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Abstract. In this paper we examine government debt and tax-transfer policies that can improve the allocation of risk between generations. Markets cannot allocate risk efficiently between two generations whenever the two generations are not *both* alive prior to the occurrence of a stochastic event. This implies that government policies transferring risk between generations have the potential to create first-order welfare improvements. Our model provides a non-Keynesian justification for debt-finance of wars and recessions, as well as an added rationale for Social Security type tax-transfer schemes which aid unlucky generations, e.g., the Depression generation, at the expense of luckier generations.

Keywords. Risk sharing, social security, debt policy

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Intergenerational Risk Sharing

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It is well known that economic efficiency requires that any risk in the economy be shared among individuals in such a way that each individual charges the same risk premium for an additional share in each lottery. If such efficient risk sharing does not occur, then in principle contingent consumption can be reallocated so as to make everyone better off. For example, a number of authors have explored the implications of the fact that individuals cannot easily avoid bearing the risk in their own labor income. Given this observation, Varian[1980] and Eaton and Rosen[1980] have argued that a personal income tax may result in a more efficient allocation of risk in the economy.[1] Even when fluctuations in labor income are shared by all workers, Merton[1984], Fischer[1982], and Enders and Lapan[1982], have argued that when there is no market in a security corresponding to aggregate labor income then the government can still reallocate risk to nonworkers through a labor income tax in a Pareto-improving way.[2] Similarly, Aizenman[1981] argued that the government can beneficially offset domestic economic shocks through modification of the exchange rate when the international securities market fails to pool risks internationally.

In each of these cases, there exists the question of why there is no market in a particular lottery, and whether the reasons that prevented the market from pooling a lottery appropriately may also prevent the government from raising utility by doing so. For example, if there is no private market allowing diversification in the risk in an individual's labor income because the moral hazard costs of doing so outweigh the benefits, then the government, also facing these moral hazard costs, can do no better than the market. In contrast, if no private market exists because of adverse selection reasons, then the government will be able to avoid these problems by making participation in the risk pooling scheme compulsory. Since it is normally unclear why a private market fails to exist in a particular lottery, it is also unclear whether there is any potential for fruitful government intervention.

Markets also do not appear able to pool lotteries faced by different non-overlapping generations. However, here the reason why risk-sharing markets fail to exist seems clear.

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[1] Buchanan[1975] argued that this risk sharing aspect of the personal tax may explain the strong political support for it.

[2] While there may be no explicit mechanism available to trade risk in labor income, firms may be able to reallocate risk between workers and capital owners through implicit labor contracts, an idea explored by Azariadis[1975] and Baily[1974].

Later generations cannot participate in the securities market for lotteries which occur before they are born because they are not alive ex ante to buy shares in these lotteries. An agent cannot profitably buy shares on behalf of later generations since there would be no legal mechanism to force these later generations to accept any losses, implying that the agent would have no incentive to pass on any gains. The problem is that later generations cannot precommit themselves to participate in a lottery even when they would gain in expected utility by doing so. By the time they can commit themselves, they know the outcome. These problems arise whenever two generations are not both active in the securities market before the outcome of a particular lottery is revealed, even if their lives do overlap at some point.

The government, however, could well have the power to precommit later generations to share in the outcome of earlier lotteries. If so, there is the potential for Pareto-improving government policies which share risk between different generations. In fact, some government policies do seem to have been used, whether consciously or otherwise, for just this purpose. For example, historically, debt has been issued to help finance unfavorable events, such as wars and recessions, and paid off only gradually over later generations. Diamond[1965] worked out in a very general setting just how debt issues result in a reallocation of wealth between generations. By the same argument, *stochastic* issues of debt result in a reallocation of *risk* between generations. A plausible argument might be made that the initial role of the Social Security program was to aid the generations who lost both financial wealth and labor income during the Great Depression.

The objective of this paper is to explore the characteristics of an optimal government risk-sharing scheme, assuming that the government has the power to precommit future generations. Since there are an arbitrarily large number of future generations to share in any particular lottery (e.g., today's recession), one might expect, by analogy with the diversification theorems in finance, that on efficiency grounds each generation ought to bear an arbitrarily small share in the outcome of any lottery.[3] This argument is formalized in Section 1.

One problem with this argument is that the process by which random outcomes are shared with future generations is by adding to the capital stock when the outcome is favorable and consuming part of the capital stock when the outcome is unfavorable. Yet accounting explicitly for the economic effects of changing the capital stock makes the problem much more complicated. These and other complications are explored in Section 2.

In these sections, we assume that the government has the power to precommit future generations, and develop a normative model of government behavior. However, the government may not plausibly be able to precommit later generations, regardless of the ex post outcomes. While the risk-sharing policy raises the expected utility of future generations, based on the information available at the time of enactment, future generations may well find themselves worse off at birth than they would be if the policy could be repealed. In Section 3, we explore several models of government behavior to forecast whether a given risk-sharing scheme would end up being repealed at a later date when some future generation, seeing past outcomes, finds the implications of the policy unfavorable for it. We

[3] This intuition has been stated previously in Stiglitz[1983a,b] and Gordon[1985].

argue here that use of both debt and Social Security to transfer risk between generations could well be time consistent.

While this paper provides an explanation for debt finance of wars and recessions, and one explanation for the enactment of Social Security, many other explanations are possible. In section IV, we compare briefly our explanation with some alternative explanations.

