Optimal Income Transfer Programs: Intensive Versus Extensive Labor Supply Responses

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Abstract

This paper investigates the optimal income transfer problem at the low end of the income distribution. The paper models labor supply behavioral responses along the intensive margin (hours or intensity of work on the job) and along the extensive margin (participation in the labor force). Optimal tax formulas are derived as a function of the behavioral elasticities, the shape of the income distribution and the redistributive tastes of the government. When behavioral responses are concentrated along the intensive margin, the optimal transfer program is a classical Negative Income Tax program with a substantial guaranteed income support and a large phasing-out tax rate. However, when behavioral responses are concentrated along the extensive margin, the optimal transfer program is an Earned Income Credit program with negative marginal tax rates at low income levels and a small guaranteed income. Numerical simulations show that, for realistic elasticities, the optimal program provides a moderate guaranteed income, imposes low tax rates on very low annual earnings levels, and then starts phasing out benefits at substantial rates. (*JEL* H21)

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1 Introduction

During the twentieth century, most developed countries have adopted large government managed income support programs. These programs have generated substantial controversy. While it is generally recognized that they considerably improve the well-being of the disadvantaged, some have pointed out that these programs may reduce substantially the incentives to work, and thus have large efficiency costs that may outweigh the redistributive gains. As the efficiency costs arise from the labor supply responses to the transfer or tax programs, it is obviously crucial to examine and model these behavioral responses as accurately as possible. The empirical literature on labor supply has emphasized two margins of labor supply responses (see Heckman (1993)). First, individuals can respond along the intensive margin. That is, they can vary their hours or intensity of work on the job. Second, individuals may respond along the extensive margin. That is, they can decide whether or not to enter the labor force. There is ample empirical evidence that the response along the latter margin is a real issue for low and secondary income earners. The contribution of this paper is to show that the margin of the behavioral response is a key element to take into consideration when designing an optimal transfer scheme.

The most natural way to redistribute to the low incomes is to provide a basic income support to households or individuals with no earnings, and then phase-out the income support as earnings increase until the benefit completely lost. Such a scheme is depicted on Figure 1a and is known as a *Negative Income Tax* (NIT) program. A NIT provides the largest support to individuals with very low or zero earnings who presumably are in the most need of support. Many European countries use NIT type programs to redistribute toward zero or low income earners. In the U.S., there is no universal income support program. However, most categorical transfer programs such as Temporary Assistance for Needy Families (TANF) for single mothers, Food Stamps, Disability Insurance, and Supplemental Security Income for the old are also designed as NIT programs.

However, a large guaranteed income associated with a high phasing-out tax rate, as depicted in Figure 1a, has adverse effects on labor supply both on the participation margin and the intensive margin. This has led economists and politicians to advocate programs that would make work sufficiently attractive to reduce the need for income support. These programs are known as earnings subsidies or *Earned Income Credit* (EIC) programs. An EIC, as depicted on Figure 1b, does not provide any income support for individuals with no earnings but all earnings below a given threshold are partially matched by the government. In economic terms, the EIC is equivalent to negative marginal tax rates at the bottom of the income distribution. The U.S. have implemented such a program, the Earned Income Tax Credit (EITC), since 1975. In the early 1990s, because traditional welfare programs were thought to discourage recipients to work, the EITC program was substantially increased and is now the largest cash transfer program for the poor in the U.S.[1] Obviously, relative to a NIT program, incentives to work are enhanced with an EIC program because low income workers keep a much larger share of each dollar earned than with a NIT program. However, the EIC provides no support for non-workers and thus does not reach the most needy people. Moreover, as shown on Figure 1b, the earned income credit has also to be taxed away at some point further up the income distribution and thus imposes labor supply disincentives along the intensive margin for workers in the phasing-out region.

The goal of this paper is to cast light on the NIT versus EIC controversy using the methods of optimal income taxation. This paper develops a formal optimal income tax model and shows that a NIT program with a substantial guaranteed income level and high phasing out rates is optimal when labor supply responses are concentrated along the intensive margin. However, when labor supply responses are concentrated along the extensive margin, then the optimal transfer is similar to an EIC with negative marginal tax rates at the bottom and a smaller guaranteed income for non-workers. In the paper, optimal tax rates formulas are derived as a function of the behavioral elasticities estimated by the empirical literature. Therefore, using the estimates of both intensive and extensive behavioral elasticities from empirical studies, it is possible to assess the optimal shape and the optimal size of the transfer program. This paper provides a number of numerical simulations to investigate this point further. For realistic elasticities, the optimal program provides a moderate guaranteed income, but imposes a zero marginal tax rate at the bottom and taxes away at substantial rates the guaranteed income further up the earnings distribution.

[1] There is pressure in other countries as well to move away from NIT programs toward EIC programs. For example, the U.K. adopted in 1988 a Family Credit which is similar to the american EITC and that has also een expanded. Canada has implemented recently on an experimental asis a Self-Sufficiency Program that is also akin to the EITC.

