Deductible Aversion and the Design of High Cost Insurance Contracts

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Introduction: Deductibles and Large Losses

An understanding of buyer's preferences with respect to deductibles is important in designing any contract of insurance, but it is of particular importance to designing contracts for which the potential losses to the insurer are large. With large potential losses, insurers may not have the capacity to accept all of the offered risk, and if full coverage is not an option, it becomes necessary to find the best deductible arrangement to configure that part of the risk which remains with the insured.

Large potential loss contracts are not uncommon. For example, in the case of terrorism insurance, even with the reinsurance backup provided by the Federal Government under the Terrorism Risk Insurance Act of 2002, it has been estimated that a terrorism attack imposing $30b in total insurance loss would impose costs on private insurers of $14b in 2004 and $20b in 2005.[1] In the case of natural catastrophes, The California Earthquake Authority, a public agency which unlike most public agencies has no access to public funds, offers earthquake insurance in California with reserves of $7b to meet potential maximum claims in excess of $20b. Indeed even the US Federal Government, with its full taxation capacity, cannot run unlimited deficits. For example, the recent extension of prescription drug benefits to Medicare recipients was designed to fit a budget of $400b over 10 years, a huge sum but still not sufficiently large for all of the risk to be borne by the Federal insurer. Estimates of the second decade costs run as high as $2tr.

In all these cases a deductible arrangement of some kind has been adopted. In the case of Medicare prescription drug benefits, for example, the deductible arrangement can be loosely summarized[2] as

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[1] See the Insurance Information Institute http://www.iii.org/media/hottopics/insurance/sept11/. For a large insurance company such as AIG, this is estimated to impose losses of $1.4b and $2.2b in 2004 and 2005 respectively, http://www.tillinghast.com/tillinghast/publications/publications/till_update_us/Terrorism_risk_ins_act/Update2_12_02.pdf.

[2] Under the newly signed Medicare law, a senior who enrolls in the new benefit would pay $250 annual deductible and about $35 monthly in return for the government paying three-quarters of annual drug costs

i) High coverage (low deductible) for small losses

ii) No coverage (100% deductible) for medium losses

iii) High coverage (low deductible) for large losses

Some commentators have called this arrangement a coverage "doughnut" with a hole in the middle, and it has been widely criticized as inconsistent with the principles of economic theory. The purpose of this paper is to revisit the economic issues raised by the problem of deductible design[3].

Preferences for deductibles and simple gambles. Since the 1950s the problem of choice of deductible has been formulated as a problem of preference over gambles. The setup is usually as follows. For the next year an individual faces a probability q of no loss and a probability $(1\text{-}q)$ of loss L. If a loss occurs, the magnitude of the loss is given by a density function $f(L)$, with the loss satisfying $0 \leq L \leq V$, where V is the maximum possible loss.

In this situation, if the individual chooses a deductible D, then they will lose L should L turn out to be less than D and D *if* L should be greater than or equal to D. The probability that L will exceed D *is* given by $(1-q)\int_D^V f(L)dL = p(D)$.Individuals who purchase insurance against this loss will pay a premium $R(D)$, where R is the annual premium when the deductible chosen is D. We assume that R is differentiable with $R'(D) < 0$ since a higher deductible lowers the risk borne by the insurance company.

To analyze attitudes to deductibles, we concentrate for the moment on a marginal change in the level of deductible, leaving side the effect of this change on the premium R. Given that the level of the deductible is currently D, this marginal change is equivalent to the simple gamble, G= {lose ϵ with probability $p(D)$, gain 0 with probability $(1\text{-}p(D))$}. As it

up to $2,250. If the senior's annual drug costs go beyond that, however, he falls into a coverage gap, during which there is no additional help from the government until drug expenses reach $5,100. Then catastrophic coverage kicks in, and the government picks up 95 percent of additional drug costs.

[3] Issues of moral hazard also affect the use of deductibles in optimal design. These issues are not discussed in this paper. For this reason we also do not discuss co-payments, the usual second best method of handling moral hazard, see Winter (2000).

stands, so long as more wealth is preferred to less, this is surely an unattractive proposition, but of course increasing the deductible lowers the premium, since $R'(D) < 0$. So whether or not the individual will accept a marginal increase in deductible amounts to the question of whether or not the saving in premium, -R'(D), is enough to compensate the individual for taking on the simple gamble G.

