Seminar Paper No. 213

PUBLIC HEALTH INSURANCE AND
OPTIMAL INCOME TAXATION

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ABSTRACT

If individuals differ not only in their inherent capacity to earn income, but also in the probability that they will fall ill, can subsidized public health insurance be justified on the grounds that it serves as an efficient tool to redistribute welfare? This question is analyzed in a model where the social welfare function is a weighted average of individual expected utilities, and where taxation is by a linear income tax. The answer is "yes", except in certain special cases.

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I. Introduction

During the last half-century, and especially since the second world war, there has been an increasing tendency in the industrialized societies for the state to assume financial responsibility for the cost of treating illness, and compensate for income lost. Many reasons can be given for this trend. One set of factors relates to the development of increasingly effective, but also complex and costly, techniques for treating different forms of serious illness. Because of the cost, many of these techniques would be inaccessible to most people if they had to pay for them out of their own savings. This factor, however, does not in itself constitute an argument for public health insurance: as long as serious illness only strikes relatively few people, and does so in an unpredictable fashion, the problem of high cost of treatment could in principle be taken care of through insurance arrangements in the private market. But in order for the private insurance market to give a satisfactory solution, several other conditions must be met. First, the insurance industry must be reasonably competitive. Second, because

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of the complex nature of much medical technology, a great deal of specialized information must be assembled and presented to consumers in an understandable way if they are to be in a position where they can make reasonable choices for themselves regarding their health insurance, as they would have to do in a private system. In most European countries, confidence that competition in the insurance industry would generate this type of information and offer insurance on "fair" terms, has been lacking, and public health insurance on uniform terms has been offered instead.

In addition to the problem of information costs and the general ~~skepticism concerning the effectiveness of competition, an even more~~ important set of reasons for state intervention has concerned the consequences of illness and differential risk of illness for the distribution of welfare between individuals. A situation where an individual's standard of medical treatment (or, more generally, level of welfare) when ill would reflect his economic circumstances when well, has been considered inconsistent with the redistributive objectives adopted in most industrialized countries. In the U.S., one of the last remaining countries without universal public health insurance, this motive has clearly been the most important argument in favour of its introduction.

In recent years, however, there has begun to emerge a certain disappointment with the evolution of the health care systems in a number of countries, primarily because of the very rapid rate at which costs have been rising, but also because of an increasingly widespread belief that the marginal contribution to health of further health care expansion may be relatively low. As a result, there has been more concern about efficiency in the allocation of resources within the health

care sector, and between it and other uses.¹ Economists, not unexpectedly, have advocated more reliance on private markets, both for insurance and actual health care, to increase the sector's efficiency.² They have argued that distributional objectives can more appropriately be attained through general income taxation, rather than specific tax-financed transfers to people who are sick. The proposals to rely more on the market mechanism have of course run headlong into a solid wall of opposition from those who believe that all people should have access to the same standards of health care, regardless of income.³ There, one might say, the matter rests.

In our view, a problem with this discussion has been a lack of precision in defining the meaning of the distributional objective with respect to health care provision. The equity motive is sometimes subsumed in the allocation analysis by loosely designating health services as a "merit want", in Musgrave's terminology. What this would mean in this context is that well people derive some psychic benefits from an increase in the welfare of sick people. But

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1) See Fuchs (1974) for a general introduction to the problem. A forceful statement of the position that more health care resources may be of limited productivity, may be found in Wildawsky (1977). The writings of Illich (1976) have also contributed to the questioning of the effectiveness of modern medical technology.

2) In the United States, proposals to continue to rely on a solution involving private markets have been made by Enthoven (1978a,b). In Sweden and Canada, modifications along these lines of the existing schemes of public health insurance have been suggested by Ståhl (1979) and Blomqvist (1979).

3) See, for example, the review of Blomqvist (1979) by Lord Taylor of Harlow (1980).

where private health insurance exists, the material welfare of sick people reflects their own past decisions with respect to insurance coverage, given its cost. One may therefore argue that the concern for the welfare of poor, sick people is not different from a general egalitarian concern (poor people should be given enough resources to enable them to reach a decent standard of consumption of all goods and services, both when they are well and, when they are ill). This is the line of argument used by those who claim that there is no reason to give special consideration to the distributional aspects of health services consumption as distinct from any other kind of consumption.

The purpose of the present paper is to attempt a clarification of the conceptual issue whether or not a tax-financed public health insurance represents an appropriate way of redistributing welfare between individuals, in a situation where individuals differ not only in their inherent capacity to earn income but also in their state of health and in the probability that they will fall ill. We will do this by modifying a simple model of the type used by other authors to study the problem of optimal linear income taxation so that it incorporates these concepts.⁴ We then investigate the principles according to which an optimal tax policy should be formulated under circumstances when the available tax instruments include not only parameters representing a conventional income tax but also other ones which represent tax-financed health insurance or make possible a system of income taxation where individuals are differentially taxed according to the risk that they will fall ill.

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4) See Sandmo (1976) and Atkinson (1977) for surveys of the literature.

Our general conclusion is that even when health services (or more generally, the consumption level of sick individuals) are not treated as a merit want, and even when health insurance markets are assumed to function perfectly and individuals know their objective probabilities of illness with certainty, the objective of distributional justice will generally call for the introduction of a tax-financed public health insurance scheme. However, the welfare gains from such a scheme, and its optimal scope, are considerably reduced if income taxation can be differentiated according to the taxpayer's risk of falling ill. ~~Hence our model suggests that the opportunities for~~ exploiting the potential efficiency gains inherent in a greater degree of reliance on private markets for health services and health insurance without violating the equity objective, depend heavily on society's ability to design an acceptable system for accomplishing such a differentiation according to risk.