1. Risk Sharing Between Generations: Base Case

We begin by exploring risk sharing in a very simple two period overlapping generations model. For simplicity, we assume there is no population growth and no technological change. Generations are therefore identical except for the period in which they are born. The generation born in period t, and its earnings, are denoted through use of a subscript t.

Members of each generation are assumed to work only while they are young and to consume only while they are old. We assume they work a fixed amount while young, earning a nonstochastic wage w. They save this labor income and earn a stochastic return, e_t, on it with mean zero and variance s, allowing them to consume $w + e_t$ when they are old.[4] Their utility depends solely on their consumption, which is stochastic. We assume, for simplicity, that their ex ante utility can be expressed as a function of their expected income and the variance of this income, and denote their utility by $U(w) - V(s)$.[5]

The outcome of the stochastic event is revealed "between periods"; that is, after the previous generation has died but before the next generation is born. For simplicity, we assume that each stochastic event is identically distributed and independent of all others. Because there are never two generations alive both before and after a stochastic event, there is no possibility of sharing risk between generations through the market. We assume, though, that risk is efficiently shared among members of each generation. Each individual therefore has expected utility of $U(w) - V(s)$. When it adds clarity, we include a subscript on the utility function indicating the generation number.

Since two generations are always alive simultaneously, however, the government can transfer income from one to the other, based on the outcome of past events, and thereby raise the expected utility of every generation.[6] For example, if the government transfers $e_{t-1}/2$ from the old to the young in each period t, then the young in period t receive net income of $w + e_{t-1}/2$. This income is saved, providing $w + e_{t-1}/2 + e_t$ the next period.[7] Part of this is paid as a transfer to the next generation, however, leaving $w + (e_{t-1} + e_t)/2$ for consumption. Expected utility of all but the initial generation t would therefore be

$$U(w) - V(\text{var}([e_{t-1} + e_t]/2)) = U(w) - V(s/2).$$

[4] This stochastic return represents the return on the "market portfolio." We assume that all idiosyncratic risks affecting subsets of the population have been diversified away.

[5] Most of our results generalize easily to an expected utility model, though exposition is simpler in a mean-variance setting.

[6] The expected utility is computed as of the date of the enactment of the program, a point we will discuss further below.

[7] We assume for simplicity that the same random income e_t is received independently of how much is saved from the previous period.

Each lottery is shared between two generations, allowing a pooling of risks and an increase in expected utility. The first generation does yet better since it shares in only one lottery. Its expected utility equals $U(w) - V(\mathrm{var}(e_1/2)) = U(w) - V(s/4)$. Thus this policy represents a Pareto improvement in expected utility — all generations can be expected to be made better off by this risk sharing arrangement.

This tax-transfer scheme can easily be redesigned so as to share each lottery between n generations. For example, the net transfer from old to young in period t can be specified to be $\sum_{i=1}^{n-1}[(n-i)/n]e_{t-i}$. The consumption of generation t would then equal $w + \sum_{i=0}^{n-1} e_{t-i}/n$. Its utility, expected as of the date of enactment of the policy, can be expressed as

$$U(w) - V\left(\mathrm{var}(\sum_{i=0}^{n-1} e_{t-i}/n)\right) = U(w) - V(s/n).$$

Again the first $n-1$ generations would fare yet better. As risk is shared among more generations — as n becomes larger — the expected utility of each generation increases. As n increases without bound, each generation's utility converges to $U(w)$ and the costs of bearing the collective risks drop to zero.

It is important to realize that the transfers are made only between the two generations that are alive contemporaneously. However the magnitude of the transfer from generation $t-1$ to generation t is a function of the random outcome of the lotteries of the $n-1$ earlier generations. Thus, in effect, risk is being shared among n generations.

In this argument, we described the government policy as a tax-transfer scheme. It could equivalently have been described as a particular stochastic government debt policy. If each lottery is to be shared equally between n generations then the government upon seeing the outcome e_t can retire $[(n-1)/n]e_t$ dollars of debt, funded by a tax on the old (those who received e_t), then reissue e_t/n dollars of debt during each of the following $n-1$ periods, paying the proceeds of each debt issue to the old in that period. This policy results in the same redistribution of risk as the tax-transfer scheme described above.

Obviously, the above model is highly simplified. However, the conclusions are robust to many types of generalizations. The basic intuition being modeled is that each lottery ought to be shared relatively equally among all current and future individuals, and there are many future individuals relative to the current number of individuals. What is social risk at any one date is idiosyncratic risk when pooled with the independent lotteries of many later generations. Thus almost all risk should be passed forward to future generations. This conclusion remains even if we introduce an autocorrelation structure to the error terms, as long as no shock leaves permanent after effects. Similarly, we can allow individuals to consume throughout their life, have lotteries which occur at any point during their life, and have any type of risk-averse utility function, and still argue that idiosyncratic risks ought to be pooled. Allowing for population growth would only increase the incentive to share risk with the future.

2. Risk Sharing Between Generations: Complicating Factors

However, the extreme conclusion that current generations should bear *none* of the risk in current output is very sensitive to several of the key assumptions made above. For example, the mechanism by which random fluctuations in income are transmitted to later generations is through random fluctuations in the capital stock. In the above argument, these fluctuations in the capital stock had no effect on wage rates or interest rates, and we did not impose a nonnegativity constraint on the capital stock. Taking account of these complications results in a substantial quantitative change in the conclusions of the argument. In addition, one might expect that risk-sharing schemes would generate moral hazard problems, which we ignored above.