The paper is organized as follows. Section 2 reviews previous work on optimal transfer programs. Section 3 presents the models of intensive and extensive responses. It derives optimal tax formulas in each of these two polar cases, and in the case where the two margins of response are present. Section 4 discusses the empirical literature on income maintenance programs and presents numerical simulations of optimal transfer schemes. Section 5 concludes and discusses avenues for future research.

2 Related Literature

Many economic studies have investigated the income support problem from a theoretical perspective.[2] An early literature, closely related to empirical studies, has proposed and analyzed a number of different schemes to provide income support to the disadvantaged using the classic static labor supply model. As described in the introduction, the Negative Income Tax program has been extensively discussed. Blank et al. (1999) provide a recent and detailed analysis of the effect of NIT programs on work incentives, and describe the standard conclusion that lowering the tax rate may not necessarily reduce distortions because lowering the tax rate while keeping the same guaranteed income increases the break-even point (the income level at which benefits are fully taxed away) implying that people further up the income distribution are affected by the program.

The main other type of programs proposed are wage or earnings subsidies. The aim of these alternative programs is to make work profitable and thus reduce the need for income transfers. Kesselman (1969) and Zeckhauser (1971), among others, argue that these schemes can be more effective than NIT type programs. However, wage subsidies are difficult to implement because they depend on the wage rate, which can be manipulated more easily than total earnings. Earned income credit programs which subsidize *earnings* and which also encourage work effort are easier to implement and have been applied at a very large scale in the US with the EITC program. Wage or earning subsidies do not reach the people who do not work and have to be phased out at some point and thus creating distortions further up the income distribution. This literature, although it provides interesting insights into the issue of transfer programs, adopts a piecemeal

[2] Atkinson (1987) provides a comprehensive survey.

approach to the income maintenance problem without specifying and solving any underlying optimization problem and does not precisely define what information the government can use when designing policy.

The theoretical literature on optimal income taxation, which grew out of the seminal contribution of Mirrlees (1971), has tried to remedy these two defects of the previous literature. However, the literature has focused almost exclusively on the intensive margin of response. Mirrlees (1971) developed a model where the government maximizes social welfare but cannot observe individual abilities and thus has to rely on distortionary income taxation. He showed that optimal marginal tax rates at any income level cannot be negative. Seade (1982) clarified the conditions under which this result holds. Thus this important theoretical result implies that an EIC which generates negative marginal rates cannot be optimal in a model with intensive behavioral responses. Seade (1977) showed that when everybody works and when the earnings distribution is bounded away from zero then the optimal marginal rate at the very bottom is equal to zero. These conditions are not met empirically and numerical simulations have shown that optimal rates at the bottom can be substantial when the Seade conditions do not hold (see e.g., Tuomala (1990) and Saez (2000a)). Therefore, simulations coming out of the Mirrlees (1971) model suggest that optimal transfer programs look like NIT type programs with a substantial guaranteed income taxed away at fairly high rates.

Optimal taxation models with labor force participation choice have attracted very little attention.[3] Two exceptions are Diamond (1980) and Mirrlees (1982). Diamond (1980) develops a simple optimal tax model where hours and wages are fixed but people can choose whether or not to participate in the labor force. He shows that optimal marginal tax rates may be negative for some income ranges. The study is theoretical and no attempt is made to express optimal tax formulas in terms of elasticities or to assess the importance of the participation decision margin relative to the standard intensive margin of response. As a result, that study has not been followed upon to cast light on the EIC versus NIT debate. Mirrlees (1982) is a model of optimal taxation with migration where individuals have a fixed income but can decide to

[3] Note however that the retirement decision is akin to a la or force participation decision. As a result, models on optimal social security taxes and enefits, such as Diamond and Mirrlees (1978) or Diamond et al. (1980), are related to what is done in the present paper.

migrate to other countries if taxes are too high. The decision to migrate and the decision to participate in the labor force can be modeled in almost identical terms. As a result, the optimal tax formulas obtained by Mirrlees (1982) are qualitatively close to the formulas obtained in the purely extensive case in the present paper, although their interpretation is very different because Mirrlees (1982) focuses his analysis mostly to the high end of the income distribution.

Last, two studies by Besley and Coate (1992, 1994) have investigated the design of income maintenance programs when the objective of the government is not to maximize social welfare but to alleviate poverty.[4] They show that in that context, work requirements (workfare) might be an effective screening device to target welfare to the less skilled individuals. Besley and Coate question the welfare maximization approach on the grounds that it requires the government to observe individuals' valuation of leisure and to make interpersonal utility comparisons. The present paper shows that it is possible to adopt a welfare maximization objective without specifying explicitly the valuation of leisure and that the redistributive tastes of the government can be summarized using straightforward marginal welfare weights at each income level.