The rest of the paper is organized as follows. In section II, we specify the basic theoretical model describing individual behaviour in the face of different tax incentives, and the social welfare maximization objective. Section III contains a discussion of the nature of the optimal tax policy under different assumptions regarding individual characteristics and feasible tax instruments. In section IV we offer a summary, and some brief concluding comments.

II. The Theoretical Model

(i) The individual's maximization problem

At the individual level, we postulate the existence of a function giving individual i 's utility as a function of four variables: his levels of consumption of goods and services when well and ill, respectively, his labour input, and his state of health. The latter is a random variable which, for simplicity, is assumed to take on only two values (corresponding to "well" and "ill") during the unit period, with the probability of illness being denoted by p_i for the i 'th individual, the probabilities being known by the individual. We assume that when an individual is ill, his labour input is zero, so that his utility then is a function solely of his consumption of goods and services, taken to include his consumption of health care services.⁵

From these considerations, we may write the i 'th individual's expected utility E_i during the unit period as

$$(1) \quad E_i = (1 - p_i) U(C_i, N_i) + p_i V(S_i) ; \quad p_i > 0 \text{ for all } i$$

where C_i and N_i are the flows of consumption and labour services when the individual is well, and S_i is his consumption when ill. $U(\cdot)$ and $V(\cdot)$, which are assumed to be strictly concave, are the functions yielding the levels of utility in the respective states; the functions are taken to be identical across individuals.⁶

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5) Note that this formulation assumes away a potential problem associated with public health insurance systems as conventionally organized, namely that health care services are made available to sick people at zero private costs. This may lead to an inefficiently high utilization of health care resources, as opposed to other goods and services, by sick people.

6) An equivalent specification would be to postulate a single utility function, but to include the individual's state of health as a shift variable in the function.

At the beginning of the unit period, before his state of health is known, the individual makes conditional choices regarding his labour input and, through the insurance market, his consumption levels when well or ill respectively. The insurance market is supposed to be competitive with insurance being offered on actuarially fair terms to each individual: if an individual enters a contract which will give him a sum of money R_i if he becomes ill, he has to pay the insurance company the sum $p_i R_i / (1 - p_i)$ if he is well instead.⁷

If he is well and working, he will receive labour income equal to $w_i N_i$, with w_i being the wage rate which is assumed to differ between individuals.

Taxation of well individuals is assumed to take the form of a linear income tax with intercept a and marginal tax rate t .⁸ Public intervention in the market for health insurance, reflecting the state's redistribution policies between the well and the ill, is similarly supposed to consist of a lump sum subsidy of b to sick people (with the proceeds from private health insurance being free of tax).⁹⁾

From the above considerations, and disregarding any personal saving, we may now write down the individual's budget constraints as:

7) We arbitrarily assume that the contract is specified such that the individual does not pay the premium if he falls ill. This assumption does not affect the substance of the analysis.

8) For a textbook presentation of the linear income tax model, see Atkinson and Stiglitz (1980).

9) In some countries where public health insurance provides compensation for loss of income, such compensation constitutes a certain proportion of average income. The formulation we use here is chosen for its computational convenience.

$$(2) \quad C_i = N_i w_i (1 - t) + a - \frac{p_i}{1 - p_i} \cdot R_i$$

$$(3) \quad S_i = R_i + b$$

The individual is assumed to maximize (1) subject to (2) and (3).

After substituting the constraints into (1), the maximum may be characterized by the following first-order conditions:

$$(4) \quad \frac{\partial E_i}{\partial N_i} = U_c^i w_i (1 - t) + U_N^i = 0$$

$$(5) \quad \frac{\partial E_i}{\partial R_i} = -U_c^i + V_s^i = 0$$

where

$$(6) \quad U_c^i \equiv \frac{\partial U}{\partial C_i}, \quad U_N^i \equiv \frac{\partial U}{\partial N_i}, \quad V_s^i \equiv \frac{dV}{dS_i}$$

Because U and V are concave functions and the constraints (2) and (3) are linear, the conditions (4) and (5) yield a unique solution to the consumer's maximization problem. Note that the optimal values of N_i and R_i , and hence also the maximized value of the consumer's expected utility E_i , can be written as functions of the parameters w_i , p_i , a , b , and t . We will assume that the maximized values of the E_i are concave in a , b , and t .¹⁰

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10) If the individual's labour supply N_i is constant, concavity of E_i is equivalent to requiring diminishing marginal utility of income.

(ii) The social maximization problem

The problem to be solved by the central decision-makers is taken to be that of finding a maximum of a social welfare function, by appropriate choice of tax parameters and subject to the constraint that the government's budget must balance. Social welfare W is taken to be of the simple additive form

$$(7) \quad W = \frac{1}{\gamma} \sum E_i^\gamma$$

where $\gamma \leq 1$, $\gamma \neq 0$, can be interpreted as a parameter describing society's degree of egalitarianism; $\gamma = 1$ corresponds to a utilitarian criterion where society's total, unweighted, expected utility is maximized whereas $\gamma \rightarrow -\infty$ corresponds to the Rawlsian criterion where, in effect, the expected utility of the worst-off member in society, becomes the social-welfare criterion.¹¹

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11) Note that in this formulation, society's concern with the welfare level of those of its members who are sick at a particular time, is only indirect, via its influence on their expected utility over time. Thus, there is no notion of health services as a merit good, or of special consumption externalities flowing from the consumption of health services by sick people.

