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Abstract

When the value of a medical treatment differs across individuals, it may be socially beneficial to treat some, but not all, patients. If individuals are ignorant of their health status *ex ante*, they should be willing to purchase insurance fully covering treatments for high-benefit patients (Hs) and denying treatment for low-benefit patients (Ls). But if prognoses are observable but not verifiable, insurers may have trouble denying care to Ls. Deductibles force Ls to reveal their status by imposing a marginal cost on treatment, but at a price of incomplete risk-sharing. Lump-sum indemnities can similarly induce Ls to forgo treatment but are rare in health insurance markets. They were once more common and remain so in non-health markets. This paper reviews the potential for health insurance indemnities. We model an insurance market for a single illness and derive conditions determining the relative efficiency of indemnities and deductibles.

We define a disease that strikes randomly, where there is no private information, and where benefits are measured as cure rates. These and other assumptions yield several rules of thumb: It is never socially or (*ex ante*) privately beneficial to offer an indemnity larger than the cost of treatment. The optimal indemnity is always larger than the optimal deductible. If Ls outnumber Hs, the best deductible contract always yields higher welfare than the best indemnity contract. As the Ls' cure rate approaches 0, the choice of indemnity or deductible depends entirely upon the relative numbers of Hs and Ls.

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1. Indemnities vs. Deductibles in Health Insurance

For some insured patients, the social costs of medical treatment exceed the private benefits which, in turn, exceed the private costs of treatment. In a first-best world, people would willingly buy health insurance with a pre-commitment to deny treatment in such cases. In reality, it is difficult to bind people to such pre-commitments, and the result is spending beyond the social optimum on at least some aspects of health care.

Given this market failure, the United States employs a number of roundabout methods to reduce costly expenditures on low-marginal benefit care. Insurers deny care by fiat (e.g., utilization review, coverage exclusions). They deter usage by imposing out-of-pocket marginal costs (e.g., high deductibles).[1] One can argue that advance medical directives accomplish this goal by moral suasion, regardless of whether that is the intention of the signatories.

In many non-health markets, insurance offsets damages by means of cash indemnities; individuals can either use the cash to reverse the damage (e.g., to have dents removed from a car), or they may use the cash for other purposes which they value more highly (e.g., a vacation). What people do with their indemnities reveals the value they place on reversing the damage. Thus, indemnities help to limit resource malallocation.

Cash indemnities are seldom used in health insurance.[2] Instead, benefits usually help allay the costs of medical services rendered. This restriction can induce people to seek costly medical services which, for them, have minimal but positive benefits. For many

[1] We use "deductibles" and "copayments" interchangeably.

[2] Traditional fee-for-service policies are also referred to as "indemnification" policies. To avoid confusion, this paper will use "indemnities" to mean payouts unrelated to services rendered, and we will avoid using "indemnification" as a synonym for "fee-for-service."

illnesses, there are obvious reasons why cash indemnities are impractical.[3] For certain illnesses, though, indemnities might be a reasonable means of restraining health care spending and making patients happier as well. Here, we model such an illness and search for conditions under which indemnities are more efficient than deductibles at deterring low-benefit patients from seeking expensive treatments.

The paper is organized as follows: Section 1.1 defines "*ex post*" moral hazard and introduces the demand-side and supply-side approaches to moderating its effects. Section 1.2 illustrates the differences between indemnity and deductible contracts by means of a simple thought problem. Section 1.3 outlines the history and rarity of indemnities in health insurance. Section 1.4 looks at the recent history of the search for optimal demand- and supply-side health insurance incentives. Section 2 constructs a model for comparing the efficiency of indemnity and deductible contracts in a restrictive setting. Section 3 is the conclusion and lists directions for future research. Most mathematical proofs are contained in the Appendix, in order to avoid interrupting the article's flow.

1.1 *Ex post* Moral Hazard, Deductibles, and Managed Care

The economics of health insurance revolves largely around two problems, adverse selection and moral hazard, that place economy and cost-sharing at loggerheads. Until the early 1980s, health economists and health insurers both searched largely for demand-side solutions. Typical was the search for the optimal deductible, which would minimize the combined utility loss from moral hazard and risk to personal wealth. Deductibles

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[3] Indemnities would seem a poor settlement mechanism for an ailment such as lower back pain, the presence of which is not easily observed, even by a specialist. Here, willingness to undergo treatment provides evidence that patient actually suffers from the ailment and is not simply gaming the insurer.

persuade low-benefit patients to self-select away from treatment by imposing a private marginal cost; such economy, though, comes at a cost of reduced cost-sharing. From the early 1980s till the present, academicians, insurers, and other interested parties (notably employers) shifted their attention to the supply-side. The tools known generically as "managed care" seek economy *and* cost-sharing, but require high administrative expenses (e.g., utilization review, capital expenditures on information management and protocol development). Managed care also induces the consumer dissatisfaction and costly gaming typically associated with nonprice rationing.

This brings us to the central question of this paper—whether indemnities can efficiently persuade high- and low-benefit patients to reveal the values they place on medical services. This paper returns to the search for efficient demand-side solutions. To do so, it assumes away adverse selection. It also assumes away the type of moral hazard we will label "*ex ante*"—where the promise of future insurance coverage induces people to take excessive health risks, thereby increasing the incidence of illness. Ignoring these two monumental problems allows us to focus solely on *ex post* moral hazard, where people who are already ill purchase excessive medical services because third parties bear the costs. Such assumptions are damningly unrealistic for many illnesses. Other diseases, though, strike more or less randomly and their presence is easily observed by outside observers. Such illnesses would accord reasonably well with our assumptions. (Importantly for purposes of the model we build, the diagnosis is assumed costlessly verifiable, but its prognosis is not.) The analysis modeled here posits such an illness and carveout, or single-benefit insurance policy, to financially protect its sufferers.[4]

In other words, we are restricting this analysis to a class of medical conditions where we do not face the classic principal-agent problem of health care—private information held by either the patient or provider. Here, all agents have perfect information, but providers cannot fully act on this information.

1.2 Indemnities and Deductibles: Pricing Life

Indemnities are so alien to health insurance that it might be helpful to illustrate indemnities and deductibles through a simple thought problem composed of two cases:

> **Case 1 (Indemnity):** You have been diagnosed with an illness that is 100% terminal if untreated. The treatment provides a 2% chance of survival but costs $500,000. Would you prefer full coverage of this treatment or $350,000 in cash?

Our evidence on how people would, in fact, react to such offers is paltry, but introspection at least suggests the possibility of accepting the cash option.[5] It seems logical that an individual's response would depend, among other things, upon age, family status, the cost of the treatment, level of financial wealth, and—crucially—the survival rate posited for those treated. If the survival rate, for instance, were 50%, far more

[4] "Single-benefit" plans commonly cover mental health, dental, and optical expenses (Weiner and de Lissovoy 1993, p. 100).

[5] There are health insurance mechanisms that require patients to make such Hobson's choices. For example, to receive care under Medicare Hospice Benefit, a patient must surrender coverage for medical treatments for the terminal illness. While the patient has the option later of switching back to medical coverage (and surrendering hospice coverage), the program demands an either/or choice. Perhaps the best evidence would come from examining the behavior of people who are wealthy enough to pay enormous sums for experimental treatments not covered by health insurance or who are self-insured. Conceptually, the simple indemnity policy described here takes a person of modest means, makes them wealthy, and allows them to decide for or against from that vantage point.

people might opt for treatment rather than for cash. In contrast, consider the thought problem restated in terms of a deductible contract:

> **Case 2 (Deductible):** You have been diagnosed with an illness that is 100% terminal if untreated. The available treatment will give you a 2% chance of survival, but it costs $500,000. Your insurance will pay for the treatment, except for a $3,000 deductible. Would you prefer the treatment or will you opt out of treatment and keep your $3,000?

The deductible is unlikely to deter many from treatments and a 2% chance. If one were to choose the cash option in Case 1 and the treatment option in Case 2, then we would have strong evidence, at least for the person so choosing, that life has a price and that *ex post* moral hazard exists. A population composed entirely of such people ought to willingly bind themselves to forgo treatment in Case 1—if they know that others will be similarly bound. (The premium will reflect the fealty of subscribers to this accord.)

1.3 Rarity of Health Insurance Indemnities

Rationing-via-indemnity is rare in health insurance. It is common in other types of insurance—automobile and homeowner policies, for example. The owner of a damaged car typically obtains several repair estimates and shares them with the insurer, who then pays a cash settlement in an amount determined by a formula whose arguments include the estimates and the policy's provisions. The purpose of the settlement is to restore the owner's utility, not to restore his car (though restoring the car may be the end result). Often, the owner is free to pocket the money, and his utility can wind up higher than, lower than, or equal to its pre-collision level, depending on his preferences and the amount on the check. Importantly, the owner's post-indemnity choices reveal the value he places on fixing the car vis-à-vis other goods.

Indemnity insurance was common in health insurance in the days prior to efficacious interventions.[6,7] A person diagnosed with a serious, perhaps fatal, illness might receive an indemnity to cover palliatives, home nursing care, and burial, but discouraging expensive treatments does not appear to have been a primary motive. Today, indemnities primarily live on in odd corners of health insurance—in policies we don't even tend to classify as health insurance. Personal accident insurance often pays a fixed indemnity for the loss of a limb or eye; as with auto insurance, the insurer doesn't care what the recipient does with the payout. Some indemnity provisions also survive in dental policies.[8] "Dread disease" policies sometimes pay indemnities, though the triggering event may be the purchase of a medical service (e.g., hospital stay) rather than mere diagnosis. [9]

The disappearance of indemnities began in earnest with the founding of Blue Cross in the 1930s, which reimbursed beneficiaries for services rendered by hospitals and other

[6] "the [insurance] industry focused primarily on lump-sum payment policies to underwrite the expense of terminal illness and subsequent burial … policy proceeds were fixed and paid independent of whether ill workers actually purchased medical services. In fact, only about 1 percent of the $97 million in sickness benefits paid in 1914 went directly for medical care, a reflection of the primitive state of medicine in reducing morbidity and mortality … By 1930 medical expenses generally outstripped wage losses due to sickness, yet only 10 percent of the benefits paid under then-existing health insurance plans went to treatment costs." Feigenbaum (1997).