In the following sections, we will try to shed some light on how each of these various complications affects the nature of the optimal risk-sharing scheme. In doing do, our objective is not to characterize the efficient policy in a very general setting. Attempting to do so leads quickly to a stochastic optimal growth model such as those treated in Merton [1975] or Brock-Mirman [1972]. The analysis of this sort of model is sufficiently complicated that it provides little or no understanding concerning what factors have important effects on the optimal degree of risk-sharing. Our objective instead is to show in a much simpler setting which factors are important in limiting the optimal degree of risk-sharing.

In these sections, we make two simplifying assumptions about government policy. First, we assume that if the government is sharing each lottery between n generations, then it can choose any proportional amount a_i of the initial lottery to allocate to the generation born i periods later, subject to the constraint that $\sum_i a_i = 1$. For simplicity, the sharing rule is not allowed to vary over time, as a function of the state of the economy, or as a function of the outcome of the lottery.

The second simplifying assumption we make is that the objective of the government is to maximize the expected utility of the steady-state generations, expected as of the date when the policy is enacted. By steady-state generations we mean those generations who share in $n-1$ past lotteries in addition to keeping some share of their own lottery. In contrast, the first $n-1$ generations alive after the policy is enacted fare better than these steady-state generations since they keep the same fraction of their own lottery, but do not have to participate in as many past lotteries. Therefore, if a policy raises steady-state expected utility, it will raise the expected utility of earlier generations as well, and therefore be a Pareto improvement.

We realize that the definition of Pareto improvement in the context of differential information is somewhat controversial. We have adopted the view that a Pareto improvement means that each generation is expected to be better off given the information available at the time of enactment of the policy. An alternative definition of Pareto improvement, examined in Peled[1982], requires that each generation have higher expected utility at birth, conditional on the information available at that time. In the context of intergenerational redistribution, this would require that each generation have higher expected utility *given* the payments it owes to the previous generation. Peled shows that, under his definition, a competitive equilibrium is Pareto efficient, and thus no government intervention is warranted.

In contrast, our definition of Pareto improvement requires only that each generation gains by the policy change in the eyes of the decision-maker, evaluated using the information available at the time the policy is enacted. Under this definition, government intervention to facilitate risk sharing is appropriate.

Using the model of the economy of Section 1 and the policy described there, a steady-state generation, born in period t, would end up with consumption equal to $w+\sum_{i=0}^{n-1} a_i e_{t-i}$ and expected utility of $U(w)-V(s\sum a_i^2)$. The policy which maximizes steady state utility is therefore simply $a_i = 1/n$ for all i. Thus the optimal policy, given the above assumptions is precisely the equal sharing policy examined previously in Section 1. In the following sections, we will examine how this optimal policy changes as we change assumptions.

Role of the Capital Stock in Transferring Risk to Later Generations

When a contingent dollar is transferred from generation t to generation $t+1$ in the above story, the physical process is that a contingent dollar is added to the capital stock in period $t+1$. However, this simple story ignores a number of implications of using capital to transmit risk.

To begin with, capital is used in production and earns a marginal product. As a result, when some contingent dollar is transferred from generation t to generation $t+1$, generation $t+1$ receives this contingent dollar *plus* the marginal product that it has produced while embodied in capital. Therefore generation $t+1$ receives a larger lottery than generation t gives up, changing the optimal degree of risk-sharing.

In addition, the physical capital stock must certainly be nonnegative. But when the policy proposed in Section 1 is used to share risk among n generations, the capital stock saved by a steady state generation would equal $w+\sum_{j=1}^{n-1}((n-j)/n)e_{t-j}$. There is nothing in the model which assures that this capital stock is positive. Moreover, as n gets larger, the stochastic process for the capital stock follows close to a random walk from one generation to the next, and a random walk has probability one of hitting any boundary (e.g., a requirement that the capital stock be nonnegative) in finite time. Our model therefore does not guarantee that net assets remain positive.

The prime force keeping the capital stock positive is presumably the large marginal product of capital when the capital stock is small. Assume, for example, that the income earned by capital equals $f(k_t)+e_t$, where $f'>0$, so that capital has a positive marginal product, and where $f(\cdot)$ satisfies the Inada conditions so that the optimal capital stock will always be positive.

In this setting, it is easy to show that at least some risk-sharing remains worthwhile. Consider, for example, a two generation tax-transfer scheme, whereby consumption of generation t equals $w+ae_{t-1}+f(w+ae_{t-1})+(1-a)e_t$. Given this transfer policy, the utility of a generation in steady-state can be expressed as

$$U[w+Ef(w+ae_{t-1})]-V[(1-a)^2s+a^2s+\mathrm{var}(f(w+ae_{t-1}))+2Eae_{t-1}f(w+ae_{t-1})].$$

The first derivative of utility with respect to a equals

$$(1)\qquad U'\frac{\partial Ef}{\partial a}-2V'[\mathrm{cov}(f,f'e_{t-1})-(1-2a)s+Ee_{t-1}f+aEe_{t-1}^2f'].$$

Evaluated at $a=0$, this derivative simplifies to $2sV'$, which is clearly positive. Therefore a small increase in risk sharing must raise steady-state utility.

However, equation (1) implies that the optimal degree of risk-sharing is less than that found in the simpler model of section I. If in equation (1) all terms but the third equal zero, then the equation implies that the optimal value of a equals 0.5, as before. However, at least as long as the distribution of e_{t-1} is symmetric around zero, we demonstrate below that each of these extra terms is negative, implying that the gain from increasing risk-sharing from any starting point is smaller. When risk-sharing is increased, both mean income is lower, and the variance of income is higher, because of the effects of risk-sharing on capital income. Therefore, in general, the optimal value of a is less that 0.5.