3 Extensive versus intensive response models

The goal of this section is to develop a model of labor supply and optimal taxation to understand how the nature of labor supply responses - intensive versus extensive - affects the shape of the optimal tax and transfer schedule. Therefore, I introduce first the pure extensive model or participation model and then the pure intensive model or effort model, and consider afterwards a mix of the two polar models. Because I want to focus on the intensive versus extensive labor supply response issue, I make two important simplification assumptions.

First, I consider income taxation at the individual level only and thus ignore completely the secondary earner labor choice decision issue that arises in the context of household income taxation. The joint taxation problem is obviously important but complicates considerably the

[4] Kan ur, Keen and Tuomala (1994) have shown that when the o jective of the government is not to maximize a classic social welfare function, ut to reduce poverty, negative marginal rates may e desira le for low incomes in the Mirrlees (1971) model. Their numerical simulations show, however, that this result is not important in practice and that simulated optimal reducing poverty schedules are very close to welfare maximizing simulated schedules.

analysis and thus is better left for future research.

Second, I assume that the government bases redistribution on realized earnings only. That is, the government does not condition transfers and taxes on other observable information. As discussed in introduction, this is consistent with the experience of European countries such as France but at odds with the U.S. transfer system. As pointed out by Akerlof (1978), in theory, the government should base redistribution not only on income but also on observable characteristics such as age, family status, etc. that are correlated with skills and ability to work. However, within categories of people with same characteristics, such as single parent families, the government continues to face a classic optimal income tax problem where the model developed here should be relevant.

3.1 The General Framework

To simplify the exposition, I consider a discrete model of occupational choice. It is possible to develop a continuous model that is equivalent.[5] Thus, in the model, there are $I+1$ types of occupations: the unemployed earning $w_0 = 0$, and I types of jobs paying salaries w_i. The salaries w_i are increasing in i, $0 < w_1 < .. < w_I$, and correspond to occupations with increasing skills. As is standard in the optimal income tax literature, I assume that there is perfect substitution of labor types in the production function and thus that salaries w_i are fixed. As discussed above, a key assumption of the paper is that the government is only able to observe income levels and thus can condition taxation of income only. The net taxes paid by each class of individuals are denoted by T_i. This tax scheme embodies both taxes and transfers. For example, if $T_i < 0$, then workers in occupation i receive a net transfer from the government. The after tax income in occupation i is denoted by $c_i = w_i - T_i$.

The total population is normalized to one and I denote by h_i the proportion of individuals in occupation i (so that $h_0 + h_1 + .. + h_I = 1$). Individuals have heterogeneous tastes and choose their occupation i according to the relative after-tax rewards in each occupation. For example, if the rewards for work are reduced relative to welfare benefits c_0, then presumably some individuals will drop out of the labor force. Thus in the aggregate, the fraction of individuals choosing occupation i depends on after-tax rewards in all occupations: $h_i = h_i(c_0, c_1, .., c_I)$.

[5] Such a continuous model is developed in an earlier version of the paper Saez (2000).

The magnitude of labor supply responses is embodied in the functions h_i. High taxation and redistribution levels for example may shift labor supply away from highly productive activities toward lower productive jobs or unemployment. The description of the formal underlying structure of individual utilities is not essential for the analysis and is therefore presented only in the appendix.

The government set taxes T_i so as to maximize welfare which is a weighted sum of individual utilities (see appendix). Taxes must finance transfers and government consumption. I assume that government consumption per capita is fixed and equal to H. The government budget constraint is,

$$\sum_{i=0}^{I} h_i T_i = H. \tag{1}$$

The welfare function can be simply characterized by marginal social welfare weights (expressed in terms of the value of public funds) that the government sets for each of the $I+1$ of occupations. These weights are denoted g_i, $i = 0, 1, .., I$ and represent the value (in terms of public funds) of giving an additional dollar to an individual in occupation i. The formal definition of these weights is given in appendix. Put another way, the government is indifferent between giving one more dollar to an individual in occupation i and g_i more dollars of public funds. As we will see, these weights are a sufficient statistic for the redistributive tastes of the government in the optimal transfer formulas that we derive. If the government values redistribution then the lower the earnings level of the individual, the higher the social marginal value of an extra dollar for that individual. As a result, the weights g_i are decreasing in i.[6]

The marginal weight g_0 deserves special attention. The pool of unemployed individuals is presumably very heterogeneous. Some individuals are unemployed because they cannot work because of disabilities or very low skill levels. Other unemployed individuals may be able to work but choose not to because they may have low tastes for work. Whether the unemployed really cannot work or are lazy is of critical importance to assess whether they deserve to get transfers. Liberals tend to hold the former view and conservatives the latter. A conservative

[6]In the extreme Rawlsian case where the government cares only a out the worse-off individuals, all weights, except g_0, are zero. This is ecause the worse-off individual is presuma ly in the pool of the unemployed ecause all working individuals have always the option to drop out of the la or force.

government willing to redistribute toward the "deserving poor" but not toward the "lazy poor" might thus set a lower weight for the unemployed than for the low skilled workers ($g_0 < g_1$). On the other hand, a liberal government might consider that the unemployed are in more need than the low skilled workers and thus set $g_0 > g_1$. Of course, whether the unemployed can work or not is not uniquely an ideological controversy, and is also an empirical issue that might be tackled analytically.[7] Here, we take as given the redistributive tastes and views of the government but we analyze in detail how the pattern of social weights affects the optimal tax and transfer schedule.