[7] "Fifty years ago, physicians were little more than diagnosticians, their activities being essentially 'limited to identification of … illness, the prediction of the likely outcome, and then the guidance of the patient and his family while the illness ran its full, natural course." Weisbrod (1991, p. 526), quoting the *Report of the President's Biomedical Research Panel 1976*.

[8] Pauly (1986, p. 642).

[9] Dread disease policies generally provide only supplemental coverage above and beyond standard health insurance benefits. American Family Life Insurance Assurance Company markets cancer policies that pay upon diagnosis; these products are especially popular in Japan. Mutual of Omaha offers a variety of products, including one that pays both an up-front benefit and reimbursement for treatment. Canada Life Assurance Co. offers lump-sum benefits on diagnosis of any of 12 diseases. These and other indemnity-like products are discussed in Panko (1999).

providers.[10] Arrow (1963) mentioned indemnities as one of three means of paying health insurance benefits.[11] Shortly thereafter, though, health insurance indemnities largely disappeared from the market and from the academic literature. Some came to view service-related benefits as *the* defining characteristic of health insurance. In the past thirty years, a small number of academic papers have suggested the use of indemnities in health insurance.[12] Pauly considered the absence of indemnities to be "puzzling."[13] Indemnities have reappeared in a few health insurance policies. As an experiment, one insurer recently offered certain cancer sufferers the ability to collect cash in lieu of treatments deemed to be futile. The indemnity was equal in value to the expected value of treatments.[14] This policy was inspired by the viatical contracts recently offered by some life insurers. A viatical allows a terminally ill person to collect in advance of his death the discounted value of a life insurance death benefit.[15]

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[10] Blue Cross's explicit goal was to shift expenditures toward hospitals, rather than to improve the health status of its subscribers (Feigenbaum 1997).

[11] Arrow (1963, p. 962).

[12] Pauly 1971; Pauly 1986; Gianfrancesco 1983; Feigenbaum 1997.

[13] "One puzzle is why indemnities are not more common. Only in dental insurance are benefits typically conditional on the submission and approval of a diagnosis and plan of treatment, which in a sense defines the 'illness' state. Perhaps the explanation is that for medical conditions, such pretreatment determination of the illness state may be more costly, or more likely to be in serious error; such procedures are quite uncommon in medical insurance. Other explanations are possible, of course—the medical profession may have been more successful in resisting such limits …, or moral hazard in unconstrained dental insurance may be that much worse." Pauly (1986, p. 642)

[14] This experiment was detailed in Trigon (1995). Non-small cell lung cancer patients were offered the option of aggressive treatments with a negligible probability of success or a cash indemnity equal to the expected cost of the treatments—an either-or proposition. Following is a statement from the study report: "Physicians also report discomfort in discussing treatment options, including the option of no treatment, with [patients]. Patients and their families seek hope and guidance from physicians who often respond in terms of statistical opportunity related to various treatment modalities. … As cost of medical care continues to be an issue of strong debate and discussion in American society, the value of clinical interventions for members of this patient population must be assessed. Although this can become an emotional and difficult issue to discuss, if clinical interventions produce no appreciable extension of life and no perceived benefit in terms of quality of life for these patients, could the money directed toward clinical interventions for these patients be better utilized in other ways by the patients themselves and, ultimately, by the providers?" For regulatory and other reasons, the peer group offered this option was small and produced fewer results than had been hoped for. The study was also reported in *Journal of the National Cancer Institute* (1996).

[15] Crites-Leoni and Chen (1997) and Kosiewicz (1998) discuss medical and legal aspects of viaticals.

It may be tempting to dismiss indemnity-based policies altogether in health insurance, where adverse selection is a huge problem, as are both flavors of moral hazard. The emotions associated with health care are also problematic; health care providers and insurers are hard-pressed to deny medical treatment and coverage to patients, even when those patients have pre-committed to abstain from service in a given circumstance. Many authors cite these and other characteristics to argue that health care markets behave differently from other markets. Certainly the problems in health care differ in degree, if not in quality, from those of other markets.

To some scholars, though, indemnities in homeowner and auto collision policies suggest some possible applications to health insurance. The typical homeowner, for instance, would not likely wish his insurer to help select his new wardrobe after a fire or even to require that he purchase a new wardrobe—perhaps he now prefers a boat. Yet this micro-management of spending behavior is analogous to the insurer's role in monitoring health care. However, we know very little about how or whether indemnity policies might work in health care markets. Yesterday's sickness/burial policies and today's isolated quasi-health indemnity policies (e.g., personal accident insurance) are too rare and limited to shed much light on the subject. The model in this paper attempts a very modest step in the direction of understanding how and whether indemnity policies might help improve health care and when they wouldn't.

1.4 Deductibles and Managed Care

Evidence shows that people consider cost when making their health care treatment decisions.[16] To an economist, the ideal in medicine is not to give treatment up to the point where the marginal benefit to the patient is zero; rather, the ideal is to equate marginal cost and benefit, a point that seems to run counter to some views expressed in the medical literature.[17] In many ways, our health care system recognizes that we cannot afford to provide medical care to all patients who might benefit. Experimental procedures may not be covered by insurance. Posters in restaurant windows ask passers-by to contribute to potential organ recipients. Battlefield triage is perhaps the most vivid indicator that survival rates guide the choice of who ought to receive medical resources.

One could argue that the disinterest in indemnities is part of a more general pattern of disinterest in demand-side incentives in health insurance. Until the 1980s, the health insurance literature focused on the search for ideal deductibles and copayments.[18] With the advent of widespread private and governmental health insurance, health care expenditures grew more rapidly than many wished; simultaneously the theoretical literature cast doubts on the whole notion of optimizing via consumer incentives.[19]

Between the 1960s and 1980s, health care spending rose dramatically as a percentage of GDP and had become a major item on the public policy agenda. Weisbrod (1991)

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[16] See Manning (1987).

[17] Glied and (1998) and Callahan (1990) survey differences between the views of medical and economics professionals on what constitutes appropriate objective functions.

[18] Ellis and McGuire (1993, p. 1356) said that the bulk of health economics research in the 1970s was in this area. Feldstein (1972) estimated the ideal deductible for minimizing the combined welfare losses from inadequate risk-pooling and from excessive insurance-induced health care expenditures. Manning et al. (1987) reported the results of the RAND Health Insurance Experiment, which strongly supported the existence and exploitability of downward-sloping demand curves in health care.

[19] Rothschild and Stiglitz (1976) and others raised concerns over whether stable equilibria in such markets would even exist. Glied (1998, p. 38) notes that one problem with demand-side incentives was that there were few dimensions on which plans could actually compete.

summarized the connections between overspending and insurance.[20] The role of moral hazard was mentioned by Glied (1994).[21]

Given the limited success of researchers in devising demand-side mechanisms for controlling costs, the focus in both the academic literature and in public policy shifted toward supply-side inducements to economize. Some looked toward a centralized model evident in Medicare and Medicaid; DRGs sorted medical procedures into a finite number of discrete categories, thereby setting the stage for *de facto* price controls. [22]

The other principal direction was managed care—a decentralized version of cost and expenditure controls intended to emulate a competitive equilibrium in health care and insurance. Managed care produced a wide range of supply-side inducements for cost containment,[23] generally involving inducements for providers to permanently enforce a situation of excess supply on the market.[24] Specific mechanisms for doing so include selection and organization of providers, methods for paying providers, and methods for monitoring service utilization (Glied 1998, pp. 4-5). Often, there are also some demand-side mechanisms, such as price differentials for in- and out-of-network providers.

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[20] "The expansion of health insurance has paid for the development of cost-increasing technologies, and … the new technologies have expanded demand for insurance." Weisbrod 1991, p. 524. Other papers exploring this interplay between insurance and technology include Cutler and Sheiner (1997); Ellis and McGuire (1993); Goddeeris (1984).

[21] In theory, moral hazard may also increase the rate of growth in health spending through its effects on the development and diffusion of new health care technologies. By reducing the costs to a consumer of using a new, costly technology, moral hazard expands the market for such innovations. At the same time, moral hazard may limit the market for innovations that promise to reduce costs. Glied (1994, p. 13)

[22] An important area of research toward this end was the development of resource-based relative value scales, which defined the value of medical care in terms of the quantity and quality of inputs. This literature was described in great detail in Hsiao et al. (1988) and 11 other articles contained in a special issue of *JAMA*.

[23] Managed care plans differ across many dimensions. A number of authors have devised taxonomies, of which Weiner and de Lissovoy (1993) is an example.

[24] Ellis and McGuire (1990) wrote that, "[Q]uantity demanded regularly exceeds quantity supplied in health maintenance organizations (HMOs), where on the margin, consumers often face no cost sharing."

After two decades of managed care, its weaknesses, too, are now apparent. There has been somewhat of a retreat from the idea that optimal insurance plans are likely to emerge solely from supply-side mechanisms. While seeking theoretical justifications for departing from a purely cost-based reimbursement (retrospective payment system), Ellis and McGuire drew from both the demand-side and supply-side literatures in investigating the theoretical advantages of combining mechanisms from both sides.[25]

In the policy arena, interest in demand-side mechanisms included the development of the Point of Service plans and Medical Savings Accounts. Ferrara (1995 and 1996) discusses MSAs in detail and, in the second paper, sketches the key characteristics of a number of such plans. In one typical plan, policyholders face a $3,000 deductible, so that all amounts less than that are 100% covered by patients on an out-of-pocket basis. The plan includes a catastrophic coverage provision so that expenses beyond the $3,000 deductible are completely covered. By imposing the full cost of small-ticket items on consumers, it discourages overuse of those services and, perhaps more importantly, the high administrative costs associated with small and frequent claims. On the negative side, the plan eliminates risk-pooling for these small-ticket items. The plan allows for complete risk-pooling for big-ticket items; but once again, consumers bear little or no marginal cost for big-ticket items and, thus, have incentive to overspend.

[25] "The problem of designing an optimal health care payment system must be recast when it is recognized that payment instruments on both the demand and the supply side can be used to attain the social goals of efficient utilization and minimization of patient financial risk. Neither the literature on optimal insurance nor the literature on optimal provider reimbursement takes account of the other side of the policy coin. Empirical evidence from the health sector leaves no doubt that both demand and supply-side payment practices influence utilization." Ellis and McGuire (1990), p. 393. Their argument is expanded in Ellis and McGuire (1993), where they argue that such a combined supply/demand mechanism is better than either separately at dealing with the pooling/moral hazard tradeoff.

