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**THE EFFECTS OF INCOME, WEALTH, AND CAPITAL GAINS**

**TAXATION ON RISK TAKING**

**J. E. Stiglitz**

**March 14, 1968**

THE EFFECTS OF INCOME, WEALTH, AND CAPITAL GAINS

TAXATION ON RISK TAKING\*

by

J. E. Stiglitz

1. Introduction

In their pioneering article on the effects of taxation on risk taking, Domar and Musgrave [3] showed that although the imposition of an income tax with full loss offset might lead to less private risk taking, total risk taking would in fact increase.<sup>1</sup> If there were no loss offset, they noted that the amount of risk taking could either increase or decrease, although the presumption was for the latter.

Their analysis rested on individual indifference curves between risk and mean. The limitations of this kind of analysis are well-known.<sup>2</sup>

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<sup>1</sup>For further discussions, see [4, 7, 8].

<sup>2</sup>If the measure of risk is variance, then it requires a quadratic utility function, or that the returns from the asset be described by a two-parameter probability distribution. And the quadratic utility function has some very peculiar properties, e.g., marginal utility becomes negative at finite incomes, risky assets are inferior goods. (See Hicks [5], Arrow [1].)

The purpose of this note is to investigate the effects on the demand for risky assets of income, capital gains, and wealth taxation, with and without loss offsets, using a general expected utility maximization model.

## 2. The Basic Model and Some Behavioral Hypotheses

An individual has initial wealth  $W_0$ . There are two assets in which he can invest his wealth. The risky asset yields a random return per dollar invested of  $e(\theta)$  where  $\theta$  has a probability distribution  $F(\theta)$ .<sup>1</sup> The safe asset yields a sure rate of return per dollar invested of  $r$ .<sup>2</sup> The individual wishes to maximize the expected utility of his wealth at the end of the period. If he invests  $(1-a)$  of his wealth in the safe asset and  $a$  in the risky asset, then his wealth at the end of the period is

$$(1) \quad W = W_0(1 + ae + (1 - a)r) .$$

If we denote by  $E$  the expectations operator, then he wishes to maximize

$$(2) \quad E\{U(W)\} = \int \{U(W_0(1 + ae(\theta) + (1 - a)r))\}dF(\theta) .$$

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<sup>1</sup>It is assumed that  $e(\theta)$  does not depend on the amount invested in the risky asset.  $r$  is assumed to be non-negative.

<sup>2</sup>The "safe" asset may also yield a random return and the analysis is unaffected, provided only that the safe asset is unambiguously safer, so that no matter how the individual allocates his wealth, his income in, say, state  $\theta'$  is greater than in state  $\theta$ . (See Figure 1b.)

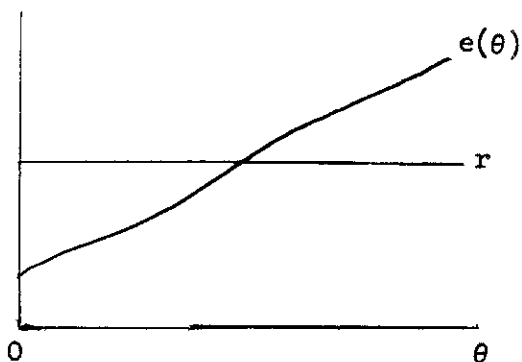


Figure 1a

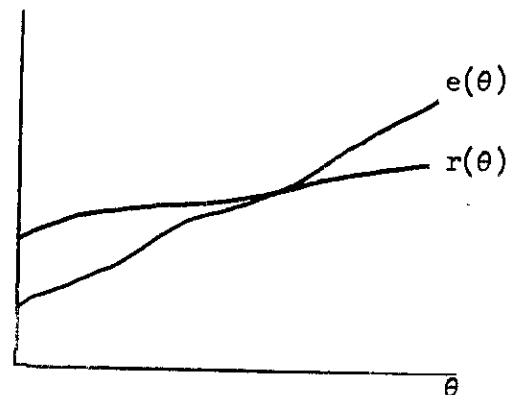


Figure 1b

If  $U'' < 0$ , in the absence of taxes a necessary and sufficient condition for utility maximization is<sup>1</sup>

$$(3) \quad EU'(e - r) = 0.$$

We now make two hypotheses about how the allocation to the risky asset changes as wealth changes:

- A. As wealth increases, more of the risky asset is purchased, i.e., the risky asset is superior.
- B. As wealth increases, the proportion of one's asset in the risky asset decreases.

These two hypotheses are equivalent to the following assumptions about the utility function:

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<sup>1</sup>If the individual can borrow as well as lend at  $r$ , and sell short as well as buy securities, i.e.,  $a$  is not constrained. If  $a$  is constrained between  $0 \leq a \leq 1$ , then (3) holds only for interior solutions; otherwise  $a(1 - a)EU'(e - r) = 0$ ;  $(1 - a)EU'(e - r) \leq 0$ ; and  $aEU'(e - r) \geq 0$ .