As an alternative to (7), one could formulate the welfare function as some weighted sum of the ex post utilities of individuals. One of the main arguments against the ex ante criterion is the potential difference between subjective and objective probabilities. But as we are assuming that the two are equal, this problem is irrelevant here. For discussions or comments on this problem, see e.g., Mishan (1971), Broome (1978) and the ensuing debate in this Journal's October issue 1979; Layard and Walters (1978, pp. 374-75), and Atkinson and Stiglitz (1980, p. 356).

For a discussion of various concepts of distributive justice see Part XI of Survey on Personal Income Distribution by Sahota (1978). The survey also contains a brief discussion of public income redistribution theories in Part IX.

Given the probabilities p_i that individuals will be ill during the period, the requirement that expected the government's revenue must at least equal its expected expenditures, may be written:

$$(8) \quad G \equiv t \sum_i (1 - p_i) N_i w_i - a \sum_i (1 - p_i) - b \sum_i p_i \geq 0.$$

Thus the optimal tax and transfer problem may be taken as choosing t , a and b to maximize (7) subject to (8).

In the specification of the model used in this paper, one of the determinants of the degree of inequality of expected welfare of different individuals, is the probability p_i of becoming ill.

This suggests that in a tax system designed to reduce inequality, it would be appropriate to differentiate the income taxes imposed on individuals according to this risk. In a variant of the basic model, we will thus allow for the possibility that the intercept a of the tax schedule will vary depending on the p_i . In considering this version of the problem, it will be convenient to classify individuals into m subsets indexed by s , characterized by the property that all individuals within that subset have the same probability of falling ill:

$$(9) \quad i \in s \iff p_i = p_s, \quad s = 1, \dots, m$$

When the value of a differs between these subsets, the term $a \sum_i (1 - p_i)$, in the government budget constraint will be replaced by

$$\sum_s a_s \sum_{i \in s} (1 - p_s),$$

and the social maximization problem in this case will involve choosing m a_s 's, b , and t .¹²

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12) The term a in the individual maximization problems will also be replaced by a_s for $i \in s$.

The assumption that the government has precise information concerning the individual p_i 's is not, of course, particularly realistic; neither is the alternative assumption that the government is totally unable to discriminate between taxpayers in different risk classes (especially when private insurers are assumed to have complete knowledge of the individual p_i 's). Allowing for intermediate degrees of imperfect information would have added greatly to the complexity of the analysis, however, and consideration of the two polar cases is sufficient to illustrate the idea that a major distributional reason for public health insurance programs may be the cost and difficulty of designing a tax system which discriminates between taxpayers according to their risk of illness.

III. The Optimal Tax Structure

In the Appendix, we derive the first-order conditions which must hold if the three parameters a , b and t are optimally chosen. The conditions are:

$$(10) \quad \frac{\partial L}{\partial a} = \sum_i (1 - p_i) Y_i = 0$$

$$(11) \quad \frac{\partial L}{\partial b} = \sum_i p_i Z_i = 0$$

$$(12) \quad \frac{\partial L}{\partial t} = \sum_i (1 - p_i) Y_i N_i w_i - \lambda \left[\sum_i (1 - p_i) w_i t \left(\frac{\partial N_i}{\partial t} \right)^* \right] = 0,$$

and $\lambda \geq 0$, $G \geq 0$, $\lambda \cdot G = 0$. Here, L is the Lagrangian expression corresponding to the maximization problem, λ , the Lagrange multiplier corresponding to the

shadow price of government revenue, and

$$(13) \quad Y_i \equiv E_i^{\gamma-1} U_c^i - \lambda(1 - w_i t \frac{\partial N_i}{\partial a})$$

$$(14) \quad Z_i \equiv E_i^{\gamma-1} V_s^i - \lambda(1 - \frac{(1 - p_i)}{p_i} w_i t \frac{\partial N_i}{\partial b}) .$$

The term with the asterisk in (12) corresponds to the pure substitution effect of a change in the income tax rate on the supply of labour (taken to be negative); it is given implicitly by:

$$(15) \quad \frac{\partial N_i}{\partial t} = -w_i N_i \frac{\partial N_i}{\partial a} + \left(\frac{\partial N_i}{\partial t} \right)^* .$$

Conditions (10) to (12) of course pertain to the optimal solution for the case when the intercept a is common to all risk classes. For the case when we may differentiate the intercept according to risk class, conditions (11) and (12) will be unchanged, but (10) will be replaced by the m conditions

$$(10') \quad \frac{\partial L}{\partial a_s} = \sum_{i \in s} (1 - p_i) Y_i = (1 - p_s) \sum_{i \in s} Y_i = 0, \quad s = 1, \dots, m.$$

where we have used (9).