2. The Model

We have introduced the notion of indemnity-based health insurance. Now, we construct a model that asks how such a contract would stack up against other insurance regimes. This model compares the welfare efficiency of two health insurance contracts, both of which induce some patients to seek treatment and others to opt out. And we can compare those two contracts with a regime of full insurance for all patients and one of zero insurance for anyone. In one contract, deductibles require patients to bear some out-of-pocket costs for treatment. In the other, cash indemnities compensate patients for abstaining from treatment.

Section 2.1 lays out the assumptions and notation for the model. There are well people (Ws) and sick people (Ss); Some Ss have a high cure rate (Hs) and others a low cure rate (Ls). We assume away adverse selection and *ex ante* moral hazard. This means that a person cannot hide the disease or his susceptibility to it; and he can neither prevent nor induce the disease, nor even affect his probability of contracting it. We also assume costless diagnosis.

Section 2.2 presents a criterion for determining whether indemnities or deductibles are more efficient at deterring Ls from treatment. By using a more specific utility function, Section 2.3 refines this criterion to an explicit function of the primitive parameters. By sacrificing some generality, this section also allows us to derive some rules of thumb—namely that the relative size of the L and H populations is a primary determinant of the relative efficiency of indemnities and deductibles. Once we have decided which is the more efficient mechanism for deterring Ls from treatment, Section 2.4 asks whether we wish to deter Ls; in some cases, we may instead wish to cover both

Hs and Ls or to cover neither. Finally, Section 2.5 discusses why the particular utility function used here was chosen.

2.1 Setup

Indemnities would be problematic for illnesses whose likelihood is partly in the control of the patient or whose presence is undetectable by the insurer. There are, however, illnesses that appear to strike randomly, that are observable to both patient and physician, and are expensive to treat.

These assumptions are restrictive, but not prohibitively so for a number of illnesses. An example might be a cardiovascular accident (CVA) or stroke.[26] The incidence of CVA is somewhat affected by long-term lifestyle and heredity, but the assumption of randomness isn't overly unrealistic. At least for a broad percentage of the population, the CVA comes with little warning—before its onset, no one knows if the victim is a W or an S. Once the CVA hits, the severity—one's status as an H or as an L—is objectively observable. Diagnosis and monitoring are not costless, but costs are small enough compared with treatment that we can ignore them. For an insurer, though, it is difficult to differentiate legally between Hs and Ls—a promise of coverage is valid for either. Some people may fall clearly into one category or the other, but defining the boundary is legally problematic. Our model assumes that treatment costs are identical for Hs and Ls; while this is unrealistic, it sets the bar higher for the model by saying "even if Ls are no more expensive to treat than Hs, it is still optimal to treat Hs and not Ls." Were we to assume higher treatment costs for Ls, such a finding would be more likely.

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[26] This example was suggested by my colleague, Dr. Richard Schieken, Chairman of the Department of Pediatric Cardiology at the Medical Campus of Virginia Commonwealth University.

Again, CVAs may be an appropriate illness for our model because adverse selection, *ex ante* moral hazard, and diagnosis and monitoring costs (relative to treatment costs) are all small enough for us to ignore. Similar conditions arguably hold for various mental illnesses (e.g., schizophrenia) and certain cancers (e.g., some leukemias).

The analysis presented here is limited to such illnesses. The model developed below defines criteria for judging the relative efficiency of deductibles and indemnities as demand-side rationing tools. We assume away many of the most important issues in health insurance—adverse selection, costly monitoring, etc. This simplifies the analysis but limits the findings to a limited range of insurable events where these assumptions are realistic. By sacrificing generality, we reduce the questions to a tractable set of problems and provide a foundation on which to build more general models in later papers. We assume the following:

[I] *Ex post* utility is a state-dependent Von Neumann-Morgenstern function where U(y; w)=U(y; s)+k, with $U_y>0$ and $U_{yy}<0$. y is *ex post* monetary wealth, w and s are the two values of a binary variable representing well and sick states, and k is a constant denoting the difference in utility between the two states for any y. This functional form means that utility is state-dependent, but marginal utility is not.

[II] The insurance policy protects against a single illness. It is a carveout—similar to a dread disease policy, although dread disease policies' benefits are often contingent upon a hospital stay or other medical service.

[III] Adverse selection is not an issue. All agents are equally likely to contract the illness. That probability is known both to subscribers and insurers.

[IV] There is no *ex ante* moral hazard; the presence or lack of insurance does not influence the behavior of insured parties *before* they contract the illness or, hence, the incidence of disease.

[V] Diagnosis is binary and unambiguous and requires no costly monitoring.

[VI] Sick people are classified as Hs or Ls, based on their probability of cure if treated. An individual's likelihood of cure, κ_H or κ_L, is costlessly observable by both the patient and the insurer. However, the prognosis is not legally verifiable, so patients can act on the information, but insurers cannot. The insurer cannot, for example, promise to pay for chemotherapy if the probability of cure is 5%, but not if it is 1%, though the patient may accept or decline treatment on the same basis. This is because patients cannot bind themselves to forgo treatment if they are Ls.

[VII] There are no loading costs or other fixed costs.

[VIII] The cost of treatment is large enough that no one can purchase it without insurance. In other words, there is no borrowing or capital market.

The driving force behind the model is that one's status as an H or an L is not legally verifiable. Insurers cannot mandate differential benefit payouts for the two groups. So, they must impose marginal costs large enough to deter the Ls, but not so high that it deters Hs. Forcing patients to reveal their preferences, though, prevents us from equating marginal utility of wealth across individuals, thus reducing welfare.

Notation falls into three general categories—primitive assumptions, contract parameters and *ex post* wealth, and welfare under different *modes*—the word used here to denote insurance regimes.

Initial conditions: These parameters define the state of the world:

π_W	percent of subscribers who are well
π_H	percent of subscribers who are sick and will experience a high cure rate if treated
π_L	percent of subscribers who are sick and will experience a low cure rate if treated
π_S	percent of subscribers who are sick: $\pi_H + \pi_L$
κ_H	the cure rate for Hs
κ_L	the cure rate for Ls
y_0	initial wealth of all agents
x	the cost of treatment
k	the welfare loss of having the disease; it is completely reversed if cured

Contract parameters (indemnities, deductibles, premiums) and *ex post* wealth:

i	A cash indemnity large enough to deter Ls from seeking treatment
i*	The minimum cash indemnity large enough to deter Ls from seeking treatment
d	A deductible large enough to deter Ls from seeking treatment
d*	The minimum deductible large enough to deter Ls from seeking treatment
p_{i*}	The insurance premium paid by all subscribers under the indemnity contract
p_{d*}	The insurance premium paid by all subscribers under the deductible contract
p_f	The insurance premium paid by all subscribers under the full-insurance contract
y	*ex post* wealth; y_0 minus premiums and deductibles paid or indemnities received

Welfare under different modes: Mode **H** is infeasible because insurers cannot be legally bound to refuse treatment if they are found to be Ls. **I**, **D**, **Z**, and **F** are feasible:

$\hat{U}_h$ Mode **H**: Hs 100% covered, Ls not treated; this mode is infeasible.
$\hat{U}_i$ Suboptimal indemnity; deters Ls, but not Hs, from seeking treatment.
$\hat{U}_{i*}$ Mode **I**: Optimal indemnity; deters Ls, but not Hs, from seeking treatment.
$\hat{U}_d$ Suboptimal deductible; deters Ls, but not Hs, from seeking treatment.
$\hat{U}_{d*}$ Mode **D**: Optimal deductible; deters Ls, but not Hs, from seeking treatment.
$\hat{U}_z$ Mode **Z**: Zero insurance; neither Hs and Ls are treated
$\hat{U}_f$ Mode **F**: Full insurance; treatment for Hs and Ls 100% covered
$\hat{U}$ MAX[$\hat{U}_{i*}$, $\hat{U}_{d*}$, $\hat{U}_z$, $\hat{U}_f$]; the optimal policy across all modes
U(-;w) State-dependent utility function in well state
U(-;s) State-dependent utility function in sick state

Importantly, these utility functions can be read as either social welfare functions or individual utility functions. Because no one knows his or her status (W, H, or L) ahead of time, the socially preferred contract is also the individual optimum. Insurers can offer zero insurance, full insurance, the optimal indemnity contract, a suboptimal indemnity contract, the optimal deductible contract, a suboptimal deductible contract; individuals will always find the socially optimal contract to be privately optimal, as well.

2.2 D/I Boundary Condition: General Case

Based on the above assumptions, Theorem 1 defines the boundary condition signaling whether the deductible mode **D** or the indemnity mode **I** is the more efficient means of inducing Ls, but not Hs, to opt out of medical treatment. Expected welfare differs under these two modes solely because of differences in the *ex post* wealth distribution; for all individuals, health is identical under these two modes. In both cases, Ws are well, all Hs are sick and treated (and a fraction κ_H cured), and all Ls are sick and untreated.

Theorem 1: The assumptions imply the D/I boundary condition $\hat{U}_{d*} \gtreqless \hat{U}_{i*}$ iff

$U(y_0-\pi_H x+\pi_H d^*;w)-U(y_0-\pi_H x-\pi_L i^*;w) \gtreqless \pi_S\kappa_L k$**, whose sign determines the relative**

efficiency of the optimal deductible contract and the optimal indemnity contract in deterring Ls from seeking medical treatment.

Theorem 1 is built on Propositions 1-5, shown below and proven in the Appendix. (P.1) states the level of welfare if mode **I** is adopted and the indemnity is set at the minimum deterrent indemnity i*. (P.2) states that the minimum deterrent indemnity is the optimal deterrent indemnity. (P.3) states the level of welfare if mode **D** is adopted and the deductible is set at the minimum deterrent deductible d*. (P.4) states that the minimum deterrent deductible is the optimal deterrent deductible. (P.5) derives the **D**/**I** boundary condition by combining (P.1) and (P.3) and is the key result of the paper.