To see that the extra terms are negative, consider each in turn. The first term measures the drop in expected capital income when more risk is shared. Since the production function is concave, adding random fluctuations to the capital stock causes expected capital income to fall. The last term inside the bracket is clearly positive since each element in the product is positive, so that this term also reduces the measure of the utility gain from increasing the degree of risk-sharing.

In order to show that the other two extra terms also reduce the measure of the gain from further risk-sharing, the following lemma is helpful:

Lemma 1. *Let $x(e)$ be some function of a random variable e. If the distribution of the random variable e is symmetric around zero, and if $x(e) + x(-e) < (>)0$ for all values of e, then $E(x(e)) < (>)0$.*

Proof. If $\phi(e)$ represents the density function of e, then, given that the density function of e is symmetric, we know that $E(x(e)) = \int_0^\infty (x(e) + x(-e))\phi(e)de$. The result follows trivially. ∎

To sign the next to last term inside the brackets in equation (4), let $x(e) = e_{t-1}f$. Then $x(e) + x(-e) = e_{t-1}(f(w + ae_{t-1}) - f(w - ae_{t-1}))$. Since capital income is an increasing function of the capital stock, this expression is positive. The lemma then implies that $E(e_{t-1}f) > 0$.

To see that the first term inside the brackets is also positive, the following lemma is helpful:

Lemma 2. *Let $F(e)$ and $G(e)$ be two continuous functions of the random variable e with zero means. Let e^* denote the minimum value of e at which both F and G are nonnegative. Then $E(FG) > 0$ as long as (1) $\text{sign}(F(e) - F(e^*)) = \text{sign}(e - e^*)$ and (2) $\text{sign}(G(e) - G(e^*)) = \text{sign}(e - e^*)$.*

Proof. Either $F(e^*)$ or $G(e^*)$ must equal zero; assume without loss of generality that it is $G(e^*)$. Let $\phi(e)$ denote the density function of e. Then, it follows directly from conditions (1) and (2) that $E(FG) \equiv \int FG\phi = F(e^*)\int G\phi + \int(F - F(e^*))G\phi \geq F(e^*)\int G\phi$ by conditions (1) and (2). But $\int G\phi = 0$ since the random variable has a zero means, so $E(FG) > 0$. ∎

In applying this lemma, let $F = f - E(f)$ and $G = f'e_{t-1} - E(f'e_{t-1}$. Since f is an increasing function of e_{t-1}, condition (1) is satisfied for any value of e^*_{t-1}. In contrast $G(e_{t-1})$ is necessarily increasing in e_{t-1} only for $e_{t-1} \leq 0$. All we can say beyond that is $G(e_{t-1}) > G(0)$ for $e_{t-1} > 0$. However, if $e^*_{t-1} < 0$, condition (2) must be satisfied. By the concavity of f, we know that $E(f) < f(E(e_{t-1}) = f(0)$. In addition, an immediate application of Lemma 1 shows that $E(f'e_{t-1}) < 0$, implying that $G(0) > 0$. Therefore $e^*_{t-1} < 0$, and Lemma 2 implies that the first-term inside the brackets in equation (4) also lowers the gain from further risk-sharing.

Consider, for example, the special case where $f(k_{t-1}) = rk_{t-1}$. Using this expression for the production function, we can solve equation (1) for the optimal value of a. We find that $a^* = 1/[1 + (1+r)^2]$. Due to the positive marginal product of capital, we find that the optimal value of a is less than 0.5.

Compounding of Lotteries

So far, we have assumed that the size of the lottery, e_t, is not tied to the size of the capital stock. However, if the return to capital is stochastic, then there is an additional cost of transferring a contingent dollar to the next generation — by the time the next generation receives it, this contingent dollar has grown in variability.

For example, assume that if the capital stock entering period t is k_{t-1}, then output in period t equals $k_{t-1}(1 + e_{t-1})$. If generation t is still allotted the share a_i of the lottery occurring i periods earlier, then its consumption in period $t+1$ would equal $w(1 + a_0 e_t) + \sum_{i=1}^{n-1} we_{t-i}a_i[\Pi_{j=0}^{i-1}(1 + e_{t-j})]$. If all the lotteries continue to be independent, then steady state utility equals

$$U(w) - V(s\sum_{i=0}^{n-1} a_i^2(1+s)^i).$$

Maximizing steady state utility with respect to the a_i, subject to the constraint that $\sum_i a_i = 1$, we find at the optimum that

$$a_i^* = \frac{(1+s)^{-i}}{\sum_{j=0}^{n-1}(1+s)^{-j}}.$$

In the limit, as n increases, $a_i^* = s/(1+s)^{1+i}$. With the optimal policy, each generation bears the share $s/(1+s)$ of its own lottery and a share in each past lottery which diminishes in size the more distant the lottery. When risk is passed to a later generation, it grows in variability due to the random return it earns each period. As a result, it is more expensive than in our base case to pass risk on to later generations, and less ought to be done.