In general, the first-order conditions are not sufficient: they may be satisfied at more than one value of the objective function. An analysis of the optimal tax structure based on the first-order conditions becomes very difficult if there are many stationary points. For simplicity, we will therefore focus attention on the case where the Lagrangian is concave in a , b and t for any λ satisfying the first-order conditions. With this assumption, the first-order conditions become sufficient

as well as necessary, so that any solution which satisfies the first-order conditions does indeed correspond to the constrained maximum.¹³

The expressions (13) and (14) will play an important part in the following discussion; they can be interpreted as the net marginal impact on social welfare of a hypothetical transfer of a small lump-sum to the i^{th} individual when he is well (Y_i) and when he is ill (Z_i). The terms multiplying λ in (13) and (14) give the net impacts on government revenue of such a measure, taking into account the indirect effect on revenue of an induced change in the individual's supply of labour. The terms $E_i^{\gamma-1} U_c^i$ and $E_i^{\gamma-1} V_s^i$ represent the social marginal utility of income accruing to the i^{th} individual when he is well and ill, respectively; note that when $\gamma = 1$, it is also equal to the individual's private marginal utility of income. For future reference, note that when the individual is allowed freely to choose what amount of health insurance to buy, we have $U_c^i = V_s^i$ as shown above. Furthermore, in the Appendix we demonstrate that in this case $(\partial N_i / \partial a) = (\partial N_i / \partial b)(1-p_i)/p_i$, from which it follows that individual optimization implies

$$(16) \quad Y_i = Z_i.$$

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13) When the objective function is concave in the choice variables, as we have already assumed to be the case, concavity of the constraints guarantees that the first-order conditions are sufficient. However, there is nothing in our model to guarantee that the government budget constraint G will be concave in a , b , and t . Even if G is not concave, however, the Lagrangian may still be concave in a , b , and t if the objective function has a sufficient degree of concavity, which is what we are assuming. The assumption of a concave Lagrangian does not guarantee a unique solution for the choice variables; indeed, in several of the cases analyzed below, the solution will not be unique.

We turn now to the interpretation of the optimal tax structure on the basis of (10)-(12). The first result which we will demonstrate is that when individuals are allowed to choose their own health insurance without restriction, and the government is able to impose an income tax which differs among risk classes, then there is no reason for the government to adopt a policy of transferring resources to sick people via public health insurance. On the other hand, we show that when the income tax cannot be differentiated according to risk class, this result no longer holds, and we give a set of simple conditions under which social welfare will increase with a program of public transfers to sick people. We also show, however, that in the optimum solution to this problem, some individuals will want to purchase negative amounts of private health insurance. (Such a situation would imply an insurance contract under which the insurance company pays the individual a premium if he remains well, but the individual contracts to transfer some of the public insurance money to the private insurance company if he falls ill.) This somewhat peculiar result leads us to consider the effects of imposing a non-negativity constraint on individual purchases of private health insurance. Such a constraint may be thought of either as representing the unwillingness of private agents to write such contracts (for example, because of information and moral hazard problems), or as government prevention of such contracts (the incentive for individuals to purchase negative private insurance to "offset" public insurance could be eliminated by transferring resources to sick people in kind rather than in cash). The somewhat surprising result which emerges from the discussion of this case is that when a non-negativity constraint is imposed, an optimal distribution policy does in general require specific

transfers to the sick, even when it is possible to differentiate the income tax according to risk of illness. Furthermore, the optimal value of the social objective function will be higher when the non-negativity constraint is imposed than it would be without this constraint.

(i) Optimal Policy with Unrestricted Private Insurance

In interpreting the optimal tax and transfer policy for the case where there is no non-negativity restriction on individuals' private insurance, consider first the condition for the marginal income tax rate t . Multiplying (10) by $\bar{Nw}$, adding to (12), and using the identity

$$(17) \quad N_i w_i - \bar{Nw} = (N_i w_i - \bar{Nw}_s) + (\bar{Nw}_s - \bar{Nw}),$$

where $\bar{Nw}$ and $\bar{Nw}_s$ are the mean labour income for the population as a whole and within the s 'th risk class respectively, condition (12) may be rewritten:

$$(18) \quad \frac{\partial L}{\partial t} = - \left[\sum_s (1 - p_s) \sum_{i \in s} Y_i (N_i w_i - \bar{Nw}_s) \right] - \left[\sum_s (1 - p_s) (\bar{Nw}_s - \bar{Nw}) \sum_{i \in s} Y_i \right] \\ + \lambda \left[\sum_i (1 - p_i) w_i t \left(\frac{\partial N_i}{\partial t} \right)^* \right] = 0.$$

To simplify the analysis, we will assume first that the distribution of labour income $N_i w_i$ in each risk class is the same, and, second, that in each risk class, labour income is an increasing function of w_i . Furthermore, we will assume that in each risk class, the covariance between labour income and the variable Y_i , is negative when $t = 0$.¹⁴

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14) This assumption is intuitively reasonable: persons with high values for w_i , and therefore, by assumption, high $N_i w_i$, will have high consumption and therefore a low value of U_i^c ; they will also (for given p_i) have a large expected utility E_i , and therefore a small value for $E_i^{\gamma-1}$ with $\gamma < 1$. Further, a high $N_i w_i$ is likely to be associated with a large absolute value for $w_i t (\partial N_i / \partial a)$, which enters Y_i with a negative sign.