(P.1) $\hat{U}_{i*} = U(y_0 - p_{i*}; w) - (p_S - p_H k_H - p_L k_L)k$, where $p_{i*} = \pi_H x + \pi_L i^*$

(P.2) $\hat{U}_{i*} > \hat{U}_i \ \forall \ i > i^*$

(P.3) $\hat{U}_{d*} = U(y_0 - p_{d*}; w) - (p_S - p_H k_H + p_H k_L)k$, where $p_{d*} = \pi_H x - \pi_H d^*$

(P.4) $\hat{U}_{d*} > \hat{U}_d \ \forall \ d > d^*$

(P.5) $\hat{U}_{d*} \gtreqless \hat{U}_{i*}$ iff $U(y_0 - \pi_H x + \pi_H d^*; w) - U(y_0 - \pi_H x - \pi_L i^*; w) \gtreqless \pi_S \kappa_L k$

Theorem 1 tells the insurer whether to offer an indemnity or deductible contract.

2.3 **D**/**I** Boundary Condition: Logarithmic Specification

Theorem 2 obtains stronger results by restricting the utility function to a logarithmic specification, where U(y; w)=ln(y) and U(y; s)=ln(y)-k. This yields a more explicit version of the **D**/**I** boundary condition obtained in Theorem 1, as well as enabling us to derive some rules of thumb that shed intuition on the **D**/**I** boundary condition.

Theorem 2: If utility is a logarithmic function U(y;w)=ln(y), the D/I boundary condition becomes $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $\frac{1+(\phi-1)\pi_L}{[\phi-(\phi-1)\pi_H]\phi^{\pi_H+\pi_L-1}} \overset{>}{\underset{<}{=}} 1$.

Theorem 2 is proven by Propositions 6-8, shown here and proven in the Appendix. (P.6) and (P.7) derive explicit terms for i* and d*, respectively. Using i* and d*, (P.8) derives the explicit **D/I** boundary condition.

(P.6) $i^* = \frac{(f-1)(y_0 - p_H x)}{1+(f-1)p_L}$, where $\phi=\exp(\kappa_L k)$

(P.7) $d^* = \frac{(f-1)(y_0 - p_H x)}{f-(f-1)p_H}$ where $\phi=\exp(\kappa_L k)$

(P.8) $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $\frac{1+(\phi-1)\pi_L}{[\phi-(\phi-1)\pi_H]\phi^{\pi_H+\pi_L-1}} \overset{>}{\underset{<}{=}} 1$

This boundary is a restricted version of the condition shown in (P.5) and again marks the point at which insurance subscribers are indifferent between the optimal indemnity policy and the optimal deductible policy. Later, we will use numerical example and graphics to illustrate the significance and behavior of this criterion.

Theorems 3, 4, and 5 derive some rules of thumb that emanate from Theorem 2. Theorem 3 shows that we can sometimes ascertain the relative efficiency of **D** and **I** merely by comparing the shares of Ls and Hs in the population; if Ls outnumber Hs, we will always prefer **D** to **I**. Theorem 4 shows that as the cure rate for Ls approaches zero, the **D**/**I** boundary condition collapses to a simple rule of thumb: if there are more Ls than Hs, use a deductible; if there are more Hs than Ls, use an indemnity (Theorem 3 only demonstrates the first half of Theorem 4.). Theorem 5 shows that the optimal indemnity i* is always larger than the optimal deductible d*, a fact that helps explain the behavior in

Theorems 3 and 4. Theorem 6 shows that the relative desirability of modes **F** and **I** depend solely on the relative size of the treatment cost x and the indemnity i*.

Theorem 3: If $p_L{}^3 p_H$, the optimal deductible policy is always more efficient than the optimal indemnity policy. This theorem consists of three propositions. (P.9) proves the equality, (P.10) the inequality, and (P.11) simply combines (P.9) and (P.10).

(P.9) If $\pi_L = \pi_H$, then $U_{d*} > U_{i*}$

(P.10) If $\pi_L > \pi_H$, then $U_{d*} > U_{i*}$

(P.11) If $\pi_L \geq \pi_H$, then $U_{d*} > U_{i*}$

Theorem 3, however, says nothing about how to decide between **D** and **I** if $\pi_L < \pi_H$. We will find that **D** is preferred if π_L is close to π_H, that **I** is preferred if π_L is *not* close to π_H. The meaning of "close" is defined formally by the **D**/**I** boundary condition but does not translate into any neat rules of thumb. However Theorem 4 shows that as the Ls' cure rate κ_L becomes small, so does "close."

Theorem 4/Proposition 12: In the limit, as the Ls' cure rate k_L approaches 0, the D/I boundary condition collapses to $\hat{U}_{i*} > \hat{U}_{d*}$ iff $p_H > p_L$.

(P.12) $\hat{U}_{i*} \gtreqless \hat{U}_{d*}$ iff $\pi_H \gtreqless \pi_L$

So, choosing between the deductible and indemnity contracts becomes simple if Ls are essentially hopeless cases. The insurer needs only to compare the population shares.

Theorem 5: The optimal indemnity is always larger than the optimal deductible.

(P.13) i*>d*

The intuition behind this is that an individual with a deductible policy must choose whether or not to seek treatment, he does so from a wealth level of y_0. If an individual with an indemnity policy must choose whether or not to seek treatment, she does so from a wealth level of y_0+i*. Thus, other things being equal, the person with the indemnity policy has a greater willingness to pay for treatment than does the person with the deductible policy. Thus, the reward for forgoing treatment must be larger for the one with the greater willingness to pay.[27] (Figure 4 in the Appendix offers an intuitive representation of this theorem.)

So, if the L and H populations are equal, indemnities will yield a less desirable wealth distribution than will deductibles. With even larger numbers of Ls, the problem becomes worse. Indemnities will only be desirable if Ls are few, relative to Hs.

2.4 **I** and **D** versus **Z** and **F**

The preceding theorems have demonstrated some of the intricacies of comparing the relative efficacy of deductible and indemnity contracts. But we have not yet addressed when we would wish to use either. The preferred contract is that one whose expected welfare is higher than all other feasible contracts, or:

(P.13) $\hat{U}=MAX(\hat{U}_{i*}, \hat{U}_{d*}, \hat{U}_z, \hat{U}_f)$

We now know from the boundary condition how to choose between **I** and **D**. Now, welfare under the more efficient of those two contracts must be compared with welfare under modes **Z** and **F**. Propositions 14 and 15 give the formula for welfare under those

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[27] This finding calls to mind the Willingness to Pay-Willingness to Accept literature from environmental economics [See Hanemann (1991) and Boyce et al. (1992). The WTP-WTA literature asks why people seem to value losses more highly than gains. (Here, the indemnity would pay for the loss of treatment, while the deductible would pay for the gain of a treatment.) In much of that literature, the mystery comes from the fact that small losses and small gains seem to differ so widely. Here, though, the losses and gains are so huge relative to wealth that there is little mystery in the outcome of this proposition. Simply put, the person accepting an indemnity is, upon diagnosis, far wealthier than the person considering the deductible, so the disparity in valuation is not surprising.

two modes. The derivations of these formulae should be obvious from inspection, so no proofs are provided.

(P.14) $\hat{U}_z = U(y_0; w) - \pi_S k$

(P.15) $\hat{U}_f = U(y_0 - p_f; w) - (\pi_S - \pi_H \kappa_H - \pi_L \kappa_L)k$, where $p_f = \pi_S x$

At this point, we can derive one final rule of thumb.

Theorem 6: The relative efficiency of modes F and I is determined solely by the relative size of the optimal indemnity i* and the cost of treatment x. More formally,

(P.16) $i^* \begin{smallmatrix} > \\ = \\ < \end{smallmatrix} x$ iff $\hat{U}_f \begin{smallmatrix} > \\ = \\ < \end{smallmatrix} \hat{U}_{i^*}$

You never want pay a patient more than the cost of treatment to forgo treatment. This is true even if you can prevent them from then purchasing treatment and pocketing the difference. The opposite inequality yields a somewhat less intuitive result. If Ls can be bribed into forgoing treatment for less than the cost of treatment, an indemnity contract will always be preferable to full insurance. The proof of this is in the Appendix.

2.5 Digression: Medical Insurance without Medicine

The model developed in this paper assumes that for a given level of wealth, utility depends on the state of health, but marginal utility of wealth (MUW) does not (assumption [1]). While this assumption is restrictive, it is not an unusual formulation in health economics papers. The assumption is employed here for several reasons, including simple practicality—the assumption lends itself to tractable solutions.

A more important reason is to focus solely on incentives for Ls to accept or forgo medical treatment; with certain utility functions (where assumption [1] does not hold), there is incentive to redistribute wealth between well and sick, even if medical treatment is not a consideration. We can best explain this distinction by positing a world in which there are no medical treatments, but there is medical insurance. In fact, “sickness” policies in the early twentieth century paid sick or dying individuals cash indemnities to cover burial costs and palliative care or to compensate the sick for their suffering. If assumption [1] holds, there can be no such flows with fair insurance, as we shall see.

Figures 1, 2, and 3 represent three different ways that one might postulate the state-dependent utility function in such a world. Figure 1 accords with assumption [1]; MUW is always equal in both states. In Figure 2, for any given level of wealth, the MUW is higher for sick people than for well people. Figure 3 shows the opposite case, where the MUW is higher for well people than for sick people.