The social weights g_i depend on disposable income c_i rather than w_i because the government takes into account the redistributive effects of the tax schedule when setting the marginal social weights (see the appendix for a formal discussion). Therefore, it is constructive to express the social weights g_i as a function of disposable income $g_i = g(c_i)/p$ where p is the marginal value of public funds. In that case, the function $g(\cdot)$ can be taken as exogenous and it reflects the absolute redistributive tastes of the government. This formulation is useful for the numerical simulations. The function $g(\cdot)$ summarizes in a transparent way the redistributive tastes of the government and is decreasing when the government values redistribution. In that sense, welfare maximization does not require explicit interpersonal utility comparisons or to measure the value of leisure for each individual.

I consider as a important special benchmark case the situation with no income effects. In that case, increasing all after-tax levels c_i by a constant amount R does not change the individual occupational choice decisions and thus does not affect the aggregate occupational distribution h_i. Formally, $h_i(c_0 + R, c_1 + R, .., c_I + R) = h_i(c_0, c_1, .., c_I)$ for all i and R. With no income effects, a marginal dollar of public funds is valued as much as an additional dollar redistributed to all classes and therefore (see the appendix for a formal proof),

$$\sum_{i=0}^{I} h_i g_i = 1. \tag{2}$$

Equation (2) provides a normalization of the welfare weights g_i. The model where each h_i

[7] Bound (1989, 1991), and Parsons (1991) present a lively scientific de ate on which fraction of disa ility insurance recipients in the U.S. can or cannot work.

depends on all after-tax rewards $(c_0, .., c_I)$ is of course too general to provide interesting results. Therefore, we specialize this model to two polar cases of interest: the extensive response model and the intensive response model.

3.2 Extensive Responses

- **Model and Optimal Taxes**

In this first model, individuals respond only through the extensive margin: the labor supply decision is binary, either work or not work.[8] This can modeled in the framework described above as follows. Each individual has a skill level $i \in \{0, 1, .., I\}$ and may only choose either to work in occupation i corresponding to his skill or be unemployed. Therefore, the only decision is a participation decision. The decision to participate depends on the relative after-tax incomes when working c_i and when unemployed c_0. This model is obviously a crude simplification of reality but captures the extensive margin the optimal tax and transfer schedule in this model.

Proposition 1 *At the optimum, the optimal schedule is such that*

$$\frac{T_i - T_0}{c_i - c_0} = \frac{1}{\eta_i}(1 - g_i). \tag{4}$$

Equations (4) for $i = 1, 2, .., I$ and (1) define the optimal set of taxes T_i for $i = 0, 1, .., I$.

Proof: The formal proof of this proposition is presented in appendix. However, I give here a simple heuristic proof that illuminates the economics behind formula (4). In order to derive the optimal set of taxes T_i, I consider a small change dT_i of tax T_i on occupation i. This tax change has two effects on tax revenue and welfare.

First, there is a mechanical increase in tax revenue equal to $h_i dT_i$ because workers with skill i pay dT_i additional taxes. By definition of the welfare weight g_i, this increase in tax revenue, however, is valued only $(1 - g_i)h_i dT_i$ by the government because each dollar raised decreases the after tax incomes of individuals in class i and this income loss is valued g_i by the government.

Second, there is a loss in tax revenue due to the behavioral response. The small tax changes induces dh_i workers to leave the labor force. By definition of η_i in (3), we have $dh_i = -h_i \eta_i dT_i/(c_i - c_0)$. Each worker leaving the labor force induces a loss in tax revenue equal to $T_i - T_0$, therefore the total behavioral cost is equal to $-(T_i - T_0)h_i \eta_i dT_i/(c_i - c_0)$. There is no change in welfare due to the behavioral response because workers leaving the labor force on the margin are indifferent between becoming unemployed and remaining employed.[9]

At the optimum, the sum of the mechanical and behavioral effects must be zero. Rearranging this equation gives immediately equation (4). It is important to note that, even though the weights g_i vary with the tax schedule, the optimal tax formula depends only on the level of the g_i's. QED.

- **Pattern of optimal transfers**

Assume that the government has redistributive tastes, so that $g_0 > g_1 > .. > g_I$. With no income effects, from (2), we know that the average (using population weights) value of the g_i's is

[9]Note that this property cannot e used when the o jective of the government is non-welfarist. This is why welfare maximization o jectives are in general easier to handle than non-welfarist o jectives.

one. Therefore, there is some i^* such that $g_i \geq 1$ for $i \leq i^*$ and $g_i < 1$ for $i > i^*$. The government wants to redistribute from high skilled occupations $i > i^*$ toward low skilled occupations $i \leq i^*$.