Role of Market Prices in Sharing Risk Between Generations

So far, we have assumed that labor income is nonstochastic, so that any random variation in output in period t is allocated solely to capital by the market, which is entirely owned by the old. However, in general, past random events will affect the current marginal product of labor. For example, assume that output in period t equals $f(k_{t-1}, l_t)e_{t-1}$, where l_t is the labor supply of the young in period t and where e_{t-1} is a random shock that becomes known prior to the birth of generation t. For example, e_{t-1} could represent the productivity of the new technology that will be available in production. Given this specification, competitive labor markets will divide the lottery e_{t-1} between the two generations in proportion to their income in period t. Since the amount of capital saved by generation t depends on the size of their labor earnings, the wage rate earned by generation $t+1$ also is affected by the outcome of e_{t-1}. In fact, every future generation will be affected by this lottery through its implications for market prices.

This division of any lottery e_{t-1} between all future generations is arbitrary, however. There is nothing in the specification to indicate how this arbitrary division of risk differs from an efficient division. Consider, for example, the following special case. Assume that production, Y_t, in any period t equals $Y_t = Ak_{t-1}^{\alpha} l_t^{1-\alpha} e_t$, and that all capital is used up in production. If firms behave competitively, the fraction α of this output is paid to capital owners while the rest is paid to labor. As before, capital owners are all old and consume their income αY_t, while laborers are young and save all their earnings $(1-\alpha)Y_t$.

In order to compare this market outcome with the optimal degree of risk-sharing, we assume in addition that the social welfare function equals $\sum_{i=0}^{\infty} \beta^i \ln C_i$, where C_i measures the consumption of generation i. Given this objective function, the first-order condition describing the optimal capital stock in any period t equals

$$E_0 \frac{1}{C_t} = \beta E_0 \frac{\partial Y_{t+1}/\partial k_t}{C_{t+1}} = \beta E_0 \frac{\alpha Y_{t+1}/k_t}{C_{t+1}}.$$

It is easy to confirm that these first-order conditions are satisfied by the policy $C_t = \gamma Y_t$ and $k_t = (1-\gamma)Y_t$ for $\gamma = 1 - \alpha\beta$. We therefore conclude that the arbitrary risk-sharing in the market is optimal if and only if $\alpha = \gamma$, so if and only if $\beta = (1-\alpha)/\alpha$. Otherwise, government intervention could be welfare-improving.

Moral Hazard Effects of a Risk-Sharing Scheme

In the base model, the risk-sharing scheme created no excess burden — individuals had an exogenous labor supply, saved everything from the first period, and consumed everything during the second period, regardless of the policy. In this section, we explore the possible moral hazard problems created by a tax-transfer scheme to share risk between generations.

What moral hazard problems are created depends on the specific form of taxation. Tax payments by any individual could be specified to be independent of that individual's actions, depending only on the outcome of the "market" as a whole. In this case, each individual's incentives are left unchanged by the transfer payment, even though risk is being shared with later generations. Of course, if individuals are heterogeneous, such a policy may not be desirable on distributional grounds.

If each individual is taxed based on his ownership share in the market lottery, then in general the tax does create a distortion cost, and these costs must be traded off with the efficiency gain from spreading risks across generations. For example, assume that each individual can invest in either of two assets, one riskless and the other risky. His income from savings will equal $i(w_a - k) + (r+e)k$, where w_a is his first-period income after including transfers, i is the riskless rate of return, k is the amount invested in the risky asset, r is the expected return on this asset, and e is the random component of the return. To maintain consistency with our original model, we simplify by setting $i = 0$. The government taxes each individual an amount equal to $\alpha(r+e-\beta)k$, for some tax parameters α and β, and transfers the proceeds in a lump-sum fashion to members of the next generation.

This tax scheme reduces to the two generation risk-sharing scheme described originally if $\beta = r$ and $\alpha = .5$. Given these parameters, we show that, in general, investors will not take account of the risk-bearing costs of that share of the risk going to the next generation when they make their investment decisions, resulting in overinvestment in the risky activity. As a result of this moral hazard cost, the optimal degree of risk-sharing would be smaller. However, the size of the moral hazard cost depends critically on the size of β. In particular, if the transfer to the next generation has an expected value just large enough to compensate them for bearing the extra risk, then we show that investment decisions are not distorted and the optimal degree of risk-sharing remains unchanged.

Under the above tax-transfer scheme, consumption of a generation in steady-state would equal[8]

$$(w + \alpha(r + e_{-1} - \beta)k_{-1} - k) + (1 + r + e)k - \alpha(r + e - \beta)k,$$

where k_{-1} refers to the capital stock inherited by the previous generation, and e_{-1} refers to the random return earned on this savings. Expected utility, expected as of the date the policy is enacted, therefore equals

$$U[w + \alpha(r - \beta)Ek_{-1} + (r(1 - \alpha) + \alpha\beta)Ek] - V[\alpha^2 sEk_{-1}^2 + (1 - \alpha)^2 sEk^2]. \tag{5}$$

Differentiating steady-state utility with respect to α, setting the derivative to zero, and performing some simple manipulations yields

$$\begin{aligned} 2\alpha sEk_{-1}^2 V' =& 2(1 - \alpha)sEk^2 V' + (r - \beta)(Ek_{-1} - Ek)U' + [U'(r(1 - \alpha) + \alpha\beta)E\frac{\partial k}{\partial \alpha} \\ & - V'2(1 - \alpha)^2 sEk\frac{\partial k}{\partial \alpha}] + [U'\alpha(r - \beta)E\frac{\partial k_{-1}}{\partial \alpha} - V'2s\alpha^2 Ek_{-1}\frac{\partial k_{-1}}{\partial \alpha}]. \end{aligned} \tag{6}$$

Since the individuals in this generation choose k optimally, the third term on the right-hand side of equation (6) must equal zero. Also, at the date the policy is enacted, the expected steady-state capital stock is constant, so $Ek_{-1} = Ek$, implying that the second term on the right-hand side of the equation also equals zero. It therefore follows that the optimal α, denoted by α^*, must satisfy

$$\alpha^* = \frac{1}{2} + AU'(r - \beta)E\frac{\partial k_{-1}}{\partial \alpha} - AV'2s\alpha^* Ek_{-1}\frac{\partial k_{-1}}{\partial \alpha}, \tag{7}$$

where $A = \alpha^*/(4sV'Ek^2)$.