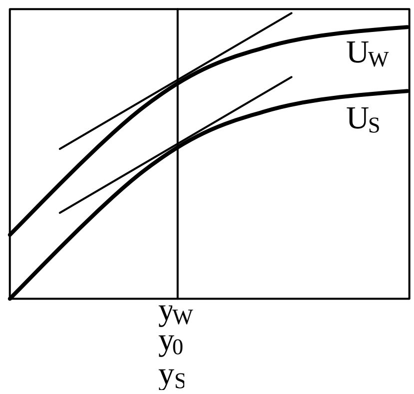

Figure 1
Marginal utility of wealth equal in well and sick states

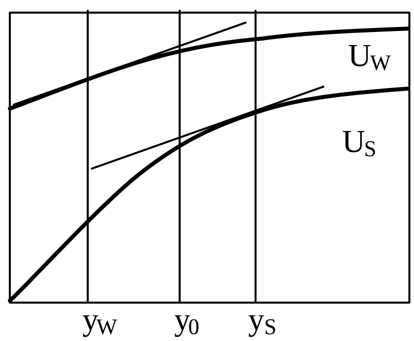

Figure 2
Marginal utility of wealth higher in sick state than in well state

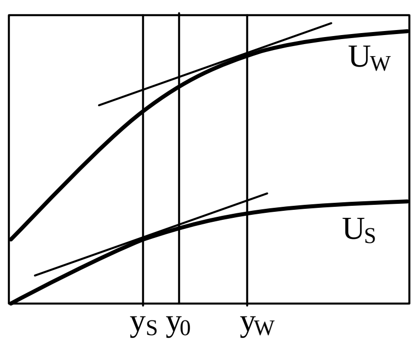

Figure 3
Marginal utility of wealth higher in well state than in sick state

In each of the three figures, y_0 is an individual's *ex ante* wealth, y_W is his *ex post* wealth if he turns out to be well, and y_S is his *ex post* wealth if he turns out to be sick. We assume this to be a fair insurance policy; all premiums paid in are later paid out as benefits (indemnities); so, $y_0-y_W=\pi_S(y_S-y_W)$ in Figure 2 and $y_0-y_S=\pi_S(y_W-y_S)$ in Figure 3.

In Figure 1, all three wealth levels are the same, meaning that premiums and payouts are both zero. This occurs because MUW in the two states is already equal, so once the subscribers know their health states, we are already at a Pareto optimum.

In Figure 2, MUW is always higher for Ss than for Ws. So, *ex ante*, all subscribers pay a premium of y_0-y_W. *Ex post*, those subscribers who are sick receive an indemnity of y_S-y_W thereby equalizing MUW between those in the two states. We can think of this as compensation for pain and suffering.

Figure 3 shows a more counterintuitive case. Here, the MUW is always higher for well people than for sick people with the same wealth. All subscribers pay a premium of y_0-y_S. Once the diagnoses are made, however, the insurance plan pays *well* people an indemnity of y_W-y_S. This indemnity seems a little odd in that it compensates well people for *lack of* pain and suffering.

Figures 2 and 3 may be more understandable in cases of intrafamily wealth redistribution. Suppose a person becomes untreatably ill and his family contributes to a fund to pay for pain-killers, hospice care, and airplane tickets for visiting family members. This is the Figure 2 case, and it presumes that a few extra dollars are more precious to the sick person than to the well relatives. Figure 3 is the opposite case: a person becomes a permanent invalid and turns some bank accounts over to her children and grandchildren on the logic that they are better able than she to enjoy the wealth.

Perhaps the Figure 3 case occurs within the families because of interpersonal utility functions or because the family structure creates implicit contracts which are enforceable because one's health condition and possessions are easily observable by other family members. Whatever the underlying logic and motivations, the Figures 2 and 3 worlds would confound the central issue of this paper—when do we want to exclude people from medical treatment, and how can we get them to self-select out of treatment?

3. Conclusion

We have modeled the relative advantages of indemnities and deductibles in discouraging the use of costly medical services by patients who receive small benefits from treatments. Under moderately restrictive conditions, several rules of thumb emerge. First, it will never be optimal for the insurer to offer deterrent indemnities that are larger than the cost of treatment. Second, if there are more Ls than Hs, insurers should use deductibles rather than indemnities. Third, if Hs substantially outnumber Ls, indemnities are more efficient than deductibles. Fourth, as the cure rate for Ls drops toward 0, the choice of indemnity policy or deductible policy approaches a simple matter of asking whether there are more Hs than Ls. Fifth, we can derive additional rules that determine whether the optimal deterrent mechanism improves on full insurance or zero insurance.

In future papers, we will want to expand this research by generalizing the model in several ways: (1) An important assumption here is that the utility cost of illness is invariant with respect to wealth. As presented in Section 2.5, other utility functions can make it harder or easier to justify indemnities. (2) We will want to examine how these findings hold up when there is a range of cure rates, rather than only two. We will also want to ask *whether*, in fact, prognoses tend to be massed at a few discrete points or spread across a continuum. The former could be the case if, for example, different prognoses result largely from discrete factors, such as the presence or absence of a comorbid condition. (3) Since adverse selection and *ex ante* moral hazard are prevalent with many illnesses, future research might quantify the *amount* of each that is consistent with an offer of indemnities. (4) Technological change is an important factor in health insurance markets, and we will want to examine how changes in the efficacy of treatments affect such markets.

It will also be important to do empirical research based on this model and variations on the model. Given the paucity of actual indemnities, such research poses some practical challenges. The likeliest source of data may come from examining how individuals of different wealth levels behave with respect to costly, risky treatments. Such information could either come from the self-insured or from patients whose illnesses are excluded from coverage (e.g., experimental treatments). Referring to Figure 4 in the Appendix, we could estimate a minimum deterrent deductible d* for people with income of y_0. Then, we could estimate the minimum deterrent deductible d** for people whose initial wealth endowment equals y_0+i*. If our model is correct, d** should coincide with i*.[28]

Perhaps the most important area of research would be to ask why it is that indemnities are so rare today in health insurance. If an indemnity contract is optimal for disease A and a deductible contract is optimal for disease B, why do we not see health insurance

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[28] This would conflict with the social psychology literature mentioned by Fuchs and Zeckhauser (1987, p.265). That literature, he notes, suggests “that individuals are risk averse with respect to gains but risk preferring with respect to losses” a condition that would drive a wedge between d* and i*.

unbundled into separate A and B policies? Several possible reasons come to mind. (1) The problem may be political. Paying a patient to forgo treatment is analytically equivalent to refusing to treat a patient unable or unwilling to pay the deductible. However, if these are perceived by the political system to be ethically different, then that perception may be sufficient reason to avoid indemnities. (2) Indemnity contracts may be more unstable dynamically in the wake of changes in technology, wealth, treatment costs, etc. (3) The time-inconsistency problem may be worse with indemnities than with deductibles. There may be a temptation for patients to seek treatment after receiving (and perhaps after spending) an indemnity. Fighting such cases in the legal system may be difficult for insurers from a public relations standpoint. (4) Perhaps adverse selection and *ex ante* moral hazard are simply too overwhelming and prevalent to permit indemnities. (5) Perhaps the boundaries between different diseases are also observable but not verifiable so that insurers and patients would engage in costly arguments over diagnosis.

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APPENDIX

Theorem 1: The assumptions imply the <u>D</u>/<u>I</u> boundary condition $\hat{U}_{d*} \gtreqless \hat{U}_{i*}$ iff

$U(y_0-\pi_H x+\pi_H d^*;w)-U(y_0-\pi_H x-\pi_L i^*;w) \gtreqless \pi_S \kappa_L k$**, whose sign determines the relative efficiency of the optimal deductible contract and the optimal indemnity contract in deterring Ls from seeking medical treatment.** Proof: Propositions 1-5.

Proposition 1: The minimum deterrent indemnity contract yields welfare of:

(P.1) $\hat{U}_{i*} = U(y_0 - p_{i*}; w) - (p_S - p_H k_H - p_L k_L)k$, where $p_{i*} = \pi_H x + \pi_L i^*$

Equation (1.1) defines an indemnity i* where Ls who have already been diagnosed are indifferent between the indemnity and fully covered medical treatment:

(1.1) $U(y_0 - p_{i*} + i^*; s) = \kappa_L U(y_0 - p_{i*}; w) + (1-\kappa_L) U(y_0 - p_{i*}; s)$

(1.1) is really a limit, since the left-hand side should be at least an epsilon larger than the right-hand side to assure that Ls refuse treatment.[29] By assumption [1] (1.1) becomes:

(1.2) $U(y_0 - p_{i*} + i^*; w) - k = \kappa_L U(y_0 - p_{i*}; w) + (1-\kappa_L) U(y_0 - p_{i*}; s) - (1-\kappa_L)k$, so

(1.3) $U(y_0 - p_{i*} + i^*; w) = U(y_0 - p_{i*}; w) + \kappa_L k$

Since Ls are deterred from seeking treatment, expected utility for all agents becomes:

(1.4) $\hat{U}_{i*}=(\pi_W+\pi_H\kappa_H)U(y_0-p_{i*};w)+\pi_H(1-\kappa_H)[U(y_0-p_{i*};w)-k]+\pi_L[U(y_0-p_{i*}+i^*;w)-k]$

$=(\pi_W+\pi_H)U(y_0-p_{i*};w)+\pi_L U(y_0-p_{i*}+i;w)-[\pi_S-\pi_H\kappa_H]k$

$(\pi_W+\pi_H\kappa_H)U(y_0-p_{i*};w)$ is the contribution to expected utility of Ws and of Hs who are cured; $\pi_H(1-\kappa_H)[U(y_0-p_{i*};w)-k]$ represents the utility contribution of those Hs who are treated but are not cured; $\pi_L[U(y_0-p_{i*}+i^*;w)-k]$ represents the Ls, who are paid i* to forgo treatment and thus remain sick. Substituting (1.3) into (1.4),

(1.5) $$\hat{U}_{i*}=(\pi_W+\pi_H)U(y_0-p_{i*};w)+\pi_L[U(y_0-p_{i*};w)+\kappa_L k]-[\pi_S-\pi_H\kappa_H]k$$

$$=U(y_0-p_{i*};w)-[\pi_S-\pi_H\kappa_H-\pi_L\kappa_L]k \text{ [Q.E.D.]}$$

Proposition 2: The minimum deterrent indemnity is the optimal indemnity, or:

(P.2) $\hat{U}_{i*}>\hat{U}_i \;\forall\; i>i^*$

Replacing i* with an arbitrary $i \geq i^*$ in (1.4) results in:

(2.1) $\hat{U}_i=(\pi_W+\pi_H)U(y_0-p_i;w)+\pi_L U(y_0-p_i+i;w)-[\pi_S-\pi_H\kappa_H]k,$ and

(2.2) $$\frac{\partial \hat{U}_i}{\partial i}=\left(\pi_W+\pi_H\right)\frac{\partial \hat{U}_i\left(y_0-p_i;w\right)}{\partial i}+\pi_L\frac{\partial \hat{U}_i\left(y_0-p_i+i;s\right)}{\partial i}$$

Remember assumption [1] and note that $\partial p_i/\partial i=-\pi_L$ and $\pi_W+\pi_H=(1-\pi_L)$; (2.2) becomes:

(2.3) $$\frac{\partial \hat{U}_i}{\partial i}=\left(1-\pi_L\right)\frac{\partial \hat{U}_i\left(y_0-p_i;w\right)}{\partial\left(y_0-p_i\right)}\frac{\partial\left(y_0-p_i\right)}{\partial i}+\pi_L\frac{\partial \hat{U}_i\left(y_0-p_i+i;w\right)}{\partial\left(y_0-p_i+i\right)}\frac{\partial\left(y_0-p_i+i\right)}{\partial i}$$
$$=-\pi_L\left(1-\pi_L\right)\frac{\partial \hat{U}_i\left(y_0-p_i;w\right)}{\partial\left(y_0-p_i\right)}+\pi_L\left(1-\pi_L\right)\frac{\partial \hat{U}_i\left(y_0-p_i+i;w\right)}{\partial\left(y_0-p_i+i\right)}$$

This expression is negative iff:

(2.4) $$\frac{\partial \hat{U}_i\left(y_0-p_i+i;w\right)}{\partial\left(y_0-p_i+i\right)}<\frac{\partial \hat{U}_i\left(y_0-p_i;w\right)}{\partial\left(y_0-p_i\right)}$$

which is true, since agents experience diminishing marginal utility of wealth. [Q.E.D.]

