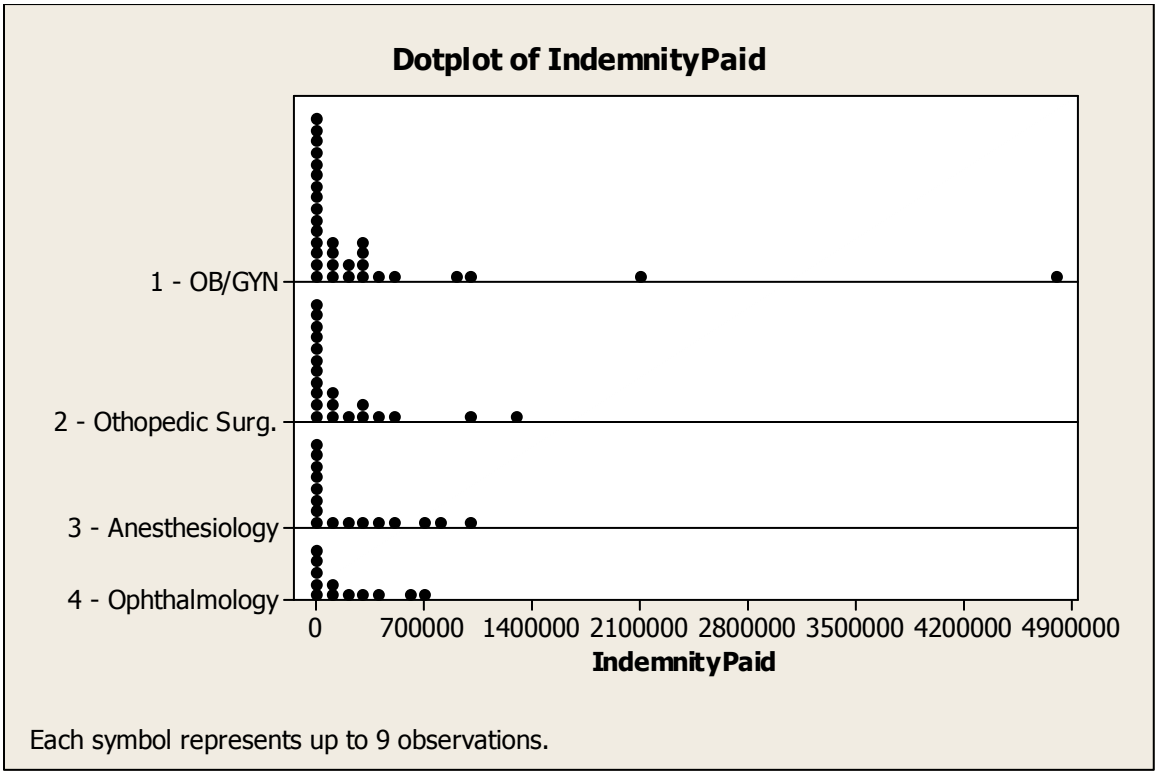

Figure 4.2: Dotplot of Claim Distribution in Selected Specialties

There seems to be evidence of correlation between the number of physicians in each specialty who choose to forgo insurance and the amount of high value claims that are filed in the specialty. This holds with the theoretical model discussed in Chapter 3. The incentive to forgo insurance is strongest when the probability distribution of claims above some C_{max} is high. Opthamologist are unlikely to have many claims high enough to use bankruptcy to discharge any of the debt. Obstetricians, however, have several

multi-million dollar claims, some of which would be dischargeable through bankruptcy. The discussion in this paper will be limited only to this qualitative observation, although a more quantitative analysis may be possible. A quantitative analysis would require some form of non-linear estimation, as the one of the estimation parameters would be $C_{max,}$ a boundary of integration in one of the model functions.

CHAPTER 5

SUMMARY AND CONCLUSION

The theoretical model presented in Chapter 3 demonstrates the attractiveness to physicians of using bankruptcy as an alternate form of malpractice insurance. The empirical evidence for this model is not ideal, but there is not enough evidence yet to rule out the existence of such a relationship. If we accept the model's assumptions about the discharge of debt in bankruptcy, it is clear that there exists an incentive for physicians to purchase inadequate private insurance or forgo private insurance all together. However, the model does not consider many of the additional costs associated with bankruptcy, such as the effect on credit history and the psychological effect of financial distress. Perhaps the large number of uninsured Florida physicians are evidence that the relationship between insurance coverage and expected loss is perceived by these physicians to be significantly strong enough to overcome the risk of bankruptcy costs. Additionally, asset protection alternatives might be strong enough to ensure that in the event of a very large claim enough debt will be discharged to warrant the additional costs of bankruptcy.