One case is straightforward. If the insurance is fair, the individual will receive a premium reduction exactly equal to the expected value of the marginal gamble. If the individual is risk averse, this will not be adequate compensation, and the marginal gamble will be declined for all levels of deductible. In the case the optimal deductible is D=0. This is known as Mossin's theorem, Mossin (1968), that risk averse individuals fully insure at fair odds.[4]

But what if insurance is not actuarially fair? Since the compensation for accepting the gamble G is now greater than the mean, it may be desirable to increase D. Indeed in one case it is certainly desirable to increase D. At full insurance an individual who evaluates gambles with any smooth valuation functional will be risk neutral. So at D=0 it is certainly the case that the gamble is attractive. As the deductible increases, however, the individual becomes more and more risk averse, so that at some point, say D^*, there is no gain from accepting the higher deductible. The deductible D^* is therefore optimal. More generally, it can be shown, see Gollier and Schlesinger (1996), that this contract structure (full insurance above a given deductible) is the optimal risk sharing arrangement between a risk neutral insurance company and a risk averse buyer. This is known as Arrow's Theorem, Arrow (1971) Arrow (1974). Mossin's theorem and Arrow's theorem are the twin pillars of the economic theory of deductibles, and criticisms of actual deductible structures such as the structure in the Medicare Prescription Drug provision are usually made from the perspective of these theorems.

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[4] This theorem has at least two caveats. In the first place, if there is an income tax offset for losses, the after tax cost of the gamble is less than stated here, and the individual might choose a positive deductible even at pre tax fair odds. In the second place as Doherty and Schlesinger (1983) note, there may be other risks in the buyer's portfolio at the point of full insurance against this given risk, and in this case covariance could cause a positive demand for deductibles .

Evidence: On the other hand, the evidence that individuals behave according to the mandates of these theorems is rather weak. For example, Mossin's result that a risk-averse expected utility maximizer will not buy full insurance in the presence of a positive marginal loading was described by Karl Borch (1974) , one of the pioneers of the expected utility approach, as "against all observation." And, although Pashigian et al (1966) are incorrect to claim that the observed pattern of deductibles chosen in the state of Missouri auto insurance market is not consistent with expected utility maximization, see Gould (1969), the degree of risk aversion implicit in deductible purchase (around 10) Dreze (1981) seems very high. Murray (1972), in a study in which he first calibrated each subject's utility function using test lotteries then noted that subject's actual chosen auto deductible, found that of 40 subjects, more than 37 failed to choose deductibles according to the their own calibrated utility function, noting that " in the vast majority of cases the predicted deductibles were higher than those actually purchased" p 35.
All of this suggests that the axioms of expected utility might not apply to the problem of choosing a deductible. However, as may be seen by reviewing the arguments above, neither the Mossin nor the Arrow theorems use the key axiom of expected utility (the independence axiom) in any way. As Schlesinger (1997) notes, all we require to prove that individuals will choose a positive deductible when the premium contains a loading is that a valuation functional exist, exhibit risk aversion, and be differentiable, and as Gollier and Schlesinger (op.cit.) note, the Arrow theorem follows just from the assumption of risk aversion, since any arrangement other than full insurance above some minimum is a mean preserving spread of the probability of loss. Thus if we wish to stay within the frame that choices over insurance contracts are choices over gambles, more drastic changes must be made than simply dropping the independence axiom. We now consider two such possible changes.

1: Dropping the Assumption of Differentiability. Most of the time in economics the assumption that the valuation function(al) is differentiable is innocuous and in any case difficult to test, since we cannot take limits below the size of the smallest unit of currency (1 cent). In the case of preferences over gambles, however, one well supported alternative to expected utility maximization, Rank Dependent Expected Utility (RDEU) maximization, Quiggin (1982) Yaari (1987), requires that the valuation functional be non-differentiable at full insurance. In this case the buyer of insurance is not risk neutral at full insurance so the simple argument requiring a positive deductible when the premium contains a loading factor fails.(In the terminology of Segal and Spivak (1990), the individual is *first order* risk averse under RDEU, *second order* risk averse when the valuation functional is differentiable.)