A'. Absolute risk aversion,  $-U''/U'$ , decreases as wealth increases.

B'. Relative risk aversion,  $-U''W/U'$ , increases as wealth increases.

It is easy to show that A and A' and B and B' are equivalent:

(3) defines an implicit equation for  $a$  in terms of  $W_0$ . Using the implicit function theorem and integrating by parts, the result is immediate (see [1]). This result can also be seen graphically as follows. We consider the special case where there are only two states of the world,  $\theta_1$  with probability  $p_1$  and  $\theta_2$  with probability  $p_2$ . If the individual just purchases only the safe security, his wealth at the end of the period is represented by the point  $S$ , with  $W(\theta_1) = W(\theta_2) = W_0(1 + r)$ . If the individual just purchases only the risky asset, his wealth at the end of the period is represented by the point  $R$ , with  $W(\theta_1) = W_0(1 + e(\theta_1))$  and  $W(\theta_2) = W_0(1 + e(\theta_2))$ . (Figure 2.) Then by allocating different proportions between the two he can obtain any point along the line  $RS$ . We have drawn in the same diagram the indifference curves

$$(4) \quad \bar{U} = p_1 U(W(\theta_1)) + p_2 U(W(\theta_2)).$$

As  $W_0$  changes, the budget line moves in parallel. The individual maximizes expected utility at the point of tangency, i.e., where the marginal rate of substitution equals the slope of the budget constraint:

$$(5) \quad \frac{p_1 U'(W(\theta_1))}{p_2 U'(W(\theta_2))} = \frac{e(\theta_2) - r}{e(\theta_1) - r} .$$

The demand for the risky asset can be written as

$$(6) \quad aW_0 = \frac{W(\theta_1) - W_0(1+r)}{e(\theta_1) - r} = \frac{W(\theta_2) - W_0(1+r)}{e(\theta_2) - r} .$$

If the risky asset is neither superior nor inferior, then it is easy to see that the Engel curves must have a slope of 45°,

since  $\frac{dW(\theta_1)}{dW_0} = (1+r) = \frac{dW(\theta_2)}{dW_0}$  . From Equation (5), this means

that

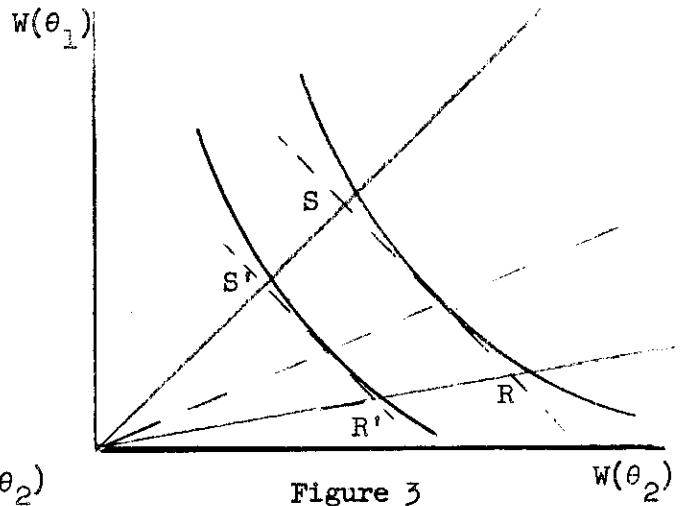
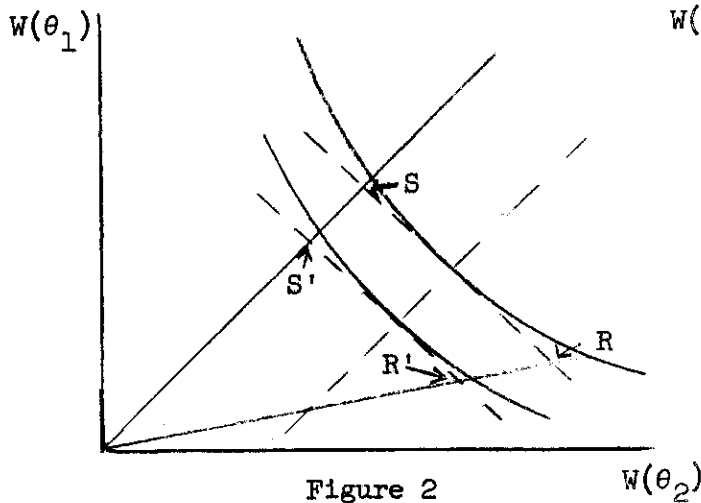
$$\frac{dW(\theta_2)}{dW(\theta_1)} = \frac{[-U''(W(\theta_1))/U'(W(\theta_1))]}{[-U''(W(\theta_2))/U'(W(\theta_2))]} = 1$$

or  $-U''/U'$  is constant. If the risky asset is superior, the Engel curve must bend down, i.e., have a slope everywhere less than unity; since  $W(\theta_2) < W(\theta_1)$  , this means that absolute risk aversion must be declining.

