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The deadweight gain of insurance taxation when risky activities are optional

The Efficiency of Insurance Taxation When Risky Activities are Optional*

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Abstract

Some risky activities are optional, for example motoring. Participation in them is most attractive for good risks, creating a tendency for advantageous selection in the associated insurance market. Taxing insurance consequently yields efficiency gains when type is hidden. Results are strengthened if optimism is present. Finally, endogenising participation implies that the standard "positive correlation" test for the presence of policy relevant asymmetric information may fail.

Key Words: Insurance, tax, efficiency gain, hidden types

JEL: D62, D82, G22, H21

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1 Introduction

Insurance mitigates individual risk. So does opting out of risky activities. Examples of such avoidable pursuits are motoring, pet ownership, growing risky crops, traveling, owning fragile high-value items and entering risky occupations. Existing hidden-types models of insurance, most notably Rothschild and Stiglitz (1976), henceforth *RS*, have ignored the possibility of avoidance. This paper shows that the opportunity to opt out of risky activities has significant implications for public policy. The reason is that bad risks have least to gain from participation in the risky activity, introducing an element of advantageous selection into the insurance market. Under these circumstances, a general insurance tax has efficiency benefits. It curbs the entry of bad risks, whose presence imposes a negative externality on good risks. An insurance tax may even yield Pareto gains, though the main point of the paper is that the marginal cost of raising public funds through general insurance taxation is *below* unity. A dollar raised through insurance taxation improves the net of tax terms offered to the insured so costs them less than a dollar. This efficiency effect implies that even regressive taxation may raise welfare. If the tax proceeds are used to fund a public good, there may be gains even if the willingness to pay of the beneficiaries is below the cost of provision and the beneficiaries are better off than the payers.

The theoretical literature on insurance market intervention mostly builds on the insight of *RS* (pp. 643-645) that, in a separating equilibrium, cross subsidization of policies may generate a Pareto improvement. A number of papers have devised schemes to implement this possibility. One way is to require a small amount of mandatory cover as Wilson (1977) and Dahlby (1981) show. Crocker and Snow (1985) demonstrate that Pareto efficient redistribution can sometimes be effected through a tax on incomplete cover contracts and a subsidy to full cover policies. A system of tradeable permits to sell low cover policies similarly implements this outcome, as analyzed by Bisin and Gottardi (2006). The qualification in all these cases is that a firm able to issue a menu of offers can replicate the Pareto improving scheme and therefore devise a profitable deviation. So it can be argued that an equilibrium requires a reason the Pareto gain cannot be realized by private action. This will be further discussed in Section 3.2.

All these papers involve an increase in the cost of partial cover relative to full cover. A case for increasing the cost of insurance in general is a side result of de Meza and Webb (2001). The assumptions are heterogeneous risk preferences, moral hazard, and claim processing costs. More risk-tolerant types take fewer precautions and place less value on insurance. An insurance tax discourages these bad risks from buying insurance (though not from engaging in the risky activity), thereby improving the terms available to the good risks. The de Meza and Webb configuration involves possible but special assumptions. Bad risks dropping out of the risky activity, as analyzed here, seems a much more generic phenomenon.[1]

The remainder of this paper unfolds as follows. A simple model in which it is possible to

[1] Avoidance is a form of precautionary or preventative activity, but it has special properties. Suppose types differ in their cost of precautionary effort. As in *RS*, the equilibrium correlation between risk and cover will be positive. There is no element of advantageous selection and in its essentials the analysis of an insurance tax is as in *RS*.

choose whether to undertake the risky activity is specified in Section 2. The implications of this optional participation model for the efficiency of insurance taxation is examined in Section 3. In particular, the marginal cost of public funds ($MCPF$) raised through an insurance tax, is calculated, along with the possibility of Pareto gain when the revenue is redistributed in the form of a lump-sum subsidy. Comparison is made with the welfare effects of requiring mandatory full insurance cover for those engaged in the risky activity. Numerical examples are also presented to show that welfare effects may be large. Some natural extensions to the model are sketched in Section 4. The empirical relevance of asymmetric information to insurance has been challenged in recent years. Section 5 shows that when risky activities are optional, existing tests are inadequate to reveal the presence of asymmetric information. Finally, brief conclusions are drawn.

2 The Model

In most respects the model follows RS. Individuals differ in their competence in some risky activity. H types have probability π_H of suffering an accident which causes them financial loss D, whilst for L types the loss probability is π_L with $\pi_L < \pi_H$. These probabilities are private information. The proportion of the low to high risk types in the population is n, which is publicly known.

Both types have the same concave utility function, $U(M, R)$, where M is consumption of private goods and services and $R \in \{0, 1\}$ is an indicator variable equal to 1 if the individual engages in the risky activity and 0 otherwise. We sometimes work with the special case $U(M, 1) = B + u(M)$, where B is the utility benefit from participating in the risky activity. All individuals have income endowment, $\overline{M}$.[2]

An insurance contract involves premium, P, and net of premium payment, I, if the financial loss occurs. There are two or more risk-neutral insurance companies engaging in Bertrand competition. The game is that the companies make simultaneous contract offers. Individuals then choose whether to engage in the risky activity and which policy to buy.[3]

2.1 Equilibrium

For the same reason as in RS, there cannot be a pure-strategy pooling equilibrium. Marginally lowering cover and reducing the premium will profitably separate out types. Three types of equilibrium are possible. When the risky activity provides little benefit, neither type participates in it. If the risky activity is sufficiently attractive both types may participate, in which case there is a separating equilibrium in which the Hs are fully insured and the Ls choose incomplete insurance, essentially the RS equilibrium. The condition for Hs to be better off participating is $U(M, 0) < U(M - \pi_H D, 1)$. This also guarentees that Ls participate as they are better off than Hs in an RS equilibrium.