If $\beta = r$, as was implicitly assumed in the base model, then the second term in equation (7) equals zero. In addition, since the government now absorbs a fraction of the random component of the return on the risky activity without changing the mean return, it is easy to show that $(\partial k_{-1}/\partial \alpha) > 0$. Each generation chooses to undertake too much of the risky activity, since it ignores the risk-bearing costs imposed on the next generation, and we see from equation (7) that the optimal value of α will, in general, be strictly smaller than 1/2.

[8] When behavior changes in response to the tax, k will evolve over time after the tax-transfer scheme is enacted. In steady-state, as now defined, the probability distribution of k remains constant.

This moral hazard cost disappears, however, if the last two terms in equation (7) sum to zero. This will happen if any extra risk transferred to the next generation is offset by a suitable risk premium. For example, if $\beta = 0$, we find comparing the third and fourth terms on the right-hand side of equation (6) that if $\alpha = 1/2$, then the fourth term must equal zero as well. If the fourth term equals zero then equation (7) implies that the optimal α does in fact equal 1/2. With $\beta = 0$ and $\alpha = 1/2$, each generation is in effect a fifty percent partner in the risky investment undertaken by the previous generation. Given the symmetric positions of the two generations, when one generation is indifferent to further investment, so is the other. Investment decisions are no longer distorted, and there are no moral hazard costs generated by the tax-transfer scheme.

In general, eliminating any distortion in the risk-sharing scheme requires that future generations be just indifferent to the change in transfers that results when an investor considers changing his investment in a risky activity. Except in this situation, moral hazard problems do complicate the design of a tax-transfer scheme.[9] Moral hazard problems do not necessarily lower the amount of risk shared with the future, however. For example, if β were less than zero, then it is straightforward to show that the optimal α^* is greater than 1/2.

3. Time Consistency of the Policy

In analyzing the government policy so far, we have assumed that what is optimal ex ante will in fact be done ex post. However, at each future date, both generations know the outcome of past lotteries. Even though every generation gains ex ante under the proposed risk-sharing policy, some generations will certainly lose ex post, for someone has to absorb whatever losses have occurred. These generations which lose ex post may well be able to repeal the risk-sharing program and so avoid the obligations they would otherwise have faced. Any risk-sharing program must therefore take into account this possibility of future default in its initial design.

Is it possible to design a time consistent risk-sharing plan, which will not be repealed regardless of the realizations of the random variable e_t? In this section, we show that while a requirement of time consistency certainly imposes constraints on the design of a risk-sharing plan, a plausible case can be made that government debt, and particularly a transfer program which always involves transfers from young to old, such as our existing Social Security Program, would be time consistent.

Any analysis of time consistency must rest heavily on the assumptions made about the political decision-making process. We begin by assuming that political decisions are determined by the median voter, and that the median voter is a member of the younger generation. In addition, we assume that voters can repeal an existing risk-sharing policy, but cannot otherwise change its design. Without this assumption, each generation would try to obtain nonstochastic transfers at the expense of other generations. Finally, we assume, for simplicity, that risks are shared between only two generations and that there are a discrete number of possible outcomes of the random variable e_t.

[9] If the amount transferred *to* an individual depends on his behavior, then further moral hazard complications arise.

It quickly follows, by a simple application of stochastic dominance, that any risk-sharing policy would eventually be repealed. An intergenerational transfer plan is simply a function, $p(e_t)$ that describes the transfer from generation $t+1$ to generation t as a function of the outcome of the random variable e_t. The constraint that the younger generation finds it in its interest to participate in the risk-sharing scheme given the outcome e_t can be written as:

$$E_t u(w_{t+1} - p(e_t) + p(\tilde{e}_{t+1}) + \tilde{e}_{t+1}) \geq E_t u(w_{t+1} + \tilde{e}_{t+1}).$$

In this expression we have used tildes to emphasize the fact that generation t, when it is young, does not yet know the outcome of its own lottery $\tilde{e}_{t+1}$, but does know the outcome of the previous generation's lottery, e_t. In order to have no incentive for default regardless of the outcome of generation t's lottery, this constraint must hold for all values of e_t.

But we claim that these constraints can only be satisfied by the trivial transfer scheme in which $p(e_t)$ is a constant, and so provides no risk-sharing. Assume, to the contrary, that $p(\cdot)$ is not constant, and let p_{max} be the maximum value that it takes on. Then in order to satisfy the above constraint for $p(e_t) = p_{max}$ we must have

$$Eu(w_{t+1} - p_{max} + p(\tilde{e}_{t+1}) + \tilde{e}_{t+1}) \geq Eu(w_{t+1} + \tilde{e}_{t+1}). \tag{8}$$

But since $p_{max} \geq p(\tilde{e}_{t+1})$ for all realizations of $\tilde{e}_{t+1}$, this constraint can be satisfied only if $p_{max} \equiv p(\tilde{e}_{t+1})$, which implies that the only feasible transfer policy is the trivial policy.[10]

If we recognize that repeal must occur under some circumstances, what would a feasible risk-sharing plan look like? It follows by a parallel argument that it can never involve a transfer from young to old. If it did, then there will be some maximum possible transfer, $p_{max} > 0$. But if the younger generation is asked to make this transfer, it will default. The maximum transfer it could get in return from its own children would be p_{max}, and under all other outcomes it would end up worse off. But this implies that any feasible risk-sharing scheme would involve solely transfers from old to young, implying that the initial generation ex ante and ex post is made worse off by the scheme, and would oppose its initial enactment.