Because of the first assumption, the second term in square brackets on the RHS of (18) is always zero. With $t=0$, the third term in square brackets will also be zero; by the first assumption, the expression inside the first square bracket is negative, so that $\partial L/\partial t > 0$ at $t=0$. Since L is assumed to be concave in t , this implies that at the optimum, $t > 0$. Furthermore, at the optimum we must have $0 < t < 1$, since the first term will go to zero as t approaches 1. It is further evident from (18) that, other things equal, the optimal tax rate is higher the smaller the substitution effect, the larger the variance of the tax base $N_i w_i$, the more sensitive the private marginal utility of consumption to a change in consumption, and the higher the degree of social egalitarianism (with a higher degree of egalitarianism corresponding to an algebraically low value of γ). These are of course standard conclusions from the optimal income taxation literature.¹⁵

Now consider the optimal amount of transfer to sick people, b . First, suppose that the intercepts a_s of the income tax schedule may be differentiated by risk class. The first-order conditions characterizing the optimal choice of the a_s 's are given by (10'), and are equivalent to

$$(10'') \quad \sum_{i \in s} Y_i = 0, \quad i = 1, \dots, m.$$

The condition (11) corresponding the optimal choice of b can be rewritten:

$$(11') \quad \sum_s p_s \sum_{i \in s} Z_i = 0.$$

But when there is no restriction on individuals' purchase of private health insurance, we will have $Y_i = Z_i$ for all i , regardless of the value of b (see (16)); in particular, if (10'') holds, (11') will hold at any value of b including

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15) See, e.g., Stern (1976).

$b = 0$. Hence, there is no case in favour of a public health insurance scheme: when the intercepts of the tax schedules can be varied according to the different risks the maximum value of the social objective function can be attained even if b is arbitrarily set to zero.

By contrast, suppose now that it is not possible to differentiate the income tax according to risk class, so that the lump sum transfer to all individuals is the common amount a . The condition (18) for the optimal choice of marginal tax rate t remains the same for this case, but the m conditions (10') are replaced by the single condition (10) for the choice of a . Combining (11), the condition for the optimal choice of b , with (10), and (16), one finds that at the optimum, $\sum Y_i = \sum Z_i = n\bar{Z} = 0$, so that (11) can also be rewritten:

$$(11'') \quad \sum_s p_s \sum_{i \in s} (Z_i - \bar{Z}) = 0.$$

Now suppose that b is arbitrarily set to zero. Even if conditions (10) and (12) are satisfied, (11'') will not generally hold: it would only be satisfied at $b = 0$ if the within-risk-class averages of the Z_i (or Y_i) happened to be uncorrelated with the probabilities of illness p_s . Thus in general, the optimal tax policy does require a non-zero lump-sum transfer to all sick people.

Under reasonable assumptions, we can show that the optimal value of b has to be positive. Since the distribution of wages in each risk class is assumed to be the same as in other classes, and since all individual utility functions are taken to be the same, differences in the within-risk-class averages of Z_i can only be caused by differences in the p_s 's between risk classes. However, for a given wage rate, it is reasonable to assume a positive relationship between p_i and Z_i . [With $b = 0$, an individual with

a high risk of illness is likely to have a relatively low level of consumption, both because his expected labour income is low, and because he has to pay a high price for health insurance. Thus, he will have a relatively high marginal utility of consumption. Furthermore, the low level of consumption, as well as the disutility of often being ill rather than well, will reduce the individual's expected utility. These effects (recalling that $\gamma < 1$) will both contribute to producing a relatively high value of Z_i or Y_i .] But since the distribution of wages is assumed to be identical for each risk class, this assumption implies that the covariance expression in (11'') is positive if $b = 0$, so that

$$(19) \quad \frac{\partial L(b=0)}{\partial b} > 0$$

As we are also assuming that L is concave in b , the optimal b must be strictly positive. Intuitively, as we increase the value of b from zero, the expected utility of people in high risk classes will rise (as they will benefit more often from the transfer), as will their consumption standard. This will constitute a redistribution from high to low risk classes that will tend to even out differences in Z_i , and therefore diminish the covariance in (11''). For an optimum, b must be increased until the covariance is reduced to zero, as stipulated by the first-order condition. Thus, when the tax treatment of well individuals cannot be differentiated according to risk, there is a case, based on equity considerations, for specific transfers to sick people.¹⁶

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16) It has been pointed out to us that this result may not hold if the linear income tax were to be specified in such a way as to cover both well and sick people, rather than just well people as assumed in the text. With this alternative specification, sick people would receive a government transfer of a (corresponding to the intercept in the income tax schedule) even if there was no public transfer specifically to sick people. The analysis of the optimal tax problem under this alternative specification can be made formally equivalent to the analysis in the paper, by defining

An interesting special case of the preceding optimal taxation problem results when the labour supply N_i is taken to be exogenous and identical for all individuals. When the distribution of wage rates is assumed independent of the risk of illness, it follows (not surprisingly) that the optimal marginal tax rate is equal to unity.¹⁷ Individuals' incomes therefore consist entirely of transfers from the government when they are well and when they are sick, and hence all remaining inequality in expected utility is due to differences in the probability of falling ill.

For the case where the income tax system does not differentiate by risk class so that there is only one common intercept a in the tax schedule, a non-zero transfer b to the sick will be part of the optimal policy, as before. If the government now sets a and b such that $U_c^i(a) \leq V_s^i(b)$ for all individuals,¹⁸ everyone will choose to buy non-negative amounts of health insurance; i.e., $R_i \geq 0$ for all i . But it is not difficult to show that if $R_i \geq 0$ and if, within the relevant income range, the individual always prefers to be well rather

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$b = a + \hat{b}$, where $\hat{b}$ is the optimum transfer to sick people when both well and sick people are covered by the income tax schedule. However, the question whether the optimal tax policy still involves specific transfers to sick people now translates into the question whether, at the optimum, $b > a$ (rather than whether $b > 0$, as in the text). But as long as the optimal a is sufficiently small so that individuals would choose to buy positive amounts of private health insurance at $b = a$, the arguments used in the text to justify the assumption of a positive relationship between p_i and Z_i (for a given w_i) continue to hold. With this assumption, expression (11'') would remain positive at $b = a$, and at the optimum, we would have $b > a$ -- that is, $\hat{b} > 0$.