[2] This assumes the only financial cost of the risky activity are those arising from an accident. This is convenient but not crucial.

[3] In a dynamic setting, experience rating is a screening device that should in principle diminish the effect of hidden types.This mechanism will not be very effective if clients have much higher discount rates than companies.

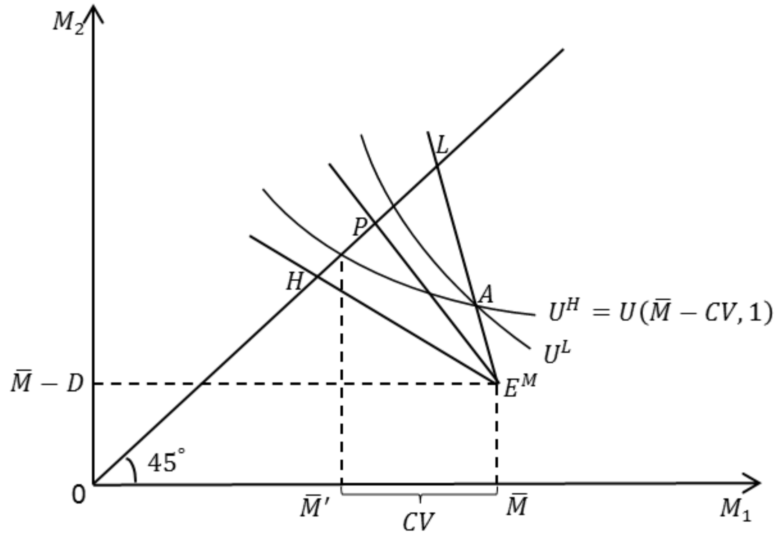

Figure 1: Separating Equilibrium

The equilibrium in which Ls participate and Hs do not is designated a partial participation (PP) equilibrium. Such an equilibrium requires $U(M - \pi_H D, 1) < U(M, 0) < U(M - \pi_L D, 1)$. That is, since it is always feasible to offer full actuarially fair insurance to an H type engaging in the risky sector, the expected utility from taking such an offer must be less than from not engaging in the risky activity. Moreover, the best that an L can achieve from participation is full, fair insurance so this offer must dominate non participation. Such an offer would also attract the Hs so it cannot be part of a PP equilibrium. The offer taken by the Ls must involve partial cover so as not to attract Hs.

Figure 1 displays a PP equilibrium. Participation involves the possibility of an accident, the occurrence of which lowers income by D. Those engaging in the risky activity therefore have income endowment E_M with M_1 good-state income and M_2 bad. The actuarially fair offer curve for the Ls is $E^M L$, of the Hs is $E^M H$ and the pooling offer curve is $E^M P$. Non participation with income M delivers the same utility as participation with full insurance at premium CV which is therefore an index of the benefit of the risky activity. If driving is a perfect substitute for other spending, i.e. $U(M, 1) = U(M + B)$, $CV = B$. An equilibrium is shown in which L types participate and obtain partial insurance at A, whilst H types are marginally better off not participating than at A. This is a least-cost separating equilibrium. Formally, it is the zero expected-profit contract that maximizes the expected utility of the low risks subject to the high risks weakly better off rejecting the contract. Contract A is preferred by the Ls to any contract along the pooling offer line, $E^M P$. So there is no incentive to break the equilibrium with a pooling offer.

At the end of Section 3.1 we examine an initial equilibrium in which B is sufficiently high that both types participate in the initial equilibrium.

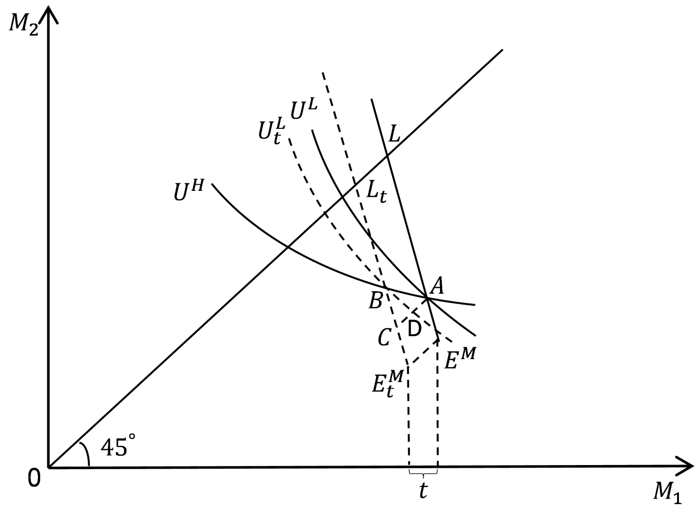

Figure 2: Mitigated burden of insurance taxation

3 The mitigated burden of insurance taxation

The basic intuition of the efficiency gain is illustrated in Figure 2. An initial PP equilibrium is at A, with the participation constraint of the Hs binding the Ls. Introduction of a lump-sum insurance tax of t shifts down the zero-profit offer curve for the Ls.[4] Specifically, the purchase of a zero-cover policy results in a shift of consumption from E^M to E_t^M, but leaves the incremental cost of cover unchanged. The new offer curve is therefore parallel to the old, resulting in a new equilibrium at B.[5] To maintain the $L's$ insurance cover with the tax, involves the offer at C. For Hs, the increased premium associated with the offer is strictly inferior to non participatiom. As a result, cover can be increased without drawing in the Hs. The new equilibrium is at B. If instead of the insurance tax, the Ls faced an equal poll tax, to deter Hs the insurance policy must be unchanged. So the Ls are positioned at C, which involves a lower indifference curve than B. If a poll tax were to have the same effect on the welfare of Ls tax revenue would fall by proportion CD/AC.