Proposition 3: The minimum deterrent deductible contract yields welfare of:

(P.3) $\hat{U}_{d*}=U\left(y_0-p_{d*};w\right)-\left(p_S-p_H k_H+p_H k_L\right)k$, where $p_{d*}=\pi_H x-\pi_H d^*$

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[29] (1.1) is depicted graphically in Figure 4 below.

The minimum deterrent deductible d* makes Ls indifferent between purchasing and not purchasing medical treatment. This yields (3.1)[30] and, equivalently, (3.2) and (3.3):

(3.1) $U(y_0 - p_{d*}; s) = \kappa_L U(y_0 - p_{d*} - d^*; w) + (1 - \kappa_L) U(y_0 - p_{d*} - d^*; s)$

(3.2) $U(y_0 - p_{d*}; w) - k = \kappa_L U(y_0 - p_{d*} - d^*; w) + (1 - \kappa_L)\left[U(y_0 - p_{d*} - d^*; w) - k\right]$

(3.3) $U(y_0 - p_{d*} - d^*; w) = U(y_0 - p_{d*}; w) - \kappa_L k$

Expected utility under the minimal deterrent deductible contract is:

(3.4)
$$\begin{aligned} \hat{U}_{d*} &= \pi_W U(y_0 - p_{d*}; w) + \pi_H \kappa_H U(y_0 - p_{d*} - d^*; w) \\ &\quad + \pi_H (1 - \kappa_H) U(y_0 - p_{d*} - d^*; s) + \pi_L U(y_0 - p_{d*}; s) \\ &= (\pi_W + \pi_L) U(y_0 - p_{d*}; w) + \pi_H U(y_0 - p_{d*} - d^*; w) - \left[\pi_L + \pi_H (1 - \kappa_H)\right] k \end{aligned}$$

Substituting (3.3) into (3.4) and consolidating:

(3.5) $\hat{U}_{d*} = U(y_0 - p_{d*}; w) - (p_S - p_H k_H + p_H k_L)k$, with $p_{d*} = \pi_H x - \pi_H d^*$ [Q.E.D.]

Proposition 4: The minimum deterrent deductible is the optimal deductible, or:

(P.4) $\hat{U}_{d*} > \hat{U}_d \ \forall \ d > d^*$

In (3.4), replace d* with $d \geq d^*$. $\pi_W + \pi_L = 1 - \pi_H$ and assumption [1] holds, so:

(4.1) $$\frac{\partial \hat{U}_d}{\partial d} = (1 - \pi_H) \frac{\partial \hat{U}(y_0 - p_d; w)}{\partial (y_0 - p_d)} \frac{\partial (y_0 - p_d)}{\partial d} + \pi_H \frac{\partial \hat{U}(y_0 - p_d - d; w)}{\partial (y_0 - p_d - d)} \frac{\partial (y_0 - p_d - d)}{\partial d}$$

(4.2) $$\frac{\partial \hat{U}_d}{\partial d} = \pi_H (1 - \pi_H) \frac{\partial \hat{U}(y_0 - p_d; w)}{\partial (y_0 - p_d)} - \pi_H (1 - \pi_H) \frac{\partial \hat{U}(y_0 - p_d - d; w)}{\partial (y_0 - p_d - d)}$$

The derivative at right is larger than the derivative at left, so (4.1) is negative. [Q.E.D.]

Proposition 5: The deductible/indemnity boundary condition is:

[30] (3.1) is depicted graphically in Figure 4 below.

(P.5) $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $U(y_0 - p_{d*};w) - U(y_0 - p_{i*};w) \overset{>}{\underset{<}{=}} \pi_S \kappa_L k$

The proof can be seen by inspection; it is merely a comparison of the expressions in (P.1) and (P.3). (P.5) completes Theorem 1 and is the key result of the paper. [Q.E.D.]

Theorem 2: If utility is a logarithmic function U(y;w)=ln(y), the <u>D</u>/<u>I</u> boundary condition becomes $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $\frac{1+(\phi-1)\pi_L}{[\phi-(\phi-1)\pi_H]\phi^{\pi_H+\pi_L-1}} \overset{>}{\underset{<}{=}} 1$. Proof: Propositions 6-8.

Proposition 6: With a logarithmic utility function, the optimal indemnity is

(P.6) $i* = \frac{(f-1)(y_0 - p_H x)}{1+(f-1)p_L}$, where $\phi=\exp(\kappa_L k)$.

Ls are indifferent between medical treatment and the minimal indemnity in (1.3) which, restated logarithmically, becomes:

(6.1) $ln(y_0 - p_{i*} + i*) = ln(y_0 - p_{i*}) + \kappa_L k$

Note that $p_{i*}=\pi_H x+\pi_L i*$, and take the natural antilogarithm of each side:

(6.2) $(y_0 - p_H x - p_L i* + i*) = f(y_0 - p_H x - p_L i*)$, where $f = e^{k_L k}$, and successively:

(6.3) $(y_0 - p_H x) + (1-p_L)i* = f(y_0 - p_H x) - f p_L i*$

(6.4) $(f-1)(y_0 - p_H x) = [1+(f-1)p_L]i*$

(6.5) $i* = \frac{(f-1)(y_0 - p_H x)}{1+(f-1)p_L}$, [Q.E.D.]

Proposition 7: With a logarithmic utility function, the optimal deductible is:

(P.7) $d* = \frac{(f-1)(y_0 - p_H x)}{f-(f-1)p_H}$

Ls are indifferent between medical treatment (with an out-of-pocket deductible) or forgoing treatment in (3.1) which, restated logarithmically, is:

(7.1) $ln\left(\mathrm{y}_0 - \mathrm{p}_{\mathrm{d}*} - \mathrm{d}*\right) = ln\left(\mathrm{y}_0 - \mathrm{p}_{\mathrm{d}*}\right) - \kappa_{\mathrm{L}}\mathrm{k}$

Note that $\mathrm{p}_{\mathrm{d}*}=\pi_{\mathrm{H}}\mathrm{x}-\pi_{\mathrm{L}}\mathrm{d}*$, and take the natural antilogarithm of each side:

(7.2) $\left(y_0 - p_H x + p_H d*\right) = \left(y_0 - p_H x + p_H d* - d*\right)f$, where again, $f = e^{k_L k}$, then:

(7.3) $\left(y_0 - p_H x\right) + p_H d* = f\left(y_0 - p_H x\right) + f\left(p_H - 1\right)d*$

(7.4) $d* = \dfrac{(f-1)\left(y_0 - p_H x\right)}{f - (f-1)p_H}$. [Q.E.D.]

Proposition 8: With a logarithmic utility function, the D/I boundary condition is:

(P.8) $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $\dfrac{1+(\phi-1)\pi_{\mathrm{L}}}{\left[\phi-(\phi-1)\pi_{\mathrm{H}}\right]\phi^{\pi_{\mathrm{H}}+\pi_{\mathrm{L}}-1}} \overset{>}{\underset{<}{=}} 1$

Restate the **D/I** boundary condition from Theorem 1 (Proposition 5) logarithmically:

(8.1) $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $\ln\left(y_0 - p_H x + p_H d*\right) - \ln\left(y_0 - p_H x - p_L i*\right) \overset{>}{\underset{<}{=}} p_S k_L k$

Taking the exponential of the right-hand side equation leaves the sign unchanged, so

(8.2) $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $\dfrac{y_0 - p_H x + p_H d*}{y_0 - p_H x - p_L i*} \overset{>}{\underset{<}{=}} e^{p_S k_L k}$

With $f = e^{k_L k}$, substitute in i* from (6.5) and d* from (7.4). Then, (8.2) becomes:

(8.3) $\hat{U}_{d*} \overset{>}{\underset{<}{=}} \hat{U}_{i*}$ iff $\dfrac{\left(y_0 - p_H x\right) + p_H \dfrac{\left(y_0 - p_H x\right)(f-1)}{f-(f-1)p_H}}{\left(y_0 - p_H x\right) - p_L \dfrac{\left(y_0 - p_H x\right)(f-1)}{1+(f-1)p_L}} \overset{>}{\underset{<}{=}} f^{p_S}$ and, successively:

(8.4) $$\hat{U}_{d*} \gtreqless \hat{U}_{i*} \text{ iff } \frac{(y_0 - p_H x)\left[1 + \frac{p_H (f-1)}{f-(f-1)p_H}\right]}{(y_0 - p_H x)\left[1 - \frac{p_L (f-1)}{1+(f-1)p_L}\right]} \gtreqless f^{p_s}$$

(8.5) $$\hat{U}_{d*} \gtreqless \hat{U}_{i*} \text{ iff } \frac{(y_0 - p_H x)\left[\frac{f-(f-1)p_H + p_H (f-1)}{f-(f-1)p_H}\right]}{(y_0 - p_H x)\left[\frac{1+(f-1)p_L - p_L (f-1)}{1+(f-1)p_L}\right]} \gtreqless f^{p_s}$$

(8.6) $$\hat{U}_{d*} \gtreqless \hat{U}_{i*} \text{ iff } \frac{\left[\frac{f}{f-(f-1)p_H}\right]}{\left[\frac{1}{1+(f-1)p_L}\right]} \gtreqless f^{p_s}$$

(8.7) $$\hat{U}_{d*} \gtreqless \hat{U}_{i*} \text{ iff } \frac{1+(\phi-1)\pi_L}{[\phi-(\phi-1)\pi_H]\phi^{\pi_H+\pi_L-1}} \gtreqless 1$$

The boundary condition is a function only of π_H, π_L, κ_L, and k. [Q.E.D.]