This stark conclusion that a risk-sharing scheme is infeasible, given the problem with time consistency, is not robust to a variety of modifications in the argument, however. For example, if the young generation must pay a sizable enough penalty if it repeals the policy, then it may no longer find it in its interest to do so. If the transfer to the old generation took the form of debt financed transfers in the past, then repeal amounts to some form of repudiation of the existing government debt. But, explicit default would involve substantive financial disruption, and could easily not be worth the cost. Implicit default

[10] In this argument, we have implicitly assumed that the rate of population growth (plus the rate of technical change) just equals the nonstochastic rate of return to capital, so that a contingent dollar allocated to the next generation results in that generation receiving a contingent dollar of extra consumption. The argument breaks down if the rate of population growth exceeds the marginal product of capital, for then the maximum possible payment from the next generation is greater than p_{max}, so that repeal is not stochastically dominant . But in this situation, the economy is beyond the golden rule level of the capital stock implying other possible ways to increase everyone's utility.

through unexpected inflation carries with it all the various costs of inflation, which could again outweigh the benefits of reducing the size of the transfer to the previous generation.[11] If these costs of full default, denoted by C, are large enough so that $Eu(w_{t+1} - p_{max} + p(\tilde{e}_{t+1}) + \tilde{e}_{t+1}) \geq Eu(w_{t+1} + \tilde{e}_{t+1} - C)$, then default would never occur. Therefore, use of debt finance to share risk between generations could well prove to be time consistent.

Our results can also be questioned due to the assumption that the median *voter* is young. Since the old are more likely to vote than the young, the median age of voters is well above the median age of those eighteen years old and over. But if the median voter is old, then a risk-sharing plan would be time consistent as long as it always involves a positive transfer from young to old, with only the size and not the sign of the transfer depending on the outcome of e_t. But this is just the form of our Social Security program, which has proved to be remarkably stable politically. Under this type of scheme, the first generation clearly gains, since it receives benefits from the next generation without paying any to the previous generation. Therefore, there would be a strong incentive to enact this program, and as long as the median voter remains old it would be time consistent.

Even if the median voter were young, our assumption that decisions depend solely on the preferences of the median voter is far too simple a model of political decision-making. Under the median voter model, the strengths of individual preferences do not matter at all, only their sign. But individuals have a variety of ways of making the strengths of their preferences known. For one, they can contribute time and resources to lobby for their position, if they have enough at stake. In addition, they can engage in logrolling by simultaneously enacting another piece of legislation which more than compensates those who lose under the initial bill. One simple way to generalize the median voter model, without making this process explicit, is simply to assume that the political decision can be characterized by the indicator function $d(\sum_i \text{sign}(G_i), \sum_i G_i)$, where G_i measures the dollar benefit the i'th individual receives under the proposed piece of legislation. The first argument of $d(\cdot,\cdot)$ measures the number of votes in favor of the bill minus the number opposed, while the second argument measures the net dollar gain that accrues to all the individuals in the society.

Under a risk-sharing scheme between two generations, in each period the old generation receives some amount $p(e_t)$, and this is the total amount they have at stake under the program if it comes up for a vote. The young generation pays $p(e_t)$ in this period, but also will be receiving a transfer $p(e_{t+1})$ in the following period, whose certainty equivalent present value we denote by $c(p(e_{t+1}))$. Therefore, $\sum_i G_i = c(p(e_{t+1}))$. This measure of the net dollar gain will certainly be positive if the program necessarily involves positive transfers from young to old. The larger the expected size of these transfers, and the greater the gains from risk-sharing (so the larger the certainty equivalent relative to the expected value), the larger will be this measure of the net dollar gain. If this net gain is large enough then the program would be time consistent even if a majority of the voters lose from it, since the old have more to gain than the young have to lose from continuing Social Security, and their extra lobbying effort can outweigh the extra votes of the young in the political decision-making process.[12] Our argument suggests that part of the political stability of

[11] For a discussion of possible social costs of inflation, see e.g. Okun[1975].

[12] If it is time consistent, then we were correct in not having the young worry about generation $t+2$

Social Security may be the gains from risk-sharing which we are arguing is an implicit motivation for the program.

4. Comparison with Alternative Explanations for Cyclical Debt Issues

In this paper, we have argued that one motivation for debt finance of wars and recessions may be to share current random outcomes with future generations. Of course, other explanations for the cyclical nature of debt issues, and for the existence of the Social Security Program, can be proposed. While it would be difficult to measure the relative importance of each of the various possible explanations for debt issues, some discussion is in order.