The analysis will now be elaborated and quantified.

3.1 The Marginal Cost of Public Funds via Insurance Taxation

The marginal cost of public funds, $MCPF$, is a measure of the efficiency cost of raising extra government revenue and therefore of the hurdle benefit that incremental public spending must exceed to be worthwhile.[6] In the case of a tax, $MCPF_t$ is the summed equivalent variations of all those affected by an incremental change in its rate divided by

[4] The figure assumes it is the company that directly pays the tax. Proceeds are used to provide a public good that enters the utility function additively.

[5] The indifference curve of the Ls through B must pass above E^M for insurance still to be taken.

[6] Dahlby (2008) provides a comprehensive account of the concept.

the net change in the revenue raised. If there are deadweight costs (or administrative expenses), the equivalent monetary losses to the payers exceed the revenue raised, so $MCPF_t > 1$.[7] In the case of an insurance tax, the payers enjoy a secondary benefit through an extension of cover, as illustrated in the previous section. It follows that for an insurance tax, $MCPF_t < 1$.

An explicit derivation follows which will also serve as the basis for numerical evaluation. In a PP equilibrium it is only Ls that are affected by the insurance tax, t. Writing the expected marginal utility of type i as EU_i' $(i = L, H)$,

$$MCPF_t = -\frac{1}{EU_L'}\frac{dEU_L}{dt} \tag{1}$$

where

$$EU_L' = \pi_L U'(M - D + I) + (1 - \pi_L)U'(M - P) \tag{2}$$

$$P = \frac{1}{1 - \pi_L}(\pi_L I + t) \tag{3}$$

$$\frac{dP}{dt} = \frac{1}{1 - \pi_L}\left(\pi_L \frac{dI}{dt} + 1\right) \tag{4}$$

$$\begin{aligned} \frac{dEU_L}{dt} &= -(1 - \pi_L)U'(M - P)\frac{dP}{dt} + \pi_L U'(M - D + I)\frac{dI}{dt} && (5) \\ &= -U'(M - P) + [U'(M - D + I) - U'(M - P)]\pi_L \frac{dI}{dt} && (6) \end{aligned}$$

A change in t affects the entry incentive of Hs, so dI/dt is derived from the binding participation constraint

$$\pi_H U(M - D + I) + (1 - \pi_H)U(M - P) + B = U(M) \tag{7}$$

$$\frac{dI}{dt} = \frac{(1 - \pi_H)U'(M - P)}{\pi_H(1 - \pi_L)U'(M - D + I) - \pi_L(1 - \pi_H)U'(M - P)} \tag{8}$$

[7] Following Atkinson and Stern (1974), Dahlby (2008, p30) provides an apparent exception. Consider a standard competitive market in which an excise tax is levied on a particular good. If the uncompensated demand curve is vertical at all tax levels, $MCPF = 1$. This despite the substitution effect being negative, in which case elementary analysis shows that a finite commodity tax must involve a deadweight cost increasing in the tax rate. The resolution of the puzzle involves considering the $MCPF$ of a lump-sum tax. A vertical demand curve implies the good is inferior, so a lump-sum tax raises demand for it. A lump-sum tax therefore increases revenue from the excise tax. To raise government revenue by a dollar, requires a lump-sum tax of less than a dollar. Thus the $MCPF$ of a lump-sum tax is below 1. Were the $MCPF$ redefined as the cost to the payers of an increase in a tax relative to the change in lump-sum income needed to provide an extra dollar of government revenue, then for all positive values of the excise tax, $MCPF > 1$.In our insurance context, the tax is fixed per policy and so lump-sum taxation has no secondary tax revenue implications. Even without redefinition, $MCPF < 1$ does imply a deadweight gain.

Substituting the various terms into Expression 1

$$0 < MCPF_t = \frac{1}{EU_L'}\left[\frac{(\pi_H - \pi_L)U'(M-P)U'(M-D+I)}{\pi_H(1-\pi_L)U'(M-D+I) - \pi_L(1-\pi_H)U'(M-P)}\right]$$

$$= \frac{U'(M-P)}{EU_L'} - \left[\frac{U'(M-D+I) - U'(M-P)}{EU_L'}\right]\left[\frac{\pi_L(1-\pi_H)U'(M-P)}{\pi_H(1-\pi_L)U'(M-D+I) - \pi_L(1-\pi_H)U'(M-P)}\right] < 1 \tag{9}$$

The first inequality follows as setting $\pi_H = \pi_L$ yields $MCPF_t = 0$. For the second inequality, note that the first term is below unity because of risk aversion and partial insurance coverage and the second term in square brackets is positive, making the whole term less than one.

An important issue is whether an insurance tax is less costly the more similar the two types. From Expression **??**, $dMCPF_t/d\pi_H > 0$ which follows as the numerator of the final curved bracket is increasing in π_H and the denominator is decreasing.

If the initial equilibrium is RS, it may seem that the $MCPF$ of a fixed tax per insurance contract must be unity. This is not the case. The tax raises everyone's gross premium equally, in effect an equal fall in safe income for all. Under the standard assumption of decreasing absolute risk aversion ($DARA$), the cost of risk is greater when income is lower (Pratt (1964) Theorem 2). If the coverage of the two policies did not change, the partial cover contract taken by the Ls that is just separating prior to the tax increment becomes strictly less attractive to the Hs than full cover when both gross premiums rise equally. Thus coverage is increased when all contracts are taxed, yielding Ls a secondary benefit.