At first glance it may seem as if intervention might be warranted to prevent presumably negligent physicians from discharging debt, while patients are left uncompensated for injuries. However, the economic efficiency of this arrangement is not

straightforward because of several competing factors. While bankruptcy may be considered a valid substitute for social insurance, it is clearly not intended as an alternative to private insurance. The creditor, who absorbs the risk of an insolvent debtor, typically charges a risk premium in the form of an interest rate, and can spread this risk over a large number of contracts. In malpractice bankruptcy physicians transfer the cost of the injury back to the patient. The patient receives no interest payment, nor do they have a large number of debtors over which to spread risk.

This would be problematic if there was no way for the patient and physician to contract around this arrangement. However, the patient can instead choose to purchase medical treatment from a physician with an appropriate amount of insurance. There is reason to believe that patients are well informed about this arrangement. Florida s.458.320 requires any uninsured physician to take action to inform a prospective patient that she has not decided to carry malpractice insurance prior to the delivery of care. Physicians who do carry malpractice insurance are required to keep a minimum limit of $250,000 per claim or $100,000 per claim depending on whether the physician has hospital privileges. While the mechanics of such care in emergency situation might be subject to debate, the patient is clearly has sufficient information and is free to contract with an insured physician during routine care.

The large number of uninsured physician in Florida may suggest that there is a demand for lower cost care, in exchange patient is willing to assume some risk of injury. As noted previously, Shapiro (1991) suggested that the arrangement in medical malpractice law essentially imposes an inefficient contract in which the patient must

purchase medical care bundled with full insurance against iatrogenic injury. The arrangement between an uninsured physician who can discharge debt in bankruptcy and a fully informed patient seeking lower cost care is a method to contract around this problem. This certainly does not suggest that this is the most efficient regime in which to offer medical care. Considering the large costs associated with malpractice torts and bankruptcy law, proponents for reform to the liability system still make a compelling argument. However, provided that patients are well informed, the mandatory requirements for medical malpractice insurance which exist in several states are counterproductive with regards to efficiency.

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APPENDIX-A

EVALUATION OF STATE CONTINGENT MODEL SECOND ORDER CONDITIONS

The second order conditions of the Langrangian maximization problem presented in the state contingent insurance model are evaluated to demonstrate that the critical point determined in the model is, in fact, a local maximum. There are two cases. The first is the traditional insurance model where expected loss and insurance coverage are exogenous. The second model evaluates the results when there is a marginal increase in the expected loss with the purchase of insurance.

For each model the second order derivatives are determined. Then the second derivative test is applied by calculating the determinant of the bordered Hessian matrix. If the result is strictly positive the point evaluated is a local maximum. See Binger and Hoffman pp. 90-91 for explanation of this method.

Recall the Lagrangian problem and corresponding first order conditions of the traditional insurance model presented in Chapter X:

(30) $$\mathcal{L}_{\max} = (1-\pi)U(S_1) + \pi U(S_2) + \lambda\left[X + \frac{\pi(X-L)}{1-\pi} - S_1 - \frac{\pi S_2}{1-\pi}\right]$$

(31) $$\frac{\partial \mathcal{L}_{\max}}{\partial S_1} = (1-\pi)U'(S_1) - \lambda = 0$$

(32) $$\frac{\partial \mathcal{L}_{\max}}{\partial S_2} = \pi U'(S_2) - \frac{\pi\lambda}{1-\pi} = 0$$

(33) $$\frac{\partial \mathcal{L}_{\max}}{\partial \lambda} = X + \frac{\pi(X - L)}{1-\pi} - S_1 - \frac{\pi S_2}{1-\pi} = 0$$

The following second order conditions result from Equations (30) – (33):

(A.1) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_1^{\ 2}} = (1-\pi)U''(S_1)$$

(A.2) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_1 \partial S_2} = 0$$

(A.3) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_1 \partial \lambda} = -1$$

(A.4) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_2^{\ 2}} = \pi U''(S_2)$$

(A.5) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_2 \partial \lambda} = \frac{-\pi}{1-\pi}$$

(A.6) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial \lambda^2} = 0$$

From the second derivatives found in Equations (A.1) – (A.6) the following bordered Hessian matrix is formed:

(A.7) $$\mathbf{H}_1 = \begin{bmatrix} (1-\pi)U''(S_1) & 0 & -1 \\ 0 & \pi U''(S_2) & \dfrac{-\pi}{1-\pi} \\ -1 & \dfrac{-\pi}{1-\pi} & 0 \end{bmatrix}$$