If we divide both sides of Equation (6) by  $W_0$  , we immediately see that if  $a$  is to remain constant, then the ratio of  $W(\theta_1)$  to  $W_0$  must remain constant and the ratio of  $W(\theta_2)$  to  $W_0$  must remain constant, i.e.,  $W(\theta_1)$  must be proportional to  $W_0$  . All Engel curves must be straight lines through the origin, and have unitary elasticity, so from Equation (5)

$$\frac{d \ln W(\theta_2)}{d \ln W(\theta_1)} = \frac{-[U''(W(\theta_1))W(\theta_1)/U'(W(\theta_1))]}{-[U''(W(\theta_2))W(\theta_2)/U'(W(\theta_2))]} = 1,$$

which implies constant relative risk aversion. If  $a$  is to decline, as  $W_0$  increases, the Engel curves must bend upward, i.e., the elasticity must be greater than unity, which implies increasing relative risk aversion.



The validity of these testable hypotheses can only be determined empirically. Certainly, the hypothesis that risky assets are not inferior seems reasonable. The second hypothesis is somewhat more questionable. Arrow [1], in addition to suggesting several theoretical reasons for its validity, has argued that the empirical evidence from studies on the demand for money also support it. Stiglitz [9] has raised some questions concerning these arguments, and the empirical support seems, at best, rather weak, and contradictory. For instance, certain cross section estate data leave some doubt whether individuals do allocate a larger per-

centage of the portfolio to safe assets as their incomes increase.<sup>1</sup>

In this paper we will show that if these hypotheses are correct, then we can make some unambiguous statements about the effects of taxation on risk taking, independent of the probability distribution of returns for the risky asset, but if these hypotheses are not correct, many of the conclusions of the original Musgrave-Domar analysis may no longer be valid.

### 3. Wealth Tax

We begin the analysis with an investigation of the effects of the wealth tax, since this is the simplest case to analyze. A proportional wealth tax at the rate  $t$  means that wealth at the end of the period is given by

$$(7) \quad W = W_0(1 + (1 - a)r + ae)(1 - t).$$

It should be immediately apparent that changing the tax rate is just equivalent to changing  $W_0$  in terms of the effect on risk taking.

Hence, we immediately obtain

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<sup>1</sup>Lampman [6] provides the following data on average portfolio allocation to bonds and cash for different estate sizes (males):

Size of Estate	Age		
	30-40	55-60	75-80
70- 80,000	12%	20.2%	26.2%
100-120,000	11.5%	19.1%	23.5%
200-300,000	11.4%	15.3%	20.7%

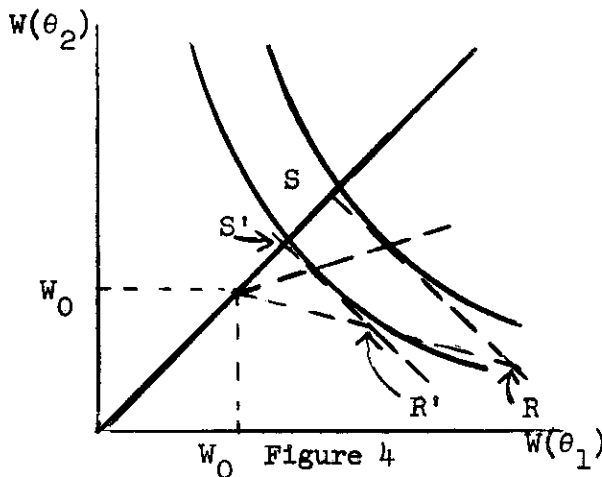
There is some difficulty in interpreting the data, however, since the investment opportunities for rich people may be different from those for poor.



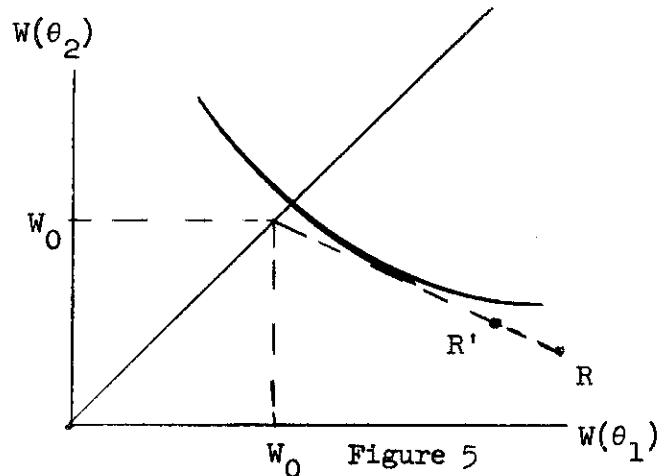
Proposition 1. A proportional wealth tax increases, leaves unchanged, or decreases the demand for risky assets as the individual has increasing, constant, or decreasing relative risk aversion.