More explicitly, in the least-cost separating equilibrium, the incentive compatability constraint is

$$\pi_H U(M - D + I - t) + (1 - \pi_H)U(M - P - t) + B = U(M - \pi_H D - t) + B \tag{10}$$

where $P = \frac{\pi_L}{1-\pi_L} I$ is the net of tax premium on the contract taken by Ls, the net indemnity is I and t is the insurance tax. From Equation 10,

$$\frac{dI}{dt} = \frac{\pi_H U'(M - D + I - t) + (1 - \pi_H)U'(M - P - t) - U'(M - \pi_H D - t)}{\pi_H U'(M - D + I - t) - (1 - \pi_H)\pi_L U'(M - P - t)/(1 - \pi_L)} > 0 \tag{11}$$

The signing of Expression 11 follows from the proof in Mossin (1968, p.555) that under $DARA$, the numerator is positive given that (7) holds.[8] The effect of t on expected utility is,

$$\frac{dEU_L}{dt} = -(1-\pi_L)U'(M-P-t) - \pi_L U'(M-D+I-t) + [U'(M-D+I-t) - U'(M-P-t)]\pi_L \frac{dI}{dt} \tag{12}$$

[8] This is the key step in Mossin's subtle proof that higher wealth decreases demand for insurance given $DARA$.

so

$$MCPF_t = -\frac{1}{EU_L'}\frac{dEU_L}{dt} = 1 - \frac{\pi_L[U'(M-D+I-t)-U'(M-P-t)]}{(1-\pi_L)U'(M-P-t)+\pi_L U'(M-D+I-t)}\frac{dI}{dt} < 1$$

The mechanisms lowering $MCPF$ when both types participate is different to that when only Ls do. In the latter case, what matters is the substitution effect of the tax in raising participation costs and hence lowering the attraction of the $L's$ contract to Hs. Given risk aversion, no other property of the utility function is required. In the former case what matters is that insurance (against a given risk) is, under standard assumptions, an inferior good. The tax thus lowers the attraction to Hs of the low cover contract taken by the Ls. More restrictions on the utility function are therefore required. As inferiority is the norm, where the initial equilibrium has both types participating, whether the tax is low or high, in most cases $MCPF < 1$ but under increasing absolute risk aversion ($IARA$), this will only be true when the tax is high enough that Hs are non participants.

Given $DARA$, it may seem that when the initial equilibrium has both types participating, the insurance tax must always involve efficiency gains. This is not the case because there is a discontinuity in $MCPF$ when the tax drives out the $H's$. As the Hs are indifferent to participation, the derivative of their utility wrt tax is smooth at this point. However, a tax increment leads to the Hs exiting and therefore a finite loss in tax revenue. At this point, $MCPF$ is infinitely high. Driving out the Hs, relaxing the incentive constraint on the Ls and allowing them to increase coverage is efficiency enhancing, but now there is also an efficiency cost. In the original equilibrium some of the social surplus generated by Hs is lost if they are driven out of the market. In essence, this is the traditional deadweight cost of taxation. Except at the point Hs exit, $MCPF_t < 1$, nevertheless for taxes high enough to drive out Hs it is possible that the average cost of public funds exceeds unity.[9]

Bringing together the results for the two types of equilibria;

Proposition 1 *In an equilibrium in which only Ls participate, the marginal cost of public funds raised through an insurance tax is positive but below unity. When both types participate, the $MCPF$ of a lump-sum insurance tax is below unity iff $DARA$ holds.*

3.2 Redistributive insurance taxation

In a PP equilibrium the proceeds of an insurance tax can be used to fund a payment of s to those who do not participants in the risky activity.[10] The subsidy payment lowers the incentive of Hs to switch activities and therefore the extension of insurance cover to the Ls that is made possible by the tax is greater than in the case where a (tax revenue neutral) public good is provided. A given tax is less costly to Ls when the proceeds are redistributed to Hs. The marginal equivalent monetary cost to Ls of transferring an extra dollar to Hs by means of an insurance tax, denoted $MCPF_t^r$, will now be computed.

[9] This is minus the equivalent variation associated with the introduction of a finite tax divided by the revenue raised. Even if $MCPF$ is continuous, the average cost of public funds ($ACPF$) is not $\int MCPF/(total\ tax\ revenue)$

[10] Redistribution of this kind is most easily accomplished by using the tax proceeds to pay a poll subsidy, s. If the insurance tax is set at $T = t + s$, the net amount paid by Ls is t and received by Hs is s.The advantage of the poll subsidy is that there is no need to identify participants explicitly.

With redistribution, the participation constraint is

$$\pi_H U(M-D+I)+(1-\pi_H)U(M-P)+B=U(M+s) \tag{13}$$

Defining the ratio of Ls to Hs in the population as n,for budget balance,

$$s=nt \tag{14}$$

The effect of a tax on the level of cover becomes

$$\frac{dI}{dt}=\frac{(1-\pi_H)U'(M-P)+(1-\pi_L)nU'(M+s)}{\pi_H(1-\pi_L)U'(M-D+I)-\pi_L(1-\pi_H)U'(M-P)} \tag{15}$$

Evaluated at $t=0$, so that P and I are the same whether or not revenue is redistributed, payment of the subsidy raises $\frac{dI}{dt}$ relative to the case of no subsidy by

$$\frac{dI}{dt}=\frac{(1-\pi_L)nU'(M+s)}{\pi_H(1-\pi_L)U'(M-D+I)-\pi_L(1-\pi_H)U'(M-P)} \tag{16}$$

By discouraging entry of the Hs, the subsidy enables greater insurance coverage for the same tax change. Defining the equivalent cost to Ls of effecting a dollar transfer to the Hs as $MCPF_t^r$,

$$MCPF_t^r=\frac{U'(M-P)}{EU_L'}-\left[\left(\frac{U'(M-D+I)-U'(M-P)}{EU_L'}\right)\left(\frac{\pi_L(1-\pi_H)U'(M-P)+\pi_L(1-\pi_L)nU'(M+s)}{\pi_H(1-\pi_L)U'(M-D+I)-\pi_L(1-\pi_H)U'(M-P)}\right)\right]<1 \tag{17}$$

As in (9), the first term is below unity and the second term is positive, so $MCPF_t^r<1$. Since the second term of (17) exceeds the second term of (9), at $t=0$, $MCPF_t^r<MCPF_t$.