As depicted on Figure 2a, equation (4) implies then that $T_i - T_0 > 0$ for $i > i^*$ and that $T_i - T_0 \leq 0$ for $i \leq i^*$. When $i^* > 0$, the government provides a *higher* transfer to low skilled workers (for whom $1 \leq i \leq i^*$) than to the unemployed even though social marginal utility of consumption is highest for the unemployed. Therefore, when the government wants to redistribute toward the low income workers ($g_i > 1$ for low i), it provides them with a tax transfer $-T_i$ larger than the tax transfer to the unemployed $-T_0$. In other words, the government implements in that case a combined lumpsum guarantee income $-T_0$ and a negative marginal tax rate at the bottom (similar to the Earned Income Tax Credit) in order to increase the size of transfers as income increases. The cost of these two welfare programs are then fully financed by higher income earners.

The intuition for having higher transfer levels to low skilled workers than to the unemployed is depicted on Figure 2b. Starting from a situation with lower transfers to low income workers than to the unemployed, increasing the transfers to the low income workers is beneficial from a pure redistributive point of view because $g_i > 1$ for i small and positive. This also encourages some of the unemployed to join the labor force which increases the tax revenue of the government. As a result, it is unambiguously welfare enhancing to increase at the margin the transfer to low income workers than to the unemployed implying that the initial situation in Figure 2b is suboptimal. Note that if, as discussed above, the government does not value redistribution to the unemployed as much as to the working poor ($g_0 < g_1$), then the previous EIC result is reinforced because it is the direct consequence of the weights of the working poor being above one.

Finally, in two important cases, the EIC bubble disappears. First, when the government cares mostly about the welfare on the worse-off individuals (the extreme case being the Rawlsian objective), it might be the case that all weights (except g_0) are below one. In that case, $i^* = 0$ and $T_i \leq T_0$ for all i, implying that the negative marginal tax rate component of the welfare program disappears and the transfer program is a classic negative income tax. Second, when the government has no redistributive tastes, then there is no guaranteed income and the weights g_i are constant (below one) and set so as to raise H dollars per capita. In that case as well, tax liability is necessarily increasing with income.

- **Income Effects**

In the case with income effects, labor supply depends not only on $c_i - c_0$ but also on c_0. In that situation, the average welfare weights may no longer be equal to one and equation (2) needs to be modified (see Saez (2000b)). However, the previous derivations carry over and equation (4) remains valid. As income effects do not affect the reasoning based on Figure 2b, the EIC bubble result also carries through as long as the low skilled workers weight g_1 is above 1.

3.3 Intensive Responses

The theory of optimal income taxation has mostly focused, following Mirrlees (1971) seminal contribution, on the intensive labor supply response to taxes. The model of Mirrlees (1971) is the classical static labor supply model where individuals choose their labor supply until marginal desutility of work equals marginal utility of money derived from the extra amount of work. Key to the analysis are the elasticities of labor supply with respect to tax rates. Piketty (1997) has developed the discrete version of the Mirrlees (1971) model. He considered only the Rawlsian case but it is straightforward to adapt the model to any welfare weights. We follow here his approach.

- **The Model**

In the discrete type model, intensive responses can be modeled as follows. If the rewards of occupation i are reduced relative to the lower income occupation $i-1$, then some individuals in occupation i reduce their effort and switch to occupation $i-1$. I also assume here that there are no income effects implying that giving a uniform lumpsum to all individuals does not affect supply for each job.[10] In that case and as shown formally in appendix, the functions h_i can be written as $h_i(c_{i+1} - c_i, c_i - c_{i-1})$. When $c_{i+1} - c_i$ increases by dc and when all the other differences $c_{j+1} - c_j$ for $j \neq i$ are kept constant, there is a displacement of workers from job i to job $i+1$. The increase in h_{i+1} is exactly equal to the decrease in h_i and therefore, we have,

[10] Income effects can e included in the analysis as in Saez (2000a). However, income effects complicate su -stantially the analysis. Moreover, as income effects along the intensive margin of response have, in general, een found to e small in the empirical literature, we consider only the simpler case with no income effects.

$\partial h_{i+1}/\partial(c_{i+1}-c_i) = -\partial h_i/\partial(c_{i+1}-c_i)$. The behavioral elasticities can be defined as follows,

$$\zeta_i = \frac{c_i - c_{i-1}}{h_i} \frac{\partial h_i}{\partial(c_i - c_{i-1})}. \tag{5}$$

This elasticity measures the percentage increase in supply of job i when $c_i - c_{i-1}$ is increased by one percent. I specify in the appendix a set of assumptions on utility functions that generate the intensive model described here. The link between this mobility elasticity and the elasticity of earnings with respect to tax rates of the usual labor supply model is investigated later on.