The obvious alternative explanation for cyclical debt policy is simply the government's active pursuit of a Keynesian stabilization policy. Whatever the current views among economists about the efficacy of stabilization policy, it is undoubtedly the case that in the past governments have attempted to use fiscal policy to stabilize the economy. However, in financing a war, such as World War II, Keynesian stabilization policy would suggest use of tax finance in order to suppress private demand to free resources for the military, whereas the data indicate that World War II was financed primarily with debt.[13] This debt has been paid off only gradually during the post-war period, consistent with our story that it is being passed forward to later generations. This extended pay-back period cannot be explained by Keynesian stabilization policy, though perhaps is not inconsistent with it either. It is also difficult to explain the introduction of Social Security during the Great Depression on stabilization grounds, particularly given that benefits did not commence for several years. If private demand depends on current income, perhaps due to liquidity constraints, then payroll taxes lower current demand while promises of future income cannot increase it. Yet the introduction of Social Security, with clear net gains to the initial Depression generations, is easily explained by our risk-sharing story.

An alternative explanation for cyclical debt issues is found in Barro[1979]. He argues that the efficiency cost of raising a given amount of government revenue through taxes is increased when the marginal tax rate varies over time. Intuitively, the excess burden of a tax is proportional to the square of the tax rate, so that the excess burden increases as the variability of tax rates increases, holding the average tax rate fixed. Therefore the government, in order to minimize the efficiency cost of collecting a given average tax revenue, will wish to maintain constant marginal tax rates over time, and absorb fluctuating annual tax revenue through fluctuations in net debt issues.

Given the presence of a progressive income tax, in order to have a constant marginal tax rate in the face of fluctuations in annual income, two approaches can be used. The first is income averaging in the tax law. While long advocated by tax economists, the degree of income averaging allowed under the existing U.S. personal income tax law is extremely limited, suggesting that this is not an important objective of the tax.[14] In

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defaulting on the payment of $p(e_{t+1})$.

[13] According to the figures in the Economic Report of the President, the increase in the Federal debt in 1942 was 1.49 times the size of Federal Government revenues. The equivalent figures in 1943 and 1944 were 2.64 and 1.40 respectively.

[14] See, e.g. Vickrey[1947].

fact, income averaging was repealed in the U.S. in 1986. Given the lack of importance of income averaging in the law, marginal tax rates will fall when income falls because of the progressivity of the tax schedule. Therefore, by Barro's argument, a fall in income should be accompanied by a tax surcharge to push individuals back into their original tax bracket. Pressure for tax surcharges during recessions has not been the rule during the post-war period, so it seems difficult to accept Barro's explanation for historical patterns of debt issue. In fact, Barro's empirical estimates show that tax revenues have fluctuated much more as income has fluctuated than his theory would forecasts. He attributes this to use of stabilization policy. To a degree, these excess fluctuations might also be explained by intergenerational risk-sharing.

Similarly, there have been many alternative rationalizations proposed for the enactment of the Social Security Program. The program provides annuity insurance which may be expensive to buy individually for moral hazard reasons, it provides an *indexed* income stream which may be hard to duplicate in the securities market, and it provides benefit levels which are contingent on many random events in an individual's life. However, any of these explanations cannot explain the timing of the introduction of Social Security, nor can they explain the large transfers received by the initial cohorts of retirees, who for the most part were old enough to have suffered substantial losses of labor income and capital during the Great Depression and World War II.

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Footnotes

1. Buchanan[1975] argued that this risk sharing aspect of the personal tax may explain the strong political support for it.

2. While there may be no explicit mechanism available to trade risk in labor income, firms may be able to reallocate risk between workers and capital owners through implicit labor contracts, an idea explored by Azariadis[1975] and Baily[1974].

3. This intuition has been stated previously in Stiglitz[1983a,b] and Gordon[1985].

4. This stochastic return represents the return on the "market portfolio." We assume that all idiosyncratic risks affecting subsets of the population have been diversified away.

5. Most of our results generalize easily to an expected utility model, though exposition is simpler in a mean-variance setting.

6. The expected utility is computed as of the date of the enactment of the program, a point we will discuss further below.

7. We assume for simplicity that the same random income e_t is received independently of how much is saved from the previous period.

8. If we introduced population growth simultaneously, then r would simply be reinterpreted to equal the excess of the interest rate over the population growth rate.

9. Such a model would be related to models of optimal savings as in Foley-Hellwig[1975], models of optimal commodity stockpiles, and also models of lifetime consumption and portfolio rules under uncertainty, as in Merton[1971].

10. This is unambiguously true when a is small.

11. When behavior changes in response to the tax, k will evolve over time after the tax-transfer scheme is enacted. In steady-state, as now defined, the probability distribution of k remains constant.

12. If the amount transferred *to* an individual depends on his behavior, then further moral hazard complications arise.

13. In this argument, we have implicitly assumed that the rate of population growth (plus the rate of technical change) just equals the nonstochastic rate of return to capital, so that a contingent dollar allocated to the next generation results in that generation receiving a contingent dollar of extra consumption. The argument breaks down if the rate of population growth exceeds the marginal product of capital, for then the maximum possible payment from the next generation is greater than p_{max}, so that repeal is not stochastically dominant . But in this situation, the economy is beyond the golden rule level of the capital stock implying other possible ways to increase everyone's utility.

14. For a discussion of possible social costs of inflation, see e.g. Okun[1975].

15. If it is time consistent, then we were correct in not having the young worry about generation $t+2$ defaulting on the payment of $p(e_{t+1})$.

16. According to the figures in the Economic Report of the President, the increase in the Federal debt in 1942 was 1.49 times the size of Federal Government revenues. The equivalent figures in 1943 and 1944 were 2.64 and 1.40 respectively.

17. See, e.g. Vickrey[1947].

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