Proposition 2 *At $t=0$, the marginal cost of raising public funds through an insurance tax is lower if the proceeds are redistributed to non participants.*

Expression 17 does not preclude $MCPF_t^r<0$, which is to say that redistribution benefits the payers. As the Hs are better off as a result of the subsidy, a Pareto gain is implied. This is illustrated in Figure 3. The initial equilibrium is at A. For insurance buying participants, the tax shifts the consumption endowment to E_t^M. The proceeds are received by the non participating Hs so increasing their utility to U_t^H. The new equilibrium is at A_t at which Ls are better off.

Formally, from Expression 17, $MCPF_t^r$ can be rewritten as

$$MCPF_t^r=\frac{U'(M-D+I)U'(M-P)(\pi_H-\pi_L)-\pi_L(1-\pi_L)nU'(M+s)\left[U'(M-D+I)-U'(M-P)\right]}{EU_L'\left[\pi_H(1-\pi_L)U'(M-D+I)-\pi_L(1-\pi_H)U'(M-P)\right]} \tag{18}$$

Therefore, $MCPF_t^r$ is negative if

$$U'(M-D+I)U'(M-P)(\pi_H-\pi_L)<\pi_L(1-\pi_L)nU'(M+s)\left[U'(M-D+I)-U'(M-P)\right] \tag{19}$$

So when the loss probability of the high risks and low risks $(\pi_H-\pi_L)$ are similar and the ratio of Ls to Hs, n, is sufficiently high, $MCPF_t^r$ can be negative. Inequality 19 is necessary for a Pareto improvement but it must also be checked that it is consistent with the separating equilibrium not being broken by pooling and with the H types preferring non-participation. A numerical example is provided in the next section.

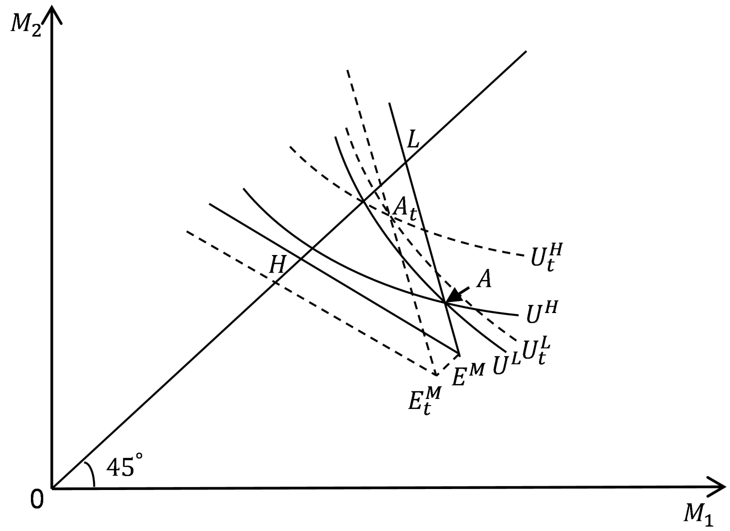

Figure 3: Pareto improvement

Proposition 3 *A poll subsidy financed by an insurance tax may yield a Pareto gain. Given the existence of an initial equilibrium, the loss probabilities of the two types must be sufficiently similar and the proportion of low risks high enough.*

Generating a Pareto improvement is not just a matter of appropriate functional forms and parameter values. If government intervention can make everyone better off, insurers may be able to take advantage of similar strategies to raise their profits. If they can, the equilibrium is broken. RS analyze the possibility of Pareto improving transfer payments in their model, also discussing what prevents the gains being achieved through private action.[11] What is required is that insurers cannot issue multiple contracts, or that every individual contract must at least breakeven.[12] It is hard to find a rationale for such contractual limitations.

When it is possible to opt out of the risky activity, the restriction on private contracting that allow Pareto improvable PP equilibria are different and more plausible. Transfers from Ls to Hs are required to relax the incentive constraint on the Ls. For an insurer to accomplish this they would have to pay people not to insure, a difficult condition to monitor. Preventing those accepting payment from purchasing from a rival might be hard and the exclusionary contract could itself be illegal.

Even if it is impossible to pay people not to insure, the necessary and sufficient conditions for a Pareto improvement are quite restrictive. Nevertheless, the case for redistrib-

[11] Bisin and Gottardi (2006) show that instead of a tax, the transfer can be effected by a tradeable consumption right. To sell the low-premium policy, insurers must buy permits issued to the whole population. Dahlby (1981) and Wilson (1977) show that requiring everyone to buy a common, stand-alone policy, which can be supplemented in the private market may be Pareto improving. As the common policy is sold on the same terms to everyone, it involves the required transfer from Ls to Hs. This would not work in the OO model as Hs would be inefficiently attracted in to the activity.

[12] Wilson (1977) also identifies the possibility of Pareto gains and the contractual restrictions required.

utive taxation does not depend on it generating a Pareto improvement. No actual policy ever does yield a Pareto gain. The issue is whether the policy raises social welfare. The lower is the cost to Ls of raising the tax revenue to be transferred to the Hs (that is the larger the efficiency gain), the more redistribution is justified. As the $MCPF_t^r < 1$, if the marginal utility of income is at least as high for Ls as Hs, redistributive insurance taxation raises utilitarian social welfare.