- **Optimal Tax Formula**

Proposition 2 *At the optimum, the optimal schedule is such that*

$$\frac{T_i - T_{i-1}}{c_i - c_{i-1}} = \frac{1}{\zeta_i}\left[\frac{(1-g_i)h_i + (1-g_{i+1})h_{i+1} + .. + (1-g_I)h_I}{h_i}\right]. \tag{6}$$

Equations (1) and (6) for $i = 1, 2, .., I$ characterize the optimal tax levels T_i.

Proof: To derive optimal tax rules in this model, we consider as above a small perturbation of the optimal tax schedule. To derive a condition on the relative tax rates between jobs i and $i-1$, I consider, as depicted on Figure 3a, a small increase dT in tax rates for jobs $i, i+1, .., I$: $dT_i = dT_{i+1} = .. = dT_I = dT$. This tax change decreases $c_i - c_{i-1}$ by dT but leaves unchanged all the other differences $c_j - c_{j-1}$ for $j \neq i$.

This tax change raises $[h_i + h_{i+1} + .. + h_I]dT$ additional taxes through the mechanical effect which are valued $[(1-g_i)h_i + (1-g_{i+1})h_{i+1} + .. + (1-g_I)h_I]dT$ by the government. This change also induces $dh_i = -h_i\zeta_i dT/(c_i - c_{i-1})$ individuals in job i to switch to job $i-1$ reducing tax revenue by $(T_i - T_{i-1})dh_i$. At the optimum, the sum of the two effects is zero implying equation (6). A formal proof of this result is provided in the appendix. QED.

When the social weights g_i are non-increasing, equation (2) implies that $(1-g_i)h_i + .. + (1-g_I)h_I \geq 0$ for any $i > 0$. Therefore, formula (6) implies that tax liability T_i is *increasing* with i.[11] In the intensive model, it is therefore never optimal to impose *negative* marginal tax

[11] O viously, c_i is increasing in i ecause no ody would choose an occupation requiring more effort and providing less after-tax income.

rates.[12] The reason for this result is depicted on Figure 3b. If there is a negative marginal rate in some range, then, by increasing slightly this rate, the government reduces work incentives in that range but this increases tax revenue raised from people in that range (precisely because the tax rate is negative in that range). Moreover, this small marginal tax rate increase allows the government to raise money from all taxpayers above that range (tax liability at any income being the sum of marginal rates up to that income). This is beneficial for redistributive reasons.

- **Optimal rates at the bottom**

To cast light on the marginal tax rate at the bottom, it is useful to use equation (2) to rewrite equation (6) for $i = 1$ as

$$\frac{T_1 - T_0}{c_1 - c_0} = \frac{1}{\zeta_1} \left[\frac{(g_0 - 1) h_0}{h_1} \right]. \tag{7}$$

This equation shows that, the higher the social weight on the unemployed g_0, the higher the marginal tax rate at the bottom. The intuition for this result is that the best way to redistribute to zero income earners is to make the lumpsum transfer $-T_0$ as large as possible, this can be achieved only by imposing large rates at the bottom. When the government values less an extra dollar to the unemployed, than an extra dollar uniformly distributed across all income groups, then $g_0 < 1$. Equation (7) shows that, in that case, $T_1 < T_0$, that is, there is a negative marginal tax rate at the bottom producing an EIC schedule. However, the condition needed to obtain that result in the intensive model ($g_0 < 1$) is drastic because it requires not only to assume that the unemployed are less deserving than the working poor but also than the average individual in the economy. In other words, it is much more difficult to make the case for an EIC program in the intensive model than in the extensive model. Therefore, with most redistributive tastes, the general conclusion of the pure intensive model is that redistribution should take place through a guaranteed income level that should be taxed away as income increase. The transfer program takes the form of a traditional Negative Income Tax and no Earned Income Credit component should be included.

[12]As mentioned in Section 2, this result was noticed y Mirrlees (1971) and clarified y Seade (1982) who provides an intuition different from the one I give here.

3.4 Mixing Extensive and Intensive Responses

The previous sections have illustrated the contrast between the intensive and extensive model for designing an optimal transfer scheme. However, the real world is obviously a mix of the two models. The goal of this section is thus to develop a model which incorporates both the extensive and the intensive margin of response in order to assess how these two effects interact and to perform numerical simulations.

In the pure extensive response model, the number of individuals in occupation i depends on $c_i - c_0$. In the pure intensive model, the number of individuals in occupation i depends on $c_i - c_{i-1}$ and on $c_{i+1} - c_i$. In the general model with both extensive and intensive responses, the supply in each job i is given by $h_i(c_i - c_0, c_{i+1} - c_i, c_i - c_{i-1})$.