This valuation functional has a right hand derivative at full insurance, and for a small increase in deductible, the gamble remains G = {-**e** with probability p(0), 0 with probability (1-p(0))}. By the rules of RDEU maximization, however, this gamble, which represents the effect of a small increase in deductible, is evaluated at full insurance as though it was the gamble H= { -**e** with probability f(p(0)), 0 with probability (1-p(0))} where f is an is an increasing concave function. So the probability of loss is over-weighted and the gamble has a mean which is lower than the mean of the actual gamble. Thus even when the premium is slightly unfair (and a fortiori when it is fair) an increase in deductible will lower the valuation. Thus an RDEU maximizer will fully insure at a mildly actuarially unfair premium. More precisely, because of risk neutrality,it is clear that they will choose full insurance provided the linear loading factor **l** satisfies (1+**l**) p(0) **§**f(p(0)).

The argument above does not depend on the insured's level of wealth. Thus if the level of wealth changes, the insured continues to fully insure at small enough loads. This fact has been used by Barniv, Schroath, and Spivak (1999) to argue that the observed pattern of demand for deductibles in flood insurance is explained by the hypothesis that at least some of the insured are RDEU maximizers. As they note, 63% of all insured choose the minimum deductible of $500 regardless of wealth. For expected utility maximizers this choice would be wealth dependent.

This argument, however, strictly applies only at full insurance. At a deductible of $500 RDEU maximizers would also change the deductible in response to a change in wealth, so the observed zero wealth elasticity seems as much a problem for RDEU as it would be for differentiable valuation functionals. Moreover, it is hard to see how RDEU maximization would lead to “doughnut structures” It is true that at small loadings the probability weighting scheme implicit in RDEU maximization pushes insureds in the direction of smaller deductibles than would be chosen by smooth valuation maximizers. This suggests, however, that the optimal contract both for RDEU maximizers and smooth valuation maximizers remains governed by Arrow’s theorem. It also suggests that it may be useful to explore other explanations for the observed behavior.

2: Dropping the Assumption of Integrability. As with the assumption of differentiability, the assumption that marginal valuations can be integrated is also usually made without question.[5] There is, however, no requirement that the marginal valuation field be integrable. When it is not, preferences may still be well defined, but we need more than one marginal valuation to define them. One well known bi-marginal preference theory is the theory of regret, Loomes and Sugden (1982), Bell (1982). Valuations which depend anti-symmetrically on two marginal movements are known as two forms, and recently Braun and Muermann (2004) (BM) have modeled the insurance purchase decision in such terms.

The regret based valuation function which they propose is

$$V(W) = EU(W) - kg(EU(W^{MAX}) - EU(W)$$

They call this approach Regret Theoretical Expected Utility (RTEU). Here k ¥0. If k=0 then the individual is clearly an expected utility maximizer. The function g satisfies $g' > 0$, $g'' < 0$ $g(0) = 0$, and $EU(W^{MAX})$ is the expected utility of an individual who knows in advance which states will occur and who therefore will not buy insurance in those states in which the payoff falls short of the premium.

In marginal terms the individual in the BM model contemplating a small increase in the level of deductible must evaluate two marginal gambles. The first gamble evaluates $\frac{dEU}{dD}$ and this is exactly the gamble G which we have already discussed. The second

[5] The situation in the natural sciences differs markedly from the situation in economics. There integrable fields are the exception, see Russell (1988)

gamble is $kg'()\left[\frac{dEU(W^{MAX})}{dD}-\frac{dEU}{dD}\right]$. Clearly the addition of this second gamble will change the insured's behavior with respect to deductibles.

As BM show, their Proposition 7, this new gamble changes Mossin's theorem. As before, at full insurance the individual is risk neutral so $\frac{dEU}{dD}$ =0. On the other hand, at full insurance the term $kg'()\left[\frac{dEU(W^{MAX})}{dD}-\frac{dEU}{dD}\right]=kg'()\left[\frac{dEU(W^{MAX})}{dD}\right]$ must be negative.

An increase in deductible by the small amount ε is still equivalent to the gamble G = {-ε with probability p(0), 0 with probability (1-p(0))} but now, since the individual will not pay the premium in those states in which no loss occurs, even if the premium is fair, it will not fully compensate the individual for taking on the gamble. Since EU(W^{MAX}) is reduced, $\frac{dV}{dD}$ >0 and so an RTEU individual will choose a positive deductible even at fair odds.