4. Income Taxation

The case of income taxation with full loss-offset is only slightly more difficult to analyze. In Figure 4, we show how an income tax moves the budget constraint in parallel. Income is measured by the distance from, say,  $R$  to  $W_0$  or  $S$  to  $W_0$ , so an income tax at the rate  $t$  reduces the returns from investing in only the safe asset or the risky asset to  $S'$  and  $R'$ , respectively.



Income tax: Demand for Risky Asset Unchanged



Income tax:  $r = 0$ .

The after tax budget constraint is the line joining  $R'$  to  $S'$ . Note, however, that  $a$  is not constant along a ray through the origin, but along a ray through the point  $W_0$ . Thus, it is immediately apparent that in this simple example if individuals have

constant or increasing relative risk aversion, or increasing absolute risk aversion risk taking will increase. But if there is decreasing relative risk aversion, just the opposite may occur.

Before taking up the more general case, we should note the special case where  $r = 0$ , i.e., the safe asset is money and has a zero rate of return. Then the after tax budget constraint is identical to the before tax budget constraint and the values of  $W(\theta_1)$  and  $W(\theta_2)$  are unaffected: all the tax does is to induce individuals to hold more risky assets. (See Figure 5.)

In the more general case, only slightly stronger conditions are required to guarantee that a proportional tax will increase risk taking. We can write after tax income,  $Y$ , as

$$(8) \quad Y = W_0(1 - t)[(1 - a)r + ae],$$

and his wealth after taxes is

$$W = W_0[1 + (1 - t)(ae + (1 - a)r)].$$

The condition for utility maximization is simply

$$(9) \quad EU'(e - r) = 0.$$

It is of the same form as the no tax condition, since both the risky and safe asset are taxed proportionately.

We wish to know, how does a change with  $t$

$$(10) \quad \frac{da}{dt} = \frac{-E \frac{U''Y}{1-t} (e-r)}{-EU''(e-r)^2(1-t)W_0}$$

or

$$(10)' \quad - \frac{da/a}{d(1-t)/(1-t)} = 1 - \frac{W_0 r EU''(e-r)}{-a EU''(e-r)^2 W_0}.$$

The denominator of (10) is always positive, so whether increasing taxes leads to more or less investment in the risky assets depends on the numerator of Equation (10). If we set  $r = 0$ , from (10)' it is immediately apparent that  $a$  increases, and in proportion to the change in  $(1-t)$ . It is also clear that if there is increasing absolute risk aversion, as in the quadratic utility function, the second term is unambiguously positive, since

$$EU''(e-r) = E \left\{ \frac{U''}{U'} \{U'(e-r)\} \right\} = E \left[ \frac{U''(W(\theta))}{U'(W(\theta))} - \frac{U''(W(\theta^*))}{U'(W(\theta^*))} \right] U'(e-r) \\ + \frac{U''(W(\theta^*))}{U'(W(\theta^*))} EU'(e-r),$$

where  $e(\theta^*) = r$ . If there is increasing absolute risk aversion, then for those states of nature for which  $e(\theta) > r$ ,  $W(\theta) > W(\theta^*)$  so  $\frac{U''(W(\theta))}{U'(W(\theta))} < \frac{U''(W(\theta^*))}{U'(W(\theta^*))}$ , and similarly for those states of nature for which  $e(\theta) < r$ . Thus the first term above is unambiguously negative and, by Equation (9), the second term is zero. Moreover, the percentage increase in  $a$  from a percentage decrease in  $(1-t)$  is greater than unity.

If in Equation (10), we recall that  $Y = W - W_0$ , we obtain the result that the numerator of (10) is equal to

$$\begin{aligned} E \left[ \left( \frac{-U''W}{U'} \right) - \left( \frac{-U''W_0}{U'} \right) \right] \frac{U'(e-r)}{1-t} &= E \left\{ \left( \frac{-U''W}{U'} - \frac{-U''(W(\theta^*))}{U'(W(\theta^*))} W(\theta^*) \right) \right. \\ &- W_0 \left[ \left( \frac{-U''}{U'} - \frac{-U''(W(\theta^*))}{U'(W(\theta^*))} \right) U'(e-r) \right] + E \left[ \frac{-U''(W(\theta^*))W(\theta^*)}{U'(W(\theta^*))} \right. \\ &\left. \left. - W_0 \frac{-U''(W(\theta^*))}{U'(W(\theta^*))} \right] U'(e-r) \right\} \end{aligned}$$

where  $\theta^*$  is defined as above. If there is constant or increasing relative risk aversion and constant or decreasing absolute risk aversion, the first term above is unambiguously positive, and by Equation (9) the second term is identically zero. Thus,  $a$  is increased, but by a smaller percentage than the percentage decrease in  $1-t$ .