(A.8) $$\begin{aligned} \text{Det } \mathbf{H}_1 = {} & [(1-\pi)U''(S_1)][\pi U''(S_2)][0] + [0]\left[\frac{-\pi}{1-\pi}\right][-1] + [-1][0]\left[\frac{-\pi}{1-\pi}\right] \\ & - [(1-\pi)U''(S_1)]\left[\frac{-\pi}{1-\pi}\right]\left[\frac{-\pi}{1-\pi}\right] - [0][0][0] - [-1][\pi U''(S_2)][-1] \end{aligned}$$

(A.9) $$\text{Det } \mathbf{H}_1 = -[(1-\pi)U''(S_1)]\left[\frac{\pi}{1-\pi}\right]^2 - [\pi U''(S_2)]$$

Recall from the assumptions made about the physician's utility function:

(23) $U''(C_x) < 0$ for $C_x \in (0,\infty)$ (Convexity)

We can then determine:

(A.10) $\text{Det } \mathbf{H}_1 > 0 \text{ for all } \pi < 1$

From Equation (A.10) the critical point evaluated in Chapter 2 is a local maximum. The condition that $\pi < 1$ represents the fairly benign restriction that the probability of a claim taking place must be less than 1.

A similar conclusion can be reached by evaluating the second order conditions of the second model presented in Chapter 2.

(48) $$\mathcal{L}_{\max} = (1-\pi)U(S_1) + \pi U(S_2) + \lambda\left[X + \frac{\pi(X-L)}{1-\pi-\partial L/\partial I} - S_1 - \frac{\pi S_2}{1-\pi-\partial L/\partial I}\right]$$

(49) $$\frac{\partial \mathcal{L}_{\max}}{\partial S_1} = (1-\pi)U'(S_1) - \lambda = 0$$

(50) $$\frac{\partial \mathcal{L}_{\max}}{\partial S_2} = \pi U'(S_2) - \frac{\pi\lambda}{1-\pi-\partial L/\partial I} = 0$$

(51) $$\frac{\partial \mathcal{L}_{\max}}{\partial \lambda} = X + \frac{\pi(X-L)}{1-\pi-\partial L/\partial I} - S_1 - \frac{\pi S_2}{1-\pi-\partial L/\partial I} = 0$$

Equations (48) – (51) yield the following second order conditions:

(A.11) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_1^{\,2}} = (1-\pi)U''(S_1)$$

(A.12) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_1 \partial S_2} = 0$$

(A.13) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_1 \partial \lambda} = -1$$

(A.14) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_2^{\,2}} = \pi U''(S_2)$$

(A.15) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial S_2 \partial \lambda} = \frac{-\pi}{1-\pi-\partial L/\partial I}$$

(A.16) $$\frac{\partial^2 \mathcal{L}_{\max}}{\partial \lambda^2} = 0$$

From the second derivatives found in Equations (A.11) – (A.16) the following bordered Hessian matrix is formed:

(A.17) $$\mathbf{H}_2 = \begin{bmatrix} (1-\pi)U''(S_1) & 0 & -1 \\ 0 & \pi U''(S_2) & \dfrac{-\pi}{1-\pi-\partial L/\partial I} \\ -1 & \dfrac{-\pi}{1-\pi-\partial L/\partial I} & 0 \end{bmatrix}$$

(A.18)

$$\text{Det}\,\mathbf{H}_2 = [(1-\pi)U''(S_1)][\pi U''(S_2)][0] + [0]\left[\frac{-\pi}{1-\pi-\partial L/\partial I}\right][-1] + [-1][0]\left[\frac{-\pi}{1-\pi-\partial L/\partial I}\right]$$
$$-[(1-\pi)U''(S_1)]\left[\frac{-\pi}{1-\pi-\partial L/\partial I}\right]\left[\frac{-\pi}{1-\pi-\partial L/\partial I}\right] - [0][0][0] - [-1][\pi U''(S_2)][-1]$$

(A.19) $$\text{Det}\,\mathbf{H}_2 = -[(1-\pi)U''(S_1)]\left[\frac{-\pi}{1-\pi-\partial L/\partial I}\right]^2 - [\pi U''(S_2)]$$

As in the first case, using the convexity assumption about the second derivative of the utility function we determine:

(A.20) Det $\mathbf{H}_2 > 0$ for all $\pi < 1$

From Equation (A.20) the critical point evaluated in Chapter 2 is a local maximum. The condition that $\pi < 1$ represents the fairly benign restriction that the probability of a claim taking place must be less than 1.