Proposition 4 *If the proceeds of an insurance tax are paid out as a poll subsidy to non participants, a sufficient condition for aggregate utility to rise is that the marginal utility of income is not lower for Ls than Hs.*

Only if the expected marginal utility of the Ls is sufficiently above that of the Hs in the initial equilibrium will redistributive taxation lower social welfare. This could be the case if Ls are poor relative to Hs or if the risky activity is complementary to other market goods.

Although in a PP equilibrium redistributing the proceeds from an insurance tax is likely to raise welfare, it does not follow that this is the optimal redistributive policy. Consider first a pure RS equilibrium in which non participation is not an option. Maximising social welfare is straightforward in this setting. First note that if information were somehow to become symmetric, there would be a strict Pareto improvement. The full-cover contract taken by Hs is unchanged but Ls are now able to obtain full cover on actuarially fair terms. This symmetric equilibrium has income certainty for both types, but Ls are better off than Hs. Therefore, a further gain is possible under any anonymous quasiconcave social welfare function by equalizing income. This outcome is achieved under asymmetric information by mandatory full cover. If it is then desired to raise tax revenue this is done efficiently by a premium tax or a poll tax with $MCPF = 1$.[13]

There are implications of this analysis for the PP equilibrium. Mandatory full insurance for risky activity participants will tend to draw in the Hs. This is dysfunctional in that Hs generate more social surplus by staying out. The beneficial effect is that Ls end up with full cover, as under full information. If the Hs were only slightly better off in the initial equilibrium than in the RS equilibrium, entry has negligible cost and mandatory insurance has virtually the same effect on utilities as in the RS case and therefore increases aggregate welfare. The alternative policy is redistributing the proceeds of an insurance tax to non participations. This avoids attracting Hs into the risky activity and as $MCPF_t^r < 1$, may also be welfare improving, as demonstrated in the examples in the next section. The drawback is that the Hs have higher disposable income through not having to pay the insurance premium or suffer losses. It is therefore ambiguous whether mandatory insurance or an insurance tax achieves higher welfare when only Ls participate. Mandatory insurance is advantageous when the risky activity is relatively attractive to Hs, the greater the accident risk of the Hs, and the lower the benefit of extending insurance for the Ls. The first column of the Table in the next section is a case where mandatory insurance and entry by Hs is best whilst the next four cases yield higher aggregate welfare from the tax/subsidy policy.

[13] The poll tax avoids the possibility that the Ls prefer not to insure.

Proposition 5 *In an initial RS equilibrium, mandatory full insurance maximizes social welfare and it may do so in a PP equilibrium.*

3.3 Numerical Results

To give some indication of magnitudes, Table 1 computes $MCPF_t$ and $MCPF_t^r$ (with the associated coverage and premium levels) for a variety of parameters assuming the utility function $U = B + \ln M$ and $\overline{M} = 100$. All the cases except for Case 6 in the Table involve equilibria in which, under *laissez faire,* only Ls participate in the risky activity.[14] Outcomes are computed for $t = 0$ and for the tax that maximizes aggregate utility when proceeds are redistributed, $t = t^*$.

Case 1 has $MCPF_t^r < 0$, at $t = 0$, so a small redistributive insurance tax yields a Pareto improvement. This is facilitated because at $t = 0$, the Hs are hardly better off by staying out, severely limiting how much insurance Ls can take. Extra insurance is therefore valuable to the Ls. In addition, there are relatively few Hs, so the income transfer to them has a large effect on their utility, making entry much less attractive, allowing a substantial extension of insurance for the Ls. A small tax therefore benefits the Ls as well as the Hs. This does not imply that Ls are better off under the optimal tax. Assuming a utilitarian social welfare function, the sum of individual utilities is maximised at optimal tax of 2.65, comprising some 17% of the total premium. At the optimal tax, Ls are worse off than in the absence of intervention. This reflects the efficiency with which transfers can be made. Nevertheless, at the optimal tax, $MCPF_t^r < 1$. Although giving Hs an extra dollar costs Ls less than a dollar, what limits the transfer is that the marginal utility of extra income to the Ls is higher than to the Hs.

Evaluated at $t = 0$, by Proposition 2, it is always true that $MCPF_t > MCPF_t^r$. When $t > 0$, this is not necessarily true. Although the effect on coverage of a marginal change in the tax rate is always greater when the proceeds are redistributed, the initial cover is also higher. The Ls are thus better off with redistribution, their expected marginal utility of income, the denominator in marginal cost of public fund calculations is greater, so starting from a finite tax it is possible that $MCPF_t < MCPF_t^r$. Though this does not (quite) occur in Cases 3, 4 and 5, it does in Cases 1 and 2. Nevertheless, Ls are always better off with redistribution because the enhancement of the utility of Hs allows the Ls to obtain higher cover.

The alternative policy to an insurance tax is compulsory full insurance. As the initial equilibrium is least cost separation, this policy induces entry by the Hs, which is inefficient in itself but achieves efficient full cover for the Ls without adverse distributional consequences. If the Hs are not much better off in the initial equilibrium than were they to enter and obtaining full cover then mandatory full insurance for risky activity participants is best, as is Case 1 here.