Theorem 3: If $p_L{}^3 p_H$, the optimal deductible policy is always more efficient than the optimal indemnity policy. Proof: Propositions 9-11.

(P.9) If p_H=p_L, then $U_{d*} > U_{i*}$

If we set π_H=π_L, we can rearrange and (8.7) to be:

(9.1) $$\hat{U}_{d*} \gtreqless \hat{U}_{i*} \text{ iff } \phi[1+(\phi-1)\pi_L] \gtreqless [\phi-(\phi-1)\pi_L]\phi^{2\pi_L},$$

For Proposition 9 only, we adopt several notational conventions. We use a to represent κ_Lk, so a=κ_Lk and $\phi=e^a$. And we use λ and ρ, respectively, to represent the left-hand side and right-hand side of (9.1). (9.1) becomes:

(9.2) $$\hat{U}_{d*} \gtreqless \hat{U}_{i*} \text{ iff } \lambda \gtreqless \rho, \quad \text{or equivalently iff } e^a[1+(e^a-1)\pi_L] \gtreqless [e^a-(e^a-1)\pi_L]e^{a2\pi_L}$$

From this, we will prove (P.9). The proof is lengthy, so Figure 4 provides a roadmap. To prove (P.9), we will show that: **[1]** $\pi_L \in (0,.5)$; **[2]** if $\pi_L=0$, $\lambda=\rho=\phi$; **[3]** if $\pi_L=.5$, $\lambda=\rho=.5\phi(\phi+1)$ **[4]** λ is increasing and linear in π_L; **[5]** ρ is increasing in π_L and strictly convex over the relevant range; **[6]** Therefore, $\lambda>\rho$ over the relevant range, so $\hat{U}_{d*} > \hat{U}_{i*}$.

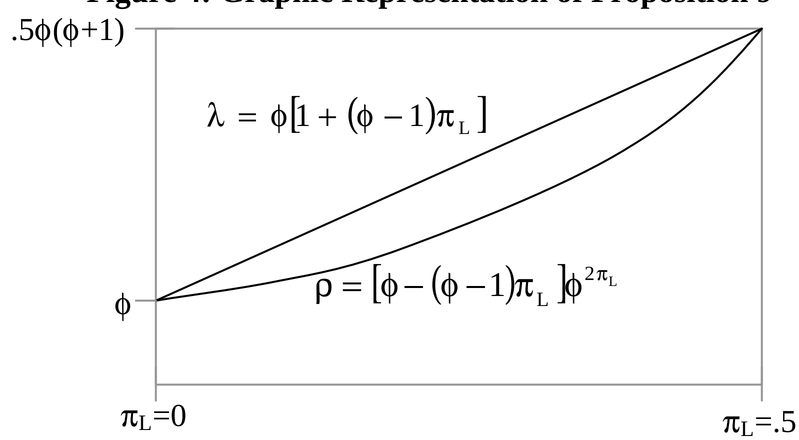
[1] through **[4]** can all be demonstrated by inspection. **[1]** $\pi_L \in (0,.5)$. If $\pi_L=\pi_H=0$, there are no sick people. If $\pi_L=\pi_H=.5$, there are *only* sick people. Therefore, the actual population shares must lie between the two. **[2]** and **[3]** can be shown by plugging the values $\pi_L=\pi_H=0$ and $\pi_L=\pi_H=.5$ into λ and ρ. Thus, the two curves coincide at the extreme values of π_L. **[4]** Since $\partial?/\partial p_L=\lambda'=\phi(\phi-1)$ and $\partial^2?/\partial p_L^2=\lambda?=0$, λ is linear in π_L. [Throughout this section, superscripts of ', '', and ''' will indicate the 1st, 2nd, and 3rd derivatives with respect to π_L.]

[5] requires us to prove two lemmae. Lemma 9.1 shows that ρ is upward-sloping. Lemma 9.2 shows that ρ is strictly convex to the axis.

Lemma 9.1: r is an increasing function of p L.

According to our notational conventions:

Figure 4: Graphic Representation of Proposition 9



(9.3) $\rho = [\phi - (\phi - 1)\pi_L]\phi^{2\pi_L} = [e^a - \pi_L e^a + \pi_L]e^{a2\pi_L}$

We further define the bracketed term as a function $Q(\pi_L, a)$, so:

(9.4) $\rho = Qe^{a2\pi_L}$

so, $\rho \underset{<}{\overset{>}{=}} 0$ iff $Q \underset{<}{\overset{>}{=}} 0$, which is true by inspection. From (9.3), we can derive:

(9.5) $\rho' = Q2ae^{a2\pi_L} + Q'e^{a2\pi_L}$, and dividing the right-hand side by $e^{a2\pi_L}$:

(9.6) $\rho' > 0$ iff $Q2a + Q' > 0$.

From (9.3) we can derive:

(9.7) $Q' = 1 - e^a < 0$, since a>0.

So for $\pi_L \in [0,.5]$, Q is at its minimum at $\pi_L = .5$. Substituting this value into (9.3) yields:

(9.8) $MIN[Q] = Q(.5, a) = .5(e^a + 1) > 0$

From (9.5), ρ' is an increasing function of Q and is at its minimum when $Q(\pi_L = .5)$.

Substituting (9.7) and (9.8) into (9.6)

(9.9) $Q2a + 1 - e^a = \frac{e^a + 1}{2} 2a + 1 - e^a = (e^a + 1)a + 1 - e^a = e^a a + a + 1 - e^a$

If (9.9) is positive for all a>0 and for all π_L, then ρ is upward-sloping. If a=0, (9.9) equals 0. And to find the sign of (9.9) for a>0:

(9.10) $\frac{\partial}{\partial a}[e^a a + a + 1 - e^a] = e^a a + e^a + 1 - e^a = e^a a + 1 > 0$ for a≥0.

So from (9.10) we know that (9.9) is always positive for relevant a and π_L. If (9.9) is positive, then we know from (9.6) that $\rho' > 0$, thus proving Lemma 9.1. [Q.E.D]

Lemma 9.2: r **is strictly convex to the axis.**

Strict convexity requires $\rho'' > 0$ for all $\pi_L \in (0,.5)$. From (9.5) we derive:

(9.11) $\rho'' = 2a\left[Q2ae^{a2\pi_L} + Q'e^{a2\pi_L}\right] + Q'2ae^{a2\pi_L} + Q''e^{a2\pi_L}$

From (9.7), we see that:

(9.12) $Q'' = 0$. Substituting this into (9.12):

(9.13) $\rho'' = 2a\left[Q2ae^{a2\pi_L} + Q'e^{a2\pi_L}\right] + Q'2ae^{a2\pi_L}$, so

(9.14) $\rho'' > 0$ iff $2a\left[Q2ae^{a2\pi_L} + Q'e^{a2\pi_L}\right] + Q'2ae^{a2\pi_L} > 0$

Consolidating terms and dividing through by $4ae^{a2\pi_L}$:

(9.15) $\rho'' > 0$ iff $Qa + Q' > 0$, and since Q''=0

(9.16) $\rho''' = aQ' < 0$

From (9.7) and (9.16), Qa+Q' is at a minimum when π_L=.5. Substituting (9.8) into (9.16):

(9.17) $\rho'' > 0$ iff $.5\left(e^a + 1\right)a + \left(1 - e^a\right) > 0$, or, consolidating and multiplying by 2:

(9.18) $e^a a + a + 2 - 2e^a > 0 \Leftrightarrow \rho'' > 0$, And,

(9.19) $a=0 \Rightarrow e^a a + a + 2 - 2e^a = 0$. Taking the derivative,

(9.20) $\frac{\partial}{\partial a} e^a a + a + 2 - 2e^a = e^a a + e^a + 1 - 2e^a = e^a a + 1 - e^a$,

so from (9.19) and (9.20)

(9.21) $e^a a + 1 - e^a > 0 \Rightarrow e^a a + a + 2 - 2e^a > 0$

(9.22) $a=0 \Rightarrow e^a a + 1 - e^a = 0$. And

(9.23) $\frac{\partial}{\partial a} e^a a + 1 - e^a = e^a a + e^a - e^a = e^a a > 0$

so from (9.22) and (9.23),

(9.24) $a>0 \Rightarrow e^a a + 1 - e^a > 0$

Now, through a chain of logic including (9.24), (9.21), and (9.18):

(9.25) $a>0 \Rightarrow e^a a + 1 - e^a > 0 \Rightarrow e^a a + a + 2 - 2e^a > 0 \Rightarrow \rho'' > 0$

This proves Lemma (9.2), so ρ is strictly convex to the x-axis. Thus, for all $\pi_L = \pi_H \in (0,.5)$, ρ lies strictly below λ. π_L, $\pi_L = \pi_H$ thus implies that a deductible policy is strictly preferred to an indemnity policy, proving Proposition 9. [Q.E.D.]