17) With an exogenous labour supply, the substitution term in (18) disappears, so that there is no excess burden of an income tax.

18) Since the utility functions U and V are supposed to be the same across individuals, it is possible to find such values of a and b .

than sick,¹⁹ there is a positive relation between p_i and Z_i , unless $\gamma=1$. The optimality condition

$$(20) \quad \sum p_i Z_i = \sum p_i (E_i^{\gamma-1} V_s^i - \lambda) = 0$$

hence requires $R_i < 0$, at least for some individuals. This can only happen if b is large enough so that $U_c^i(a) > V_s^i(b)$ for these individuals.

But if this inequality holds for some individuals, it will hold for all individuals, as all differences in wage incomes are taxed away with $t=1$. Therefore, everybody will choose $R_i < 0$. Thus, when the labor supply is fixed, and $\gamma < 1$, the optimal tax policy requires transfers to sick individuals that are large enough to induce all individuals to

choose negative amounts of private health insurance. Furthermore one can show that the optimal scheme is such that people with a higher risk of falling ill will enjoy a higher consumption standard, both when they are well and when they are ill. Intuitively, an egalitarian welfare objective will thus imply that one seeks to compensate individuals with high p_i (who are "often sick") by higher transfers and hence consumption levels, both when they are well and ill. (This does not imply that their expected utility is higher, since their probability of being in the unfavorable state "ill" is higher.) Only for the special case where $\gamma=1$, i.e., for the "utilitarian" case, will the optimal consumption levels be the same for all well and sick individuals, respectively. Such a solution, however, implies that the expected welfare E_i will vary among individuals, being lower the higher the individual's risk of illness.

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19) This assumption is implicitly used throughout the paper.

(ii) Non-Negativity Restrictions on Private Insurance

In this section, we briefly consider the consequences for optimal tax policy of introducing a non-negativity restriction on the amount of private health insurance bought by individuals. As noted above, the imposition of such a restriction can be motivated by appealing to the likely unwillingness of private insurers to conclude contracts involving negative insurance. Alternatively, it may be taken to reflect government prohibition of such contracts. We will in fact argue that in the present model of optimal distributive taxation, there is, somewhat surprisingly, a case for prohibiting negative insurance. This follows because the level of social welfare that can be attained when the non-negativity restriction is imposed, is higher than the maximum welfare level when it is not.

To illustrate this result as simply as possible, consider the case where all individuals face the same probability p of falling ill. Without a non-negativity restriction on R_i , there is then no case for public health insurance: if $Y_i = Z_i$ and p_i is constant for all i , (11) will automatically be satisfied, for any value of b , if (10) holds. However, even though a change in b will not affect social welfare, it will affect the amount of private health insurance that individuals buy: As b increases, individuals compensate by buying correspondingly less private insurance.

Now let us start with a low value of b , so that everybody buys positive amounts of private insurance. Then increase b to that level b^* where the first individual (indexed by j) is just induced to choose $R_j = 0$,

but all others continue to have $R_i > 0$.²⁰ At this point, one still has $U_c^i = V_s^i$ (from (5)) for all individuals, and the condition (10) for the optimal choice of a still applies.

If we now increase b slightly more, one of two things might happen, depending on the restrictions that j faces. If the individual is allowed to purchase negative insurance he will work less and consume more when well, and we will still have an interior solution. But on the other hand, if negative health insurance is not permitted, there is no way for the individual (with $R_j = 0$ already), to transfer purchasing power from himself when ill to himself when well. In particular the increase in b will not directly affect his labor supply; i.e.²¹ $\partial N_j(b^*) / \partial b^+ = 0$. We continue to have $Y_i = Z_i$ for all $i \neq j$. For the j^{th} individual, however, we have

$$(21) \quad Y_j = E_j^{Y-1} U_c^j - \lambda(1 - w_j t \frac{\partial N_j}{\partial a}) \leq E_j^{Y-1} V_s^j - \lambda = Z_j^+$$

where the inequality follows from the fact that $U_c^j = V_s^j$ (by construction), and the assumption that $\partial N_i / \partial a \leq 0$ for all i . When (21) is a strict inequality, i.e., when $\partial N_j / \partial a < 0$, therefore²²

$$(22) \quad \frac{dL(b^*)}{db^+} = \sum_{i \neq j} Z_i + Z_j^+ > \sum_{i \neq j} Y_i + Y_j = 0,$$

the last equality being due to condition (10). By construction, the expression (22) implies that, starting from the largest possible value of

20) Throughout this discussion we assume that a and t are adjusted to their optimal values as we vary b , which implies that the government's budget restriction is fulfilled with equality.

21) The sign "+" denotes a right-hand derivative.

22) A directional derivative is used as a and t are continuously adjusted to their optimal values.

the social welfare function with no non-negativity restriction, it is possible to attain a higher value of social welfare by imposing a non-negativity restriction on at least one individual's purchase of private health insurance. It follows that, in general, the optimal tax system will necessarily require a choice of b higher than b^* , and such that $R_i = 0$ for at least some individuals. This higher b will, in combination with a non-negativity restriction on private insurance, improve social welfare relative to the highest attainable level when negative insurance was permitted. An entirely analogous argument can be used to show the same result for the case where there are many different risk classes but the intercept a_s in the tax schedule may be varied according to risk class.