The optimal tax formulas in the mixed model are derived in the appendix using the same methodology as in Section 3. The optimal tax formula expressed in terms of the intensive elasticities ζ_i and the participation elasticities η_i is given by,

$$\frac{\tau_i}{1-\tau_i} = \frac{1}{\zeta_i \ h_i} \sum_{j=i}^{I} h_j \left[1 - g_j - \eta_j \frac{T_j - T_0}{c_j - c_0} \right]. \tag{8}$$

Comparing equations (6) and (8), we see that the mixed model is identical to the intensive model with weights g_j replaced by $\hat{g}_j = g_j + \eta_j (T_j - T_0)/(c_j - c_0)$. Therefore, adding the participation margin amounts to attributing a higher welfare weights $\hat{g}_j$ to income groups that are prone to leave the labor force and that receive a lower transfer than the unemployed ($T_j > T_0$).

Each of the two polar cases analyzed in Section 3 can be obtained from equation (8) by letting either one of two elasticities (η or ζ) tend to zero. As a result, if the participation elasticity is large relative to the earnings elasticity, the optimal schedule will have an EIC component with larger transfers for low income workers than for the unemployed. More precisely, because of the extensive margin of response, the pseudo weights $\hat{g}_i$ need not be decreasing even if the real weights g_i are decreasing. As a result, optimal tax rates are not necessarily non-negative as in the pure intensive model. On the other hand, if the elasticity η is small relative to ζ, then the optimal schedule will have non-negative rates everywhere as in the standard intensive model.

The key difference between the intensive and the extensive model is illustrated on Figure 4. Starting from an NIT transfer system, suppose the government contemplates increasing incentives for low skilled workers by reducing T_1. In the extensive model, the behavioral response is only on the participation margin and thus decreasing T_1 unambiguously increases labor supply. On the other hand, in the intensive model, in addition to inducing some of the unemployed to work in occupation 1, decreasing T_1 makes occupation 1 more attractive to workers in occupation 2 and thus reduces labor supply through that channel. As a result, increasing T_1 has ambiguous effects on labor supply in the intensive model. Alternatively, using the concepts of contract theory, the intuition can be formulated as follows. In the extensive model, increasing low income salaries does not tempt higher income earners to reduce their effort to imitate low income workers but does tempt the unemployed to start working. In the intensive model, increasing low income salaries tempts both the unemployed but also higher income earners.

A government contemplating increasing incentives at the bottom as in Figure 4 must precisely weigh the positive participation effect and the negative intensive labor supply effect. The models developed here give precise formulas to trade-off optimally these two effects. Next section proposes a simple calibration of the model using a range of elasticities.

4 Empirical Calibration

4.1 Empirical Literature

As mentioned in Introduction, the empirical literature on labor supply and behavioral responses to taxes and transfers is large. Hausman (1985), Pencavel (1986), and Blundell and MaCurdy (1999) provide extensive reviews of the literature. Most studies find that the intensive labor supply elasticities of males are small. However, elasticities of labor force participation have been found to be much larger for some classes of the population such as the elderly, single mothers or secondary earners. The model developed here is based on individual taxation, but most empirical studies focus instead on subgroups of the population such as prime male workers, wives, or single mothers and rarely estimate elasticities for the full population. As a result, it is difficult to calibrate elasticities very precisely from the existing empirical literature and the following discussion should be seen as only illustrative. For our simulations, we need to pay special attention to elasticities of earnings and participation at the bottom of the income distribution. Two pieces of evidence are of particular interest.

First, in the late 1960s, a series of Negative Income Tax experiments were implemented in the U.S. These experiments provide in principle an ideal set-up to estimate both participation and intensive elasticities of labor supply. Robbins (1985) surveys the empirical results based on NIT experiments. Both intensive and extensive elasticities for males are small (around 0.2). The behavioral response for wives, single female heads and the young is higher and concentrated along the participation margin. Participation elasticities are often in excess of 0.5 and sometimes close to 1.[13]

Second, recent studies exploiting the recent increases in the EITC (see e.g. Eissa and Liebman (1996), Meyer and Rosenbaum (1998)), have shown that the effect on participation of single female heads is substantial.[14]

To summarize, the literature suggests that participation elasticities at the low end of the income distribution maybe large (perhaps above 0.5). Elasticities of earnings with respect to the tax rate are substantially smaller (perhaps around 0.25). The elasticity of participation at the middle and high end of the income distribution is very likely to be small. There is little consensus about the magnitude of intensive elasticities of earnings for middle income earners, though this elasticity is likely to be of modest size for middle income earners and higher for high income earners. Gruber and Saez (2000) summarize this literature and display empirical estimates between 0.25 and 0.5 for middle and high income earners.

4.2 Numerical Simulations

• **Relating transition elasticities to labor supply elasticities**

The discrete model of mobility that I have used is different from the traditional labor supply model where individuals maximize a standard utility defined on consumption and hours of work. However, it can be easily shown that the two models have the same structure and that the elasticity of mobility ζ_i can be related the the usual labor supply elasticity. In order to calibrate the discrete model using the empirical elasticities from the labor supply literature, it

[13] Ashenfelter (1978), for example, using data from the North Carolina-Iowa Rural Income Maintenance Experiment, reports elasticities for wives around 0.9 while elasticities for hus ands are only around 0.2.