This result goes against the evidence that individuals prefer smaller deductibles than is predicted by smooth integrable valuation functions, but it only holds when premiums are fair. When premiums are unfair, BM show that the situation is a little more delicate, BM Proposition 9. The easiest case is to consider is again the case of full insurance. Since the probability of no accident is q, and the RTEU maximizer is risk neutral, they will choose a deductible for all loadings λ satisfying $\lambda \leq \frac{1}{1-q}$ i.e. all loadings small enough. Once the loading becomes large enough to compensate the individual for the fact the premium (though fair) is not saved in those states in which loss no occurs, i.e. is saved only with probability (1-q), then $kg'()\left[\frac{dEU(W^{MAX})}{dD}\right]$ will become positive and thus $\frac{dV}{dD}$ will become negative. This result, as BM show, in fact holds at all levels of deductible so that at high enough loadings, the RTEU maximizer chooses a smaller deductible than the EU maximizer whereas at low loadings the deductible is higher As with the RDEU model, however, it is not clear that this explains the demand for low deductibles. As Barniv et al (op.cit.) note, flood insurance for example has a very low loading and in this case RTEU maximization drives the demand for deductibles in precisely the wrong direction. It is an empirical question whether loadings are large enough to allow regret theory to explain the high demand for deductibles and it is also an open question whether or not the Arrow theorem holds in this case.

Context Models of Choice of Deductible: Both the RDEU and the RTEU models of insurance demand are firmly within the framework of post 1950s models of choice. That is, they both take as the “manifold of choice” a set of gambles, and they both define preferences as a field of marginal valuations on this manifold. That they make opposite predictions about behavior points to the fact that as we move away from the assumption that gambles are evaluated by a smooth integrable functional (whether satisfying the independence axiom or not), the range of explainable behavior expands until virtually anything goes.

Moreover, if the choice set is a set of gambles, the independence axiom is eminently reasonable. Would anyone presented with a clear violation of this axiom behave differently from Jimmie Savage and not request that they be allowed to change their mind? Given this, it becomes reasonable to ask whether it makes sense to frame the insurance deductible choice question as a choice over gambles at all. For the gambling frame to be appropriate, individuals must be able to translate the insurance problem into a gambling choice, have a well defined set of preferences over gambles and have an estimate of the probability of loss and the loadings on the contract. If any of this is missing, some other frame may be appropriate.

But what other frame? That is to say, what do individuals think they are doing when they choose deductible A over deductible B? One obvious but still very controversial method for answering this question is to ask them. Murray (op.cit.) did just this, and though the sample is small (just 40 subjects) the answers are worth noting, because virtually none of the respondents gave answers which could even remotely be translated into a preference field over gambles.
He states

> "There are a few interesting trends which begin to appear in the reasons stated by the subjects for purchasing their level of deductible. For those choosing a $50 deductible, two said that it was picked by their parents. Each of three persons said "It was the smallest possible", "It gave general protection" and " It was the best deal." One interesting response was that "Any accident I have will be less than $200 since I am a careful driver."
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> For those with a $100 deductible, three said that their agent chose it and one said that the bank picked it. This supports the author's perception that agents tend to recommend the $100 deductible to most of their clients. The most commonly given response (8) was that this was cheaper. (It would seem that if this were the motivating factor the individual would buy an even larger deductible, since that would be cheaper yet.) One reason for saying that the $100 was cheaper appeared when the subject was asked to list the alternative deductibles available. In more than 90 per cent of the answers, only $50 and $ 100 were listed as alternatives. The buyer simply is not aware that other alternatives exist. Other responses were: "Could always squeeze out $100" (Two people gave this response which comes closest to coinciding with a utility analysis) "Makes for fewer claims and that's better" and "Never had any accidents where I had to pay."

All of this suggests that it may be useful to develop models of deductible choice which begin from a different point of view. Of course, in describing other factors which may influence this behavior, there is no reason why one single model should fit all actors. Some buyers may be RDEU maximizers, some may be RTEU maximizers (indeed some may even be EU maximizers.) Loomes and Segal (1994) further develop this point of view.