If there is decreasing relative risk aversion, investment in the risky asset may be unchanged or decreased as the result of the imposition of an income tax. To see this more clearly, consider the following utility function, and assume that the probability of  $e < 0$  is zero:

$$U(W) = \int_{W_0}^W A(W - W_0)^\alpha dW + U(W_0), \quad A > 0, \quad \alpha < 0$$

Then, for  $W > W_0$ , marginal utility is just

$$U' = A(W - W_0)^\alpha > 0$$

so absolute risk aversion is

$$-\frac{U''}{U'} = -\frac{d \ln U'}{dW} = \frac{-\alpha}{W - W_0} > 0$$

and is decreasing, since

$$\frac{d - \frac{U''}{U'}}{dW} = \frac{\alpha}{(W - W_0)^2} < 0$$

while relative risk aversion is

$$\frac{-U''W}{U'} = \frac{-\alpha W}{W - W_0} > 0$$

and is decreasing,

$$\frac{d - \frac{U''W}{U'}}{dW} = \frac{\alpha W_0}{(W - W_0)^2} < 0 .$$

But since  $\frac{-U''}{U'}(W - W_0) = \frac{-U''Y}{U'} = -\alpha$ , a constant, it is clear that the numerator of Equation (10) is zero. Thus, for a perfectly well-behaved utility function, with diminishing marginal utility and decreasing absolute risk aversion, the imposition of the income tax leaves the demand for risky assets unaffected. Similarly, we can construct examples where it decreases the demand for risky assets. We can summarize the results in the following

Proposition 2. Increased income taxes lead to increased demand for risky assets if

- (a) The return to the safe asset is zero, or
- (b) Absolute risk aversion is constant or increasing, or
- (c) Absolute risk aversion is decreasing and relative risk aversion increasing or constant.

If none of the above three conditions is satisfied, it is possible for increased taxes to reduce risk taking.

Table 1

Effects of Income Tax on Risk Taking:  $\frac{-d\ln a}{d\ln(1-t)}$

Relative Risk Aversion	Absolute Risk Aversion		
	Decreasing	Constant <sup>1</sup>	Increasing <sup>1</sup>
Decreasing	Ambiguous	X	X
Constant	$0 < \frac{-d\ln a}{d\ln(1-t)} < 1$	X	X
Increasing	$0 < \frac{-d\ln a}{d\ln(1-t)} < 1$	1	> 1

4. Special Treatment of Capital Gains

Our present taxation laws do not, however, treat all risks alike; indeed, one of the main justifications for the special capital gains provisions is that they encourage risk taking. This, how-

<sup>1</sup>It is impossible to have constant or increasing absolute risk with non-increasing relative risk aversion.

ever, may not always be the case. Take, for instance, the extreme case of a tax only on the safe (or the relatively safe) asset, with no taxation on the risky asset. It is easy to show that the demand for the risky asset increases or decreases as

$$-W_0 EU''r(1-a)(e-r(1-t)) + EU'r \begin{matrix} > \\ < \end{matrix} 0$$

and by exactly analogous arguments to those presented above, we can show that the tax on the safe asset alone will lead to more risk taking if there is constant or increasing absolute risk aversion as with the quadratic utility function. If there is decreasing absolute risk aversion, it is surely possible for the tax on the safe asset to lead to less rather than more risk taking. In Section 6, we shall compare this tax explicitly with a proportional income tax.

##### 5. No Loss Offset

We now examine the effects of no loss offset provision in an otherwise proportional income tax. Diagrammatically, the after tax budget constraint looks as depicted in Figure 6(a), if  $r$  is greater than zero, or as in Figure 6(b), if  $r = 0$ . We can see that there is an "income effect" and a "substitution effect," and in the cases discussed in the previous section, these will be of opposite signs, so that the