A non-rigorous interpretation of these (at least to us) somewhat counter-intuitive results, is as follows. Even though money can be transferred in lump-sum fashion between risk classes to compensate for the different probabilities of falling ill, with an endogenous labour supply, and hence a tax rate $t < 1$, there will still exist within-class differences in welfare, both among well people and sick people. Transfers of money to poor people who are well, will decrease their labour input via the income effect. Because labour income is taxed it has a social productivity in excess of its private return, so that this decrease will entail an additional cost to the rest of society of the transfer to the poor. A transfer scheme to sick individuals, however, will directly affect the labour supply only of those who have private health insurance, which they will then reduce in order to increase their consumption of goods and leisure when they are well. If they are at a corner with $R_i = 0$ (as the poorest individuals may be), their labour supply will only be affected by the financing of the transfer scheme, i.e., the effects through a and t . Hence, when some individuals are at a corner

solution, the additional cost of a transfer, via the induced changes in labour supply, will be smaller for a transfer to poor sick people than poor well people. Therefore, an optimal tax system may require that the former transfer is driven to a point where the marginal utility of consumption of the poor and sick is lower than that for the poor but well, i.e., it may require that some poor people are driven to a corner solution with zero private health insurance.

Even with a single risk class, or when the intercepts a_s can be differentiated according to risk, it is possible (but not necessary) that the optimum value for b is sufficiently high so that private health insurance is entirely eliminated, i.e., all individuals are driven to a corner solution with $R_i = 0$. The likelihood of this is less the greater the degree of after-tax income inequality (i.e., the lower the value of t), and the lower the income elasticity of demand for leisure (i.e., the smaller in absolute values the $\partial N_i / \partial a$).²³

When individuals face different probabilities of falling ill, and the tax schedule has a single intercept, it was shown in the previous section that there was a case for a public health insurance scheme, even without a non-negativity restriction on R_i . This result was interpreted to mean that a non-zero value of b would increase social welfare because it represented an indirect way of transferring individual welfare to those individuals facing a high probability of illness. With the non-negativity restriction

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23) Indeed, when those terms are zero, interior solutions with $R_i > 0$ for all i are optimal.

on R_i , a positive value for b also represents a method of transferring welfare to poor people (regardless of their risk of illness), that is less costly than general cash transfers, so that the case for a public health insurance scheme is stronger yet. Because the scheme of transfers to the sick does double duty in this sense, it is now more likely that the optimal tax and transfer policy will involve a b high enough to entirely eliminate private insurance. On the other hand, if the a_s may be separately chosen, the objective of transferring welfare to those facing a high probability of illness can be directly accomplished by an appropriate choice of a_s . While a non-zero b is still part of the optimal policy (as long as there continues to be a non-negativity restriction on the R_i), it is now less likely that it would involve a b -value high enough to completely eliminate private health insurance.

IV. Concluding Comments

The starting point of this paper is that the welfare of individuals in a society may depend not only on their income earning capacity, but also on variables relating to their state of health. Taking this into account might have important consequences for the design of tax policy intended to redistribute wealth between society's individuals in an efficient manner. In particular, it raises the possibility that a system of tax-financed public health insurance will be part of an optimal redistribution policy, if it is included in the set of allowable policy instruments.

Within the framework of the simple model used in this paper, we found that in general, there is a case for including public health insurance in the distribution policy, except under special circumstances. Intuitively, the result follows for two principal reasons. First, if individuals face different probabilities of falling ill (so that the terms on which they may obtain private health insurance are different), and it is considered impossible or impractical to differentiate the income tax treatment of individuals according to their risk of falling ill, then a public health insurance scheme may represent an appropriate, though indirect, method of increasing the welfare of individuals with relatively low expected utility. Second, if individuals can be prevented from acquiring negative private insurance, public health insurance may be an efficient way of increasing the expected welfare of individuals with low earnings capacity: because sick individuals do not work (by assumption), an increase in their expected welfare through subsidized public health insurance will not have a negative income effect on their labour supply, whereas unrestricted cash transfers to all poor people will have such an effect.

The special circumstances in which there is no case for public health insurance are, first, that the income elasticity of the demand for leisure is zero (so that unrestricted transfers have no income effect on individuals' labour supply), and second, that all individuals face the same probability of falling ill, or that the income tax schedule can be differentiated according to risk of illness. The standard

conclusion that straight cash transfers constitute a superior way of redistributing welfare is thus valid only under those restrictive conditions.

Another interesting aspect of our analysis is that in general, the optimal amount of public health insurance will not be large enough to entirely "crowd out" private health insurance (i.e., to induce individuals to voluntarily abstain from buying positive amounts of private insurance).²⁴ A situation where individuals will want to continue to buy private insurance is especially likely to occur if it is feasible to differentiate the income tax by risk, since the case for public health insurance then rests only on an asymmetry between the labour supply response to a transfer to well and ill people respectively.

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24) In a model of the present type, an outright prohibition of private health insurance would either be pointless or welfare reducing.

APPENDIX

The optimal choice of the parameters a, b and t.