Case 2 is the same as Case 1 except the relative number of Hs is increased. This does not change the insurance contract necessary to achieve separation when $t = 0$. The response of coverage to a non redistributed tax is therefore also unchanged and so consequentially is the initial $MCPF_t$. If though the revenue raised is redistributed,

[14] In all cases it is checked that least-cost separation is not broken by a pooling offer, that the Hs are better off not participating and that the tax does not stop the Ls insuring.

it is now spread amongst more Hs, hence it does not increase the attraction of non participation as much as in Case 1. As a result, cover increases less in response to taxation and $MCPF_t^r$ is not as low as in Case 2. With a given redistributive tax, insurance coverage would be lower with more Hs. The value of extra insurance is thus increased but raising the tax is less effective in promoting insurance. The net effect is that the optimal redistributive tax is higher than before, but coverage is still lower. Mandatory insurance again involves entry by Hs, the increased number of which means the efficiency cost of this effect is higher than Case 1. The optimal tax now beats mandatory insurance in terms of welfare.

Case 3 raises the loss probability of the Hs from that of Case 2. Other things equal, entry is now less attractive to the Hs. Equilibrium cover is therefore higher, depressing the value to Ls of further expansions. Were the Hs to enter, insurance is now more valuable to them, so higher premiums do not entail such large increases in cover to compensate the Hs. Both $MCPF_t$ and $MCPF_t^r$ are therefore higher at the initial equilibrium. The optimum tax is lower, but the efficiency cost of attracting the even worse performing Hs through mandatory cover is greater than Case 2, so in terms of aggregate utility, it is again inferior to the optimum tax.

Relative to Case 2, Cases 4 and 5 make participating in the risky activity less attractive for both types. In Case 4, the financial loss of an accident is increased and in Case 5 the benefits are lowered. The effects on $MCPF_t$ and $MCPF_t^r$ are similar to Case 3 where it is only the Hs for whom the risky activity is made less attractive. In Case 4, where the financial loss is raised relative to Case 2, entry is less attractive for Hs allowing higher initial coverage for the Ls. Although cover is now more responsive to tax, the value of the extra cover is diminished and the net effect is to raise the marginal cost of public funds.

In Case 6, the benefit of participation is sufficiently great that the initial equilibrium is RS. Consistently with Proposition 1, $MCPF_t < 1$.

The general message of the Table is that optimal tax rates are high relative to the equilibrium premium and the marginal cost of public funds is well below unity.

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Ratio of Ls to Hs	4	1	1	1	1	1
Utility from participation	0.3	0.3	0.3	0.3	0.25	0.4
Monetary loss of accident	70	70	70	90	70	70
Accident probability of Ls	0.2	0.2	0.2	0.2	0.2	0.2
Accident probability of Hs	0.4	0.4	0.5	0.4	0.4	0.4
At $t = 0$:						
- Premium	5.32	5.32	7.30	11.74	7.55	4.23
- Net payout	21.27	21.27	29.20	46.97	30.22	16.94
- dI/dt	1.27	1.27	0.95	1.60	1.62	0.13
- dI^r/dt (Redistribution)	7.71	2.88	2.36	3.48	3.61	N/A
- $MCPF_t$	0.67	0.67	0.80	0.74	0.75	0.98
- $MCPF_t^r$ (Redistribution)	-0.26	0.44	0.66	0.56	0.55	N/A
At Optimal RedistributiveTax						
- Optimal tax t^*	2.65	4.93	3.21	2.67	3.02	N/A
- Premium	15.30	15.95	13.39	17.75	14.51	N/A
- Net payout	47.96	39.13	37.50	57.63	42.95	N/A
- dI/dt^*	1.47	1.69	1.08	1.91	1.96	N/A
- dI^r/dt^* (Redistribution)	13.40	4.61	2.83	4.61	4.96	N/A
- $MCPF_t$	0.72	0.76	0.84	0.81	0.82	N/A
- $MCPF_t^r$ (Redistribution)	0.76	0.77	0.79	0.77	0.80	N/A
- Performance of Mandatory Insurance	*Better*	$Worse$	$Worse$	$Worse$	$Worse$	N/A

Table 1

4 Extensions

The beneficial effects of insurance taxation extend to multiple types, moral hazard, and monopoly. After sketching these extensions the the case of underestimation of loss probability is examined.

With multiple participant types, the worst under insure to prevent entry by the best non participants. To achieve separation, cover must be increasing in loss possibility. An insurance tax, by making entry less attractive, allows the worst entrants to extend their coverage, relsaxing the constraint on the next best types and so on. Benefits trickle up, creating efficiency gains for each payer type.

Allowing those engaging in the risky activity to reduce the probability of loss by undertaking costly effort does not fundamentally change the analysis. In a two-type PP equilibrium, the offer taken by L types will still be rendered unattractive to H types by lowering cover from the full information level. An insurance tax provides an alternative barrier to entry so lessens the need for inefficient coverage reductions.

Turning to monopoly, suppose that the Ls prefer participation with no insurance to non participation. Hs would not enter under actuarially fair insurance, so definitely prefer non participation to uninsured participation. Were full cover offered at a premium equal to the Ls willingness to pay, the Hs would be as well off from this contract as are the Ls so they would certainly take it. To exclude the Hs, which is potentially profitable as they are not willing to pay an actuarially fair premium, cover must be incomplete. An insurance tax per contract is then absorbed by the monopolist with no effect on coverage or terms. It is neutral in terms of efficiency. When the tax proceeds are redistributed to the uninsured, the equilibrium contract may be affected. The Hs find participation less attractive, so cover can increase, an efficiency gain.

A final extensioned is to biased risk assessment. As Adam Smith (1776) noted, "The chance of gain is by every man more or less overvalued, and the chance of loss is by most men undervalued and scarce by any man, who is in tolerable health and spirits, valued more than it is worth.'(Book 1, Chapter 10, p. 107). Amongst evidence he cited was that in his time, many houses and ships were uninsured and risky occupations offered lower expected returns. Partly in response to empirical anomalies, interest in the role of optimism in insurance markets has recently grown.[15] The consequence here, perhaps paradoxically, is to increase the benefits of taxing insurance. An extension of coverage is now more valuable than warranted by the self evaluation of the Ls.