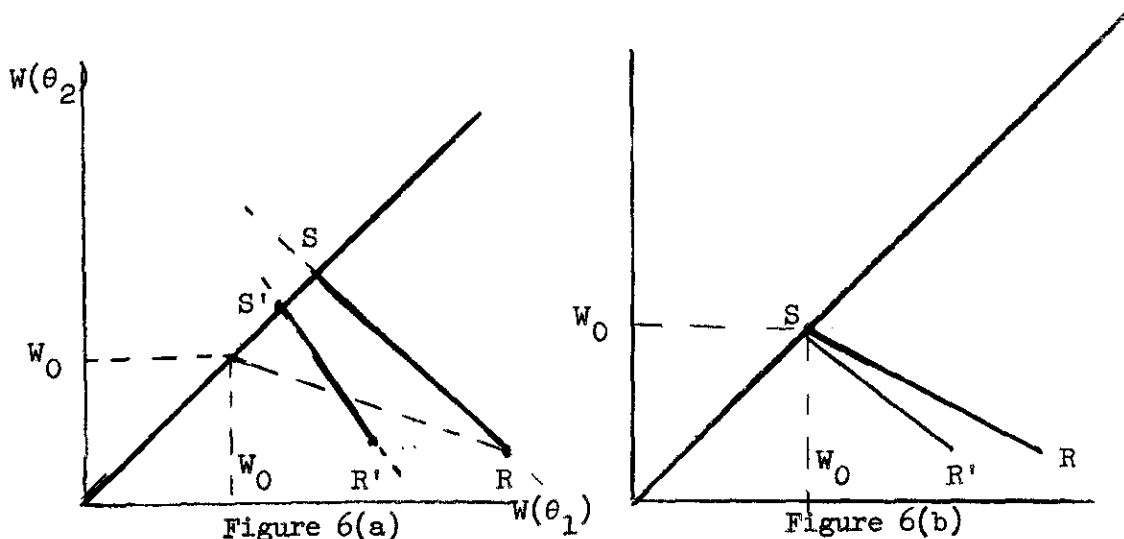


Figure 6(a) Budget Constraints: No Loss Offset  
 Figure 6(b) Budget Constraints: No Loss Offset with  $r = 0$ .  
 net effect is ambiguous. It is easy to see, however,

Proposition 3(a). For sufficiently large tax rates, the demand for risky assets is reduced.

To see this, all we have to observe is that for tax rates near one hundred percent, almost the entire portfolio is allocated to the safe asset. Since the indifference curves are convex, the demand curves for the different assets as a function of the tax rate are continuous.

Moreover, it is easy to show that there will always be less risk taking than with full loss offset. Consider first the effects of partial off-setting, where we are allowed to deduct a portion of

losses from the risky asset from other income. Income, when  $e < 0$ , can be written

$$[ae(1 - v) + (1 - a)r(1 - t)]W_0 \quad v \leq t$$



No loss offset is the extreme case where  $v = 0$ . Without loss of generality, we adopt the following convention about  $\theta$ :  $\theta$  is defined over the interval  $[0,1]$ ,  $e(0) = \min e$ ;  $\frac{de(\theta)}{d\theta} > 0$ ;  $e(\theta^*) = 0$ .

Now, what happens as  $v$  is reduced? This will depend on the sign of

$$\int_0^{\theta^*} [-U''\{e(1-v) - r(1-t)\}eaW_0 - U'e]dF(\theta)$$

which is unambiguously positive. Hence, we have

Proposition 3(b). There is always less risk taking with no loss offset or partial loss offset than with full loss offset.

We shall now attempt to find some more precise conditions under which risk taking unambiguously increases or decreases. For simplicity we limit ourselves to the case where  $r = 0$ . We can write the first order conditions for expected utility maximization as

$$(11) \quad \int_{\theta^*}^1 U'e(1-t)dF(\theta) + \int_0^{\theta^*} U'edF(\theta)$$

so the sign of  $da/dt$  is that of

$$(12) \quad \int_{\theta^*}^1 [-U''eaW_0 - U'e]dF(\theta) = \int_{\theta^*}^1 \left[ \frac{-U''(W - W_0)}{U'} - 1 \right] U'edF(\theta)$$

We thus obtain:

Proposition 3(c). If  $r = 0$  the imposition of an income tax with no loss offset decreases risk taking if relative risk aversion is less than or equal to unity.<sup>1</sup>

One more condition will now be derived. If we integrate equation

(12) by parts, letting  $H(\theta) = \int_{\theta^*}^{\theta} U' e dF(\theta)$ , and  $\alpha = \frac{Y}{W}$ , we obtain

$$(13) - \int_{\theta^*}^1 H(\theta) \left\{ \frac{d - \frac{U''W}{U'}}{dW} \alpha + \frac{-U''W}{U'} \frac{d\alpha}{dW} \right\} \frac{dW}{d\theta} + \left\{ \left( \frac{-U''(W - W_0)}{U'} \right)_{\theta=1} - 1 \right\} H(1) .$$

If there is increasing relative risk aversion the integral expression is negative. Assume that the maximum return is  $m$ , so that  $W < W_0 m$ ;

since  $\left( -\frac{U''W}{U'} \right) \frac{W - W_0}{W} \leq \frac{-U''W}{U'} \frac{(m - 1)}{m}$ , for the second term to be negative, all that we require is that relative risk aversion be less

than  $\frac{m}{(m - 1)}$  at its maximum. If  $m$  is 1.5 (a 50% rate of return),

then relative risk aversion need only be less than 3. Thus we have

Proposition 3(d). If  $r = 0$ , the imposition of an income tax with no loss offset decreases risk taking if there is increasing relative risk aversion, and if  $(m - 1)$  is the maximum rate of return, the maximum value of relative risk aversion in the relevant region is

less than  $\frac{m}{m - 1}$ .