For choice problems which resemble the choice of deductible from a menu of deductibles, there is evidence that individuals do not approach the decision with hard wired preferences at all. Instead their preferences and therefore their choices are determined by the set of choices offered. This choice theory, called the context theory of choice, has shown remarkable success at predicting choices in situations, such as deductible choice, where the choice is made infrequently and with minimal information.

It has become a standard part of the literature on marketing, see, Simonson and Tversky (1992), Tversky and Simonson(1993), and Simonson (1993).

In the case of insurance deductible choice, the context theory would argue that many individuals choose the deductible simply by choosing the lowest deductible or possibly the second lowest deductible (to avoid extremes). The evidence that individuals do have such a propensity is very strong. In every empirical study with which we are familiar, encompassing different line of insurance and different premium structures, the majority of the agents chose either the lowest deductible or the second lowest deductible, See Table 1.

Table 1: Fraction of Participants Choosing the Smallest Deductibles:

AUTHOR(S) OF STUDY	TYPE	VALUE OF SMALLEST DEDUCTIBLE	FRACTION CHOOSING LOWEST DEDUCTIBLE %	VALUE OF SECOND SMALLEST DEDUCTIBLE	FRACTION CHOOSING SECOND LOWEST DEDUCTIBLE %
Pashigian et al (op.cit.)	Auto	$50	62	$100	46
Murray (op.cit.)	Auto	$50	30	$100	60
Barniv et al (op.cit.)	Flood	$500	63	$1000	22.7
eHealthinsurance: http://images.ehealthinsurance.com/ehealthinsurance/expertcenter/UITxCreditFactSheet.pdf	Health	$500	40.5 (26% of families)	$1000	22 (24% of families)

As far as we know there are as yet no laboratory tests of context models of insurance deductible choice, but following the Tversky/Simonson methodology one is easy to design. Suppose we present subjects with a menu of deductibles and premia and observe their choices. Now expand the menu by adding a new deductible which is smaller than any in the original set. All preference based theories of choice predict that the only switching which will take place is switching into the lowest deductible class. Switching into what is now the second lowest deductible class is evidence of context dependent preferences.

Context models of choice are reasonably straightforward to test if insureds are presented with a menu of deductibles. There is more difficulty when only one deductible is offered. For example, the original C.E.A. earthquake contract had a single deductible of 15%. Based on market research the reluctance of homeowners to buy this contract was widely attributed to this deductible being too high. What is less clear is why homeowners would think this way. By law the contract premium was required to be actuarially fair, and given a small administrative loading, this structure would seem to be Arrow ideal.

Some commentators believe that homeowners calculate that if they are at risk for say a $200,000 loss with a 15% deductible they will have paid $30,000 in premia before they could recover a penny. Whatever the reasoning, the introduction of a new contract with a 10% deductible has hardly been a success. Only 15% of homeowners in California now purchase earthquake insurance, (down from 30% in 1996) and of those who do buy this insurance only 1/5 choose the 10% deductible, 4/5 remaining with the original 15%. Currently there is pressure to introduce a 5% deductible and it will be interesting to see if this makes the product any more attractive.

Implications for High Cost Insurance Contract Design: The finding that individuals generally prefer low deductibles has clear implications for the design of high cost insurance contracts. The CEA experience suggests that the Arrow solution is not viable. With this in mind, the structure adopted for Medicare Prescription Drug Coverage seems not so bizarre. A low deductible for small losses seems necessary to induce individuals to participate in the program at all. A large deductible in the middle range is necessary to control the outgoings. Finally a low deductible is necessary at the high end to prevent the bankruptcy of very sick seniors. Viewed this way it is not clear that politicians had many alternatives to the chosen plan.

Conclusion: In the private sector marketers of insurance must choose contract structures which their customers will buy. The customer, right or wrong, is always right. In the public sector, however, matters are not so simple. There is now serious debate as to whether or not politicians should offer citizens only rational preference based solutions or should go along with behavioral choices perhaps in the interests of being re-elected, see Camerer et al (2003). Based on the ideas of Thaler and Sunstein (2003) one way out of this dilemma would be make the Arrow contract (high deductible) the default option and allow free choice over other schemes, see also Choi et al (2003). It remains to be seen whether or not in this case the stasis of the default option would overcome the context driven push towards the lowest possible deductible

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