To illustrate, suppose that insurers are realistic, but subjective loss probabilities of Hs and Ls are below the true level. Suppose that under rational expectations, only Ls enter. Optimism makes the risky activity more attractive, but let beliefs not be so biased that Hs enter. The participation constraint of the Hs, expression 7 now in effect has a lower π_H which, as previously noted, raises dI/dt. Evaluating the effects on the welfare of Ls at true probabilities, the cost of public funds continues to be given by Expression **??**, except with the lower subjective π_H.

Proposition 6 *In a separating PP equilibrium with binding participation constraint optimism lowers the marginal cost of public funds.*

When optimism is high, the Hs enter. A tax sufficiently high to discourage the entry of Hs now benefits them measured at true probabilities (their outcome is the same as under rational expectations) as well as benefitting the Ls through greater coverage.

4.1 Adequacy of the "positive correlation" test

This paper has made the classical assumption that insurance buyers have private information concerning their risk. A number of empirical papers have recently challenged this view. In particular, Chiappori and Salanie (2000) find that comprehensively insured newly qualified French motorists are no more accident prone than those with only third-party coverage. They argue that were moral hazard or hidden types present, the insured would display higher accident rates, controlling for characteristics observed by the insurance

[15] de Meza and Webb (2001) and Koufopoulos (2008) note that heterogeneous optimism, like heterogeneous risk preference, can lead to the insured having lower accident rates than the uninsured. Sandroni and Squintani (2007) show that in the *RS* model with optimism Pareto improvements may not be possible. Spinnewijn (2010) and Coelho and de Meza (2012) report some evidence that the uninsured are more optimistic than the insured.

company.[16] This is the "positive correlation" test. As the correlation is not significantly different from zero, they conclude that drivers have no informational advantage over insurance companies.[17] Applying a similar test to more seasoned Israeli drivers, Cohen (2005) finds that choosing more insurance is associated with higher accident rates. The reason for the difference with beginning drivers may be that individuals learn about their characteristics from experience, but as there was no information sharing in Israel, drivers with poor records may be able to hide their tracks by switching companies. Cohen and Siegelman (2010) survey the evidence on selection effects more generally and find that, depending on the nature of the risk and the group covered, selection may be adverse, advantageous or neutral.

The analysis of this paper suggests the positive correlation test omits a relevant element. If those who are uninsured because they choose not to participate in the risky activity would have higher than average accident rates were they to participate, there is a market failure. Consider, for example, elderly drivers. Those particularly at risk (or their family) may be aware of their peril and most of those in this category may cease to drive. Insurance companies are unlikely to have access to detailed information concerning the deterioration in capacities. For those who continue as motorists, differences in risk may be less extreme. Within this group, choice of how much insurance to take may be dominated by differences in risk preferences, income and other factors that are unrelated to risk exposure. Comparison of motorists with more and less insurance may show little difference in accident rates. To be specific, suppose the only private information concerns a medical condition that impairs driving ability. Under full information, those with this condition do not drive. As shown here, this remains true when type is hidden, but the effect is to limit the maximum cover available in the market. Asymmetric information has impacted the insurance market and welfare improving intervention is possible. If risk preferences differ between those without the condition, so will insurance choices. The most risk averse of the good risks get less insurance than under full information and the less risk averse take even less insurance.[18] Amongst the insured, cover is not correlated with loss probabilities.The standard test therefore falsely concludes that there is no policy relevant asymmetric information.[19]

To see whether the participation decision involves appreciable selection effects, it is necessary to know what the loss rates of the non participants would be had they entered. This may seem an intractable measurement problem, but exogenous premium changes provide opportunities to do so. For example, the EU has recently prohibited gender-based premiums. As a result, motoring premiums for women will tend to rise and for men

[16] The theory behind the "positive correlation" test is developed in Chiappori et al. (2006). There are three important assumptions; i) competition ii) processing claims is costless iii) rational expectations. See de Meza and Webb (2001), Koufopoulos (2009) and Jullien, Salanie, and Salanie (2007)

[17] Chiappori, Julien, Salanie and Salanie (2006) also test the positive correlation property on a different dataset of young French motorists. Incorporating administrative costs they now find evidence of asymmetric information.

[18] Heterogeneous risk preferences will only lead to coverage differences if there are administrative costs in processing claims.

[19] A similar issue arises if selection is by some observable choice. For example, some types of car may attract bad drivers. Controlling for car driven, as does the "positive correlation" test, misses a route by which hidden types manifests itself.

to fall. So it can be investigated whether this affects trends in the numbers of male and female drivers and their relative claim rates.

5 Conclusions

The theme of this paper is that when losses can be attributed to participation in activities that are risky but optional, an insurance tax yields efficiency gains. By making the risky activity less attractive, bad risks are discouraged from participating, enabling good risks to take more insurance. This implies that revenue raised by means of a general insurance tax involves a marginal cost of public funds that is below unity, an efficiency gain. Redistributive taxation is particularly effective in extending cover, as it not only lowers the absolute benefits of participation but raises the gain from non participation. Indeed, an insurance tax with the proceeds distributed as a poll subsidy may even benefit the insured. Moral hazard, multiple types and optimism do not eliminate these benefits and sometimes enhance them. Rather paradoxically, mandatory insurance for those engaging in the risky activity is an alternative to insurance taxation as a means of raising welfare. It is ambiguous which policy does best, but there are circumstances where both should be used.

The test of the relevance of the analysis is whether the accident prone are less likely to engage in risky activities, such as motoring, than are observationally identical participants.[20] This is an aspect of selection effects that has not been investigated empirically and is not captured by the standard "positive correlation" test.

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