These results do tend to support the presumption that risk taking will be reduced by income taxes without loss offset provisions, particularly at low levels of wealth.

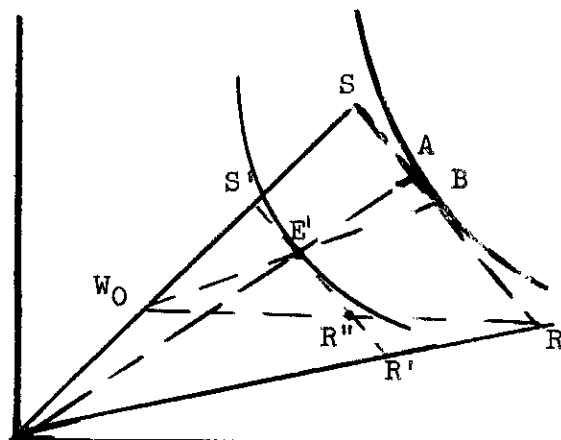
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<sup>1</sup>The Bernoulli utility function,  $U = \ln W$ , has constant relative risk aversion of unity. For small values of  $W$ , if the utility function is bounded from below, relative risk aversion must be less than unity, while if the utility function is bounded from above, it must be greater than unity. See [1].

## 6. Welfare Implications

Even if risk taking is increased by a given type of tax, it is not clear that such a tax should be adopted: after all, risk taking is not an end itself. Indeed, there are some who have argued that the stock market pools risk sufficiently effectively that there may be no discrepancy between social and private risks<sup>1</sup>, [2, 10] and hence no justification to governmental encouragement of risk taking. It is important to observe, however, that some of the taxes considered may be more effective in obtaining a given end than others. Alternative taxes can be evaluated in terms of (a) losses in expected utility, (b) changes in demands for risky assets and (c) revenues raised in each state of nature. Note that the last is much more stringent than comparisons simply between average revenues; two taxes may have the same expected revenue, but in any given situation, differ.

(a) Wealth vs. Income Tax. In Figure 7, we have depicted the results of income and wealth taxes which lead to the same reduction in expected utility. As we have already noted, the demand for risky assets is constant along a ray through the origin for the wealth tax and along



- SR Budget constraint without taxes
- S'R'' Budget constraint with income taxes
- E' Equilibrium with income taxes or wealth taxes
- S'R' Budget constraint with wealth tax

Figure 7

<sup>1</sup>There are some difficulties in defining these concepts rigorously, but it is not our purpose here to go into these issues.

a ray through  $W_0$  for the income tax. It is immediately apparent that the income tax leads to more risk taking than the wealth tax. On the other hand, revenue is measured by the vector  $EB$  for the income tax and  $EA$  for the wealth tax: one is larger in one state, the other in the other state. It should be noted that, in general, there may not exist wealth taxes with the same effect on the demand for risky assets or yielding the same revenue in each state of nature as an income tax.

(b) Preferential Treatment of Capital Gains vs. Proportional Income Tax. We consider the extreme case of no taxation of the risky asset, for which demand is constant along a  $45^\circ$  line. In Figure 8, we compare the effect of an income tax and a tax only on the income from the safe asset which leave the individual at the same level of expected utility. In one case, risk taking is greater for the former tax, in the other, for the latter: the special treatment of the risky assets need not increase risk taking. Again, one tax has a higher revenue in one state, the other in another state.