The problem is to

$$\max_x \frac{1}{Y} \sum E_i^Y ; \quad x = a, b, t$$

$$\text{s.t. } G \equiv t \sum (1-p_i) N_i w_i - a \sum (q-p_i) - b \sum p_i \geq 0$$

$$\text{where } E_i = (1-p_i) U(a + (1-t) N_i w_i - \frac{p_i}{1-p_i} R_i, N_i) + p_i V(R_i + b)$$

Form the Lagrangian

$$L \equiv \frac{1}{Y} \sum E_i^Y + \lambda G$$

which implies that the conditions for an optimum are

$$(A1) \quad \frac{\partial L}{\partial x} = \sum E_i^{Y-1} \frac{\partial E_i}{\partial x} + \lambda \frac{\partial G}{\partial x} = 0 ; \quad x = a, b, t.$$

(i) For an optimal a:

$$\begin{aligned} \frac{\partial E_i}{\partial a} &= (1-p_i) U_c^i + (1-p_i) (U_c^i (1-t) w_i + U_N^i) \frac{\partial N_i}{\partial a} + p_i (-U_c^i + V_s^i) \frac{\partial R_i}{\partial a} = \\ &= (1-p_i) U_c^i \text{ from eq:s (4) and (5).} \end{aligned}$$

$$(A1) \Rightarrow \sum (1-p_i) E_i^{Y-1} U_c^i - \lambda (\sum (1-p_i) - t \sum (1-p_i) w_i) \frac{\partial N_i}{\partial a} = 0, \text{ i.e.}$$

$$(10) \quad \sum (1-p_i) Y_i = 0, \text{ where}$$

$$(13) \quad Y_i \equiv E_i^{Y-1} U_c^i - \lambda (1-t w_i) \frac{\partial N_i}{\partial a}.$$

(ii) For an optimal b:

$$\begin{aligned} \frac{\partial E_i}{\partial b} &= (1-p_i) \left(U_c^i (1-t) w_i + U_N^i \right) \frac{\partial N_i}{\partial b} + p_i (-U_c^i + V_s^i) \frac{\partial R_i}{\partial b} + \\ &+ p_i V_s^i = p_i V_s^i \text{ from eq:s (4) and (5).} \end{aligned}$$

$$(A1) \Rightarrow \sum p_i E_i^{\gamma-1} V_s^i - \lambda \left(\sum p_i - \sum (1-p_i) t w_i \frac{\partial N_i}{\partial b} \right) = 0, \text{ i.e.}$$

$$(11) \quad \sum p_i Z_i = 0, \text{ where}$$

$$(14) \quad Z_i \equiv E_i^{\gamma-1} V_s^i - \lambda \left(1 - \frac{1-p_i}{p_i} t w_i \frac{\partial N_i}{\partial b} \right)$$

(iii) For an optimal t:

$$\begin{aligned} \frac{\partial E_i}{\partial t} &= (1-p_i) \left(U_c^i (1-t) w_i + U_N^i \right) \frac{dN_i}{dt} + p_i \left(-U_c^i + V_s^i \right) \frac{\partial R_i}{\partial t} - \\ &- (1-p_i) U_c^i N_i w_i = -(1-p_i) U_c^i N_i w_i \text{ from eq:s (4) and (5).} \end{aligned}$$

$$(A1) \Rightarrow - \sum (1-p_i) E_i^{\gamma-1} U_c^i N_i w_i + \lambda \left(\sum (1-p_i) N_i w_i + t \sum (1-p_i) w_i \frac{\partial N_i}{\partial t} \right) = 0.$$

Finally, by decomposing the last derivative as in eq. (15)

$$\begin{aligned} &- \sum (1-p_i) E_i^{\gamma-1} U_c^i N_i w_i + \lambda \sum (1-p_i) (1-t w_i \frac{\partial N_i}{\partial a}) N_i w_i + \\ &+ \lambda \sum (1-p_i) t w_i \left(\frac{\partial N_i}{\partial t} \right)^* = 0, \text{ i.e.} \end{aligned}$$

$$(12) \quad - \sum (1-p_i) Y_i N_i w_i + \lambda \sum (1-p_i) t w_i \left(\frac{\partial N_i}{\partial t} \right)^* = 0.$$

Derivation of $(\partial N_i / \partial a) = (\partial N_i / \partial b) (1-p_i) / p_i$

Differentiation of eq:s (4) and (5) in the text gives (omitting index i):

$$\begin{cases} \left(U_{cc} w(1-t) + U_{Nc} \right) dC + \left(U_{cN} w(1-t) + U_{NN} \right) dN = 0 \\ - U_{cc} dC - U_{cN} dN + V_{ss} dS = 0. \end{cases}$$

Inserting expressions for dC and dS and rearranging, gives

$$\begin{bmatrix} w(1-t)A + B & -\pi A \\ -A & \pi U_{cc} + V_{ss} \end{bmatrix} \begin{bmatrix} dN \\ dR \end{bmatrix} = \begin{bmatrix} AR d\pi - A da \\ -U_{cc} R d\pi + U_{cc} da - V_{ss} db \end{bmatrix}$$

where $A \equiv U_{cc} w(1-t) + U_{Nc}$, $B \equiv U_{Nc} w(1-t) + U_{NN}$, and $\pi \equiv \frac{p}{1-p}$.

By Cramer's Rule

$$(A2) \quad \frac{\partial N}{\partial a} = -\frac{A}{D} V_{ss}, \quad (A3) \quad \frac{\partial N}{\partial b} = -\frac{A}{D} \frac{p}{1-p} V_{ss},$$

where D is the determinant of the matrix on the LHS of the system above.

Combining (A2) and (A3) (reintroducing index i)

$$\frac{\partial N_i}{\partial a} = \frac{(1-p_i)}{p_i} \frac{\partial N_i}{\partial b}.$$

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