Proposition 10 uses Proposition 9 to demonstrate a similar result in inequality form:

(P.10) If $\pi_L > \pi_H$, then $U_{d*} > U_{i*}$

If $\pi_L > \pi_H$, then (8.8) becomes

(10.1) $$\frac{1+(f-1)(p_{L*}+x)}{f-(f-1)(p_{L*}-x)} > f^{2p_{L*}-1}$$

where $\pi_L = \pi_{L*} + \xi$ and $\pi_H = \pi_{L*} - \xi$ and ξ is some constant. Now, we can compare the expected utilities of $(\pi_L, \pi_H) = (\pi_{L*}, \pi_{L*})$ and $(\pi_L, \pi_H) = (\pi_{L*}+\xi, \pi_{L*}-\xi)$. RHS can be written as $f^{p_{L*}+x+p_{L*}-x-1}$, and this does not change as ξ changes. The LHS is

(10.2) $$\frac{1+(f-1)(p_{L*}+x)}{f-(f-1)(p_{L*}-x)},$$ and taking the derivative:

(10.3) $$\frac{\partial}{\partial \xi}\frac{1+(\phi-1)(\pi_{L*}+\xi)}{\phi-(\phi-1)(\pi_{L*}-\xi)} = \frac{(\phi-1)[\phi-(\phi-1)(\pi_{L*}-\xi)]-(\phi-1)[1+(\phi-1)(\pi_{L*}+\xi)]}{[\phi-(\phi-1)(\pi_{L*}-\xi)]^2}$$

The sign of this depends on the sign of the numerator, which we can divide by ϕ-1:

(10.4) $[\phi-(\phi-1)(\pi_{L*}-\xi)]-[1+(\phi-1)(\pi_{L*}+\xi)]$

which reduces to

(10.5) $\phi-(\phi-1)(\pi_{L*}-\xi)-1-(\phi-1)(\pi_{L*}+\xi)] = (\phi-1)(1-2\pi_{L*})$

Since $\phi>1>2\pi_L$, (10.5) is positive. As π_L increases from π_{L*}, the RHS expression also increases. Since a deductible is preferred if $\pi_L = \pi_L$, therefore, a deductible is preferred at $(\pi_L, \pi_H) = (\pi_{L*}, \pi_{L*})$ or at any $(\pi_L, \pi_H) = (\pi_{L*}+\xi, \pi_{L*}-\xi)$, [Q.E.D.]

Proposition 11 combines Propositions 9 and 10 to prove Theorem 3:

(P.11) If $\pi_L \geq \pi_H$, then $U_{d*} > U_{i*}$ [Q.E.D.]

Theorem 4/Proposition 12: In the limit, as the Ls' cure rate k_L approaches 0, the <u>D</u>/<u>I</u> boundary condition collapses to $\hat{U}_{i*} > \hat{U}_{d*}$ iff $p_H > p_L$. Proof: Proposition 12.

If we are indifferent between the optimal deductible and indemnity contracts, then (8.8) says that:

$$(12.1) \quad \frac{\phi^{-\pi_L}\left[1+\phi\pi_L-\pi_L\right]}{\phi^{\pi_H}\left[1+\phi^{-1}\pi_H-\pi_H\right]}=1$$

In this case, it is also true that:

$$(12.2) \quad \frac{m(\phi)}{n(\phi)}=\frac{\phi^{-\pi_L}\left[1+\phi\pi_L-\pi_L\right]-1}{\phi^{\pi_H}\left[1+\phi^{-1}\pi_H-\pi_H\right]-1}=1$$

If this function holds, then ϕ, π_H, and π_L are such that we are indifferent between <u>**I**</u> and <u>**D**</u>.

l'Hôpital's Rule states that:

$$(12.3) \quad \lim_{f\to 1}\frac{m(f)}{n(f)}=\lim_{f\to 1}\frac{m'(f)}{n'(f)} \text{ if } \lim_{\phi\to 1} m(\phi)=\lim_{\phi\to 1} n(\phi)=0$$

So take the derivatives of m and n with respect to ϕ and divide m′ by n′:

$$(12.4) \quad \frac{m'(\phi)}{n'(\phi)}=\frac{\left[\phi^{-\pi_L}\right]\left[\pi_L\right]+\left[-\pi_L\phi^{-\pi_L-1}\right]\left[1+\phi\pi_L-\pi_L\right]}{\left[\phi^{\pi_H}\right]\left[-\phi^{-2}\pi_H\right]+\left[\pi_H\phi^{\pi_H-1}\right]\left[1+\phi^{-1}\pi_H-\pi_H\right]}$$

$$=\frac{\pi_L\phi^{-\pi_L}\left[1-\phi^{-1}-\pi_L+\phi^{-1}\pi_L\right]}{\pi_H\phi^{\pi_H-1}\left[1-\phi^{-1}-\pi_H+\phi^{-1}\pi_H\right]}$$

$$=\frac{\pi_L\phi^{-\pi_L}\left(1-\phi^{-1}\right)\left(1-\pi_L\right)}{\pi_H\phi^{\pi_H-1}\left(1-\phi^{-1}\right)\left(1-\pi_H\right)}$$

$$=\frac{\pi_L\phi^{-\pi_L}\left(1-\pi_L\right)}{\pi_H\phi^{\pi_H-1}\left(1-\pi_H\right)}$$

So, applying l'Hôpital's Rule:

(12.5) $$\lim_{\phi \to 1} \frac{\pi_L \phi^{-\pi_L}\left(1-\pi_L\right)}{\pi_H \phi^{\pi_H - 1}\left(1-\pi_H\right)} = \frac{\pi_L\left(1-\pi_L\right)}{\pi_H\left(1-\pi_H\right)}$$

Since ϕ=exp(κ_Lk), $\lim_{k_L \to 1} f = 1$, so, from (12.5), we can also conclude that:

(12.6) $$\lim_{k_L \to 0} \frac{p_L f^{-p_L}\left(1-p_L\right)}{p_H f^{p_H - 1}\left(1-p_H\right)} = \frac{p_L\left(1-p_L\right)}{p_H\left(1-p_H\right)}$$

(12.2) holds if the indemnity and deductible policies are equally efficient. (12.7) says that as the Ls' cure rate approaches 0, we will be indifferent where π_H is approximately equal to π_L. The choice of indemnity or deductible becomes simple. If $\pi_H<\pi_L$, use a deductible policy. If π_L is more than slightly less than π_H, use an indemnity policy.

Theorem 5: The optimal indemnity is always larger than the optimal deductible.

(P.13) i*>d*

Subtracting (P.7) from (P.6):

(13.1) $$i^* - d^* = \frac{(f-1)(y_0 - p_H x)}{1+(f-1)p_L} - \frac{(f-1)(y_0 - p_H x)}{f-(f-1)p_H}$$

Since the numerators of the two terms are identical, the sign of this expression equals the opposite sign of the difference of the denominators:

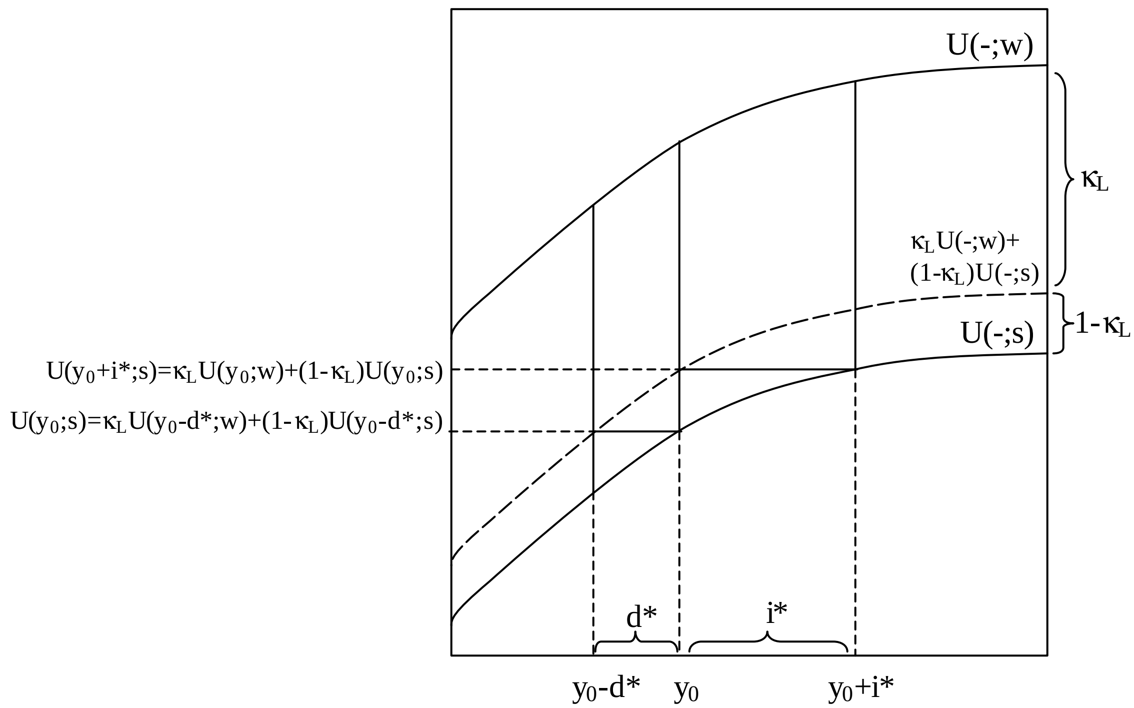
(13.2) $$\operatorname{sgn}(i^* - d^*) = \operatorname{sgn}\left(\left[f-(f-1)p_H\right]-\left[1+(f-1)p_L\right]\right)$$

$$=(1-f)(1-p_S)$$

This expression is negative because ϕ>1 and π_S<1. i* is always greater than d*. [Q.E.D.]

Figure 5 depicts equations (1.1), (3.1), and (13.2). There are two horizontal lines representing expected utility of Ls only under different contracts. The upper of the two, equivalent to (1.1) shows the Ls' expected utility if treated equals Ls' expected utility if they are not treated but receive i*. The lower line shows Ls' expected utility if they are treated (at a marginal cost of d*) and if they are not treated. It is easy to see from the diagram why the i*>d*.

Figure 5: Graphic Representation of Theorem 5



Theorem 6: The relative efficiency of modes <u>F</u> and <u>I</u> is determined solely by the relative size of the optimal indemnity i* and the cost of treatment x. More formally,

(P.16) $i^* \overset{>}{\underset{<}{=}} x$ iff $\hat{U}_f \overset{>}{\underset{<}{=}} \hat{U}_{i^*}$

This compares welfare under **<u>I</u>** (P.1) and under **<u>F</u>** (P.15), which differ only in their insurance premiums $\pi_H x + \pi_L i^*$ and $\pi_S x = \pi_H x + \pi_L x$, respectively. Thus, if i*>x, welfare is higher with full insurance (P.15). If i*<x, welfare is higher with (P.1).