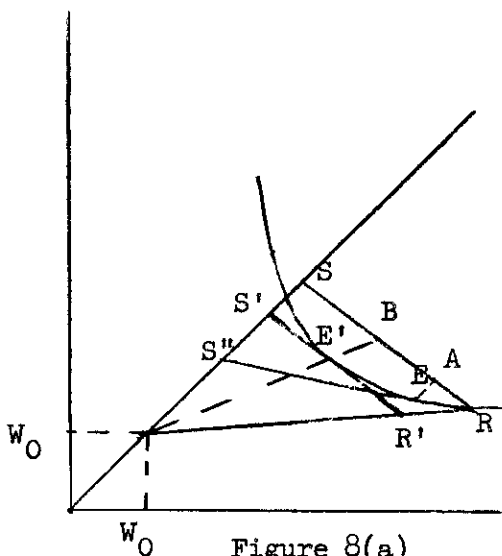


Figure 8(a)  
Demand for Risky assets smaller  
for income tax than Preferential  
treatment of capital gains

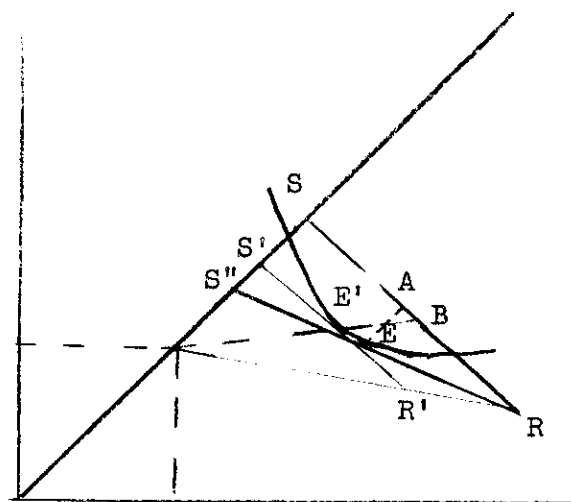


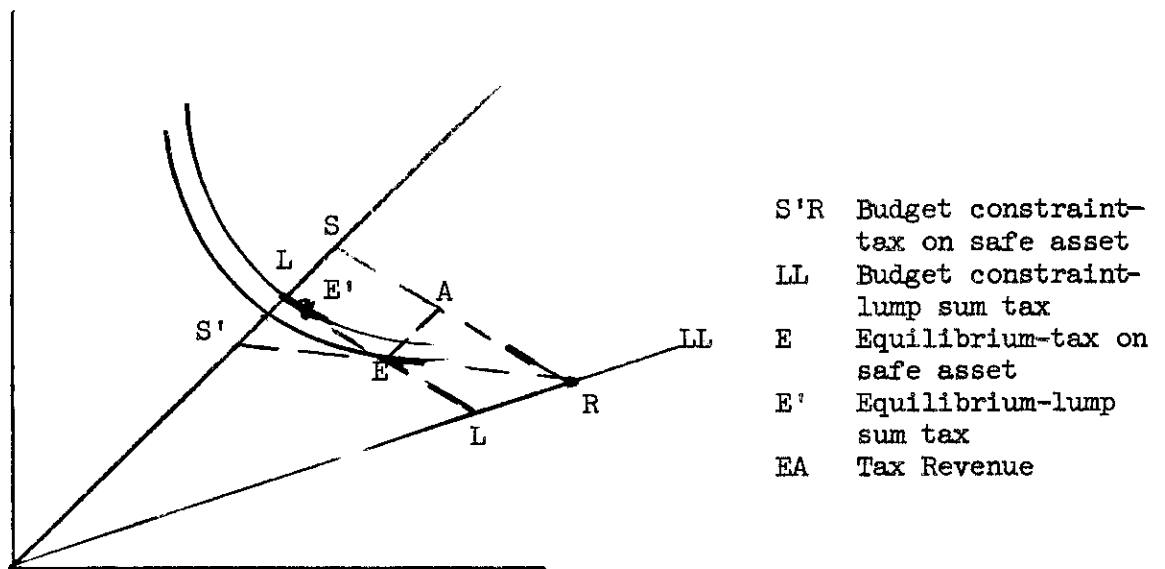
Figure 8(b)  
Demand for Risky assets larger  
for income tax than Preferential  
treatment of capital gains

Similar results obtain for comparisons with wealth taxes.

(c) Wealth Tax vs. Lump Sum Taxes. We now compare a wealth tax with a lump sum tax of equal revenue in each state of the world. (A lump sum tax as usual is a tax independent of the behavior of the individual.) Since the lump sum tax is given by the vector EA, in Figure 7, the after lump sum tax budget constraint is given by S'R', so the equilibrium is still at E'. Thus, a wealth tax is equivalent to a lump sum tax of the same revenue, with respect to risk taking.

(d) Income Tax vs. Lump Sum Taxes. Similarly, it can be shown that an income tax is identical in its effects on risk taking to a lump sum of equal revenue.

(e) Income Tax with Special Provisions for Capital Gains vs. Lump Sum Taxes. Again, we consider the extreme case of a tax only on the safe asset. As Figure 9 illustrates, although the demand for the risky assets is always less under lump sum taxes (of equal revenue), expected utility is always higher.



The important point to observe is that even if one wished to encourage greater risk taking, and even if preferential treatment of capital gains did so effectively it is not clear that such treatment is the most desirable way of doing so.

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