[14] For example, Eissa and Lie man (1996) report participation elasticities for single mothers with low education around 0.6.

is important to analyze the relation between the elasticities of mobility and the labor supply elasticity. In the classical model of labor supply with no income effects, labor supply responses are measured by the elasticity of earnings with respect to one minus the marginal tax rate $\varepsilon = [(1-\tau)/w]\partial w/\partial(1-\tau)$. In the discrete model, I can define an implicit marginal tax rate τ_i between occupations i and $i-1$ as, $\tau_i = (T_i - T_{i-1})/(w_i - w_{i-1})$ or equivalently $1 - \tau_i = (c_i - c_{i-1})/(w_i - w_{i-1})$. In appendix, I show that the elasticities ε_i at each income level that generate behavioral responses of the same magnitude as the elasticities ζ_i are such that,

$$\zeta_i(w_i - w_{i-1}) = \varepsilon_i w_i. \tag{9}$$

- **Calibration**

Numerical simulations are based on the discrete model mixing the extensive and intensive margin of behavioral response. In the simulations, I use a discrete grid of 17 income levels. I describe in appendix the technical details of the simulations. A number of parameters are crucial for tax schedule simulations.

First, the elasticity parameters summarizing the behavioral responses are prominent. As there is no strong consensus on the size of these parameters, I present simulations using a range of plausible parameter values. The values for the participation elasticity η is taken as constant and equal to 0, 0.5 or 1 for incomes below \$20,000 and equal to 0 for incomes above \$20,000. The intensive elasticity ε_L for incomes below \$20,000 is taken as constant and equal to 0, 0.25 or 0.5. The middle and high income (above \$20,000) elasticities ε_H is taken as constant and equal to 0.25 or 0.5. All simulations have been carried out assuming no income effects.[15]

Second, the social welfare weights which summarize the redistributive tastes of the government may also affect the optimal level and patterns of taxation. I summarize the redistributive tastes of the government using a simple parametric form for the curve of marginal weights $g(c) = 1/(p \cdot c^{\nu})$ where p denotes the marginal value of public funds and ν is a scalar parameter. The higher is ν, the higher are the redistributive tastes of the government. $\nu = +\infty$ corresponds to the Rawlsian criterion while $\nu = 0$ corresponds no redistributive tastes. Most of the simula-

[15]Simulations including income effects in the pure extensive model of Section 3.1 have een performed. Income effects have little effect of the size and shape of the optimal transfer program ut can have a su stantial effect on the percentage of unemployed workers.

tions are presented with $\nu = 1$ which represents fairly strong redistributive tastes. With $\nu = 1$, the government values N times less marginal consumption when disposable income is multiplied by N. Note that this calibration always produces weights g_i decreasing with i and does not discriminate against the unemployed.

Third, the income distribution is calibrated using the empirical yearly earnings distribution from the March 1997 Current Population Survey (CPS). I limit the sample to individuals aged 18 to 60 and I exclude students. The details are explained in appendix. The rate of non-labor force participation (zero yearly earnings reported) for this group is slightly above 15%.

Last, the exogenous revenue requirement of the government H obviously affects the general levels of taxation and transfers. I assume that the government wants to collect the same amount that is actually collected with the income tax (state and federal) net of redistribution done with the earned income tax credit. This amount is around \$8,000 per household, implying an average annual tax per adult around \$5,000. Therefore, in the simulations, H is taken as equal to \$5,000. Therefore, the tax schedules presented are roughly comparable to the actual welfare and income tax schedule.

- **Results**

The results of numerical simulations are presented in the four panels of Figure 5 and in Tables 1 and 2. Figure 5 displays optimal disposable income schedules $c(w) = w - T(w)$ as a function of earnings w. As the emphasis is on the low income end, the graphs are plotted for the income range \$0 to \$20,000. The 45^o degree line gives the benchmark schedule with no tax or subsidy. Each figure displays the optimal schedules for three values of the participation elasticity η (0, 0.5 and 1) and fixed values of the intensive elasticities for high and low incomes (ε_L and ε_L) and the redistributive tastes (parameter ν).Income effects are assumed away in all simulations.

In the top-left panel, $\varepsilon_L = 0.25$, $\varepsilon_H = 0.25$ and $\nu = 1$ and there are no income effects. This panel shows that increasing η affects substantially the shape of the optimal transfer program. With $\eta = 0$, the program is a traditional NIT with a substantial guaranteed income (\$9,900) and high phasing out rates (around 70%). However, when η increases, an EIC bubble appears at the low end. The guaranteed income is reduced (\$4,500 for $\eta = 1$) and earnings are slightly subsidized over the income range \$0 to \$6,000. From \$6,000 to \$15,000, the transfer is taxed away at a high rate (in excess of 50%).

The top-right panel of Figure 5 displays the same graphs with a higher intensive elasticity for low incomes $\varepsilon_L = 0.5$. Increasing ε_L, reduces the size of the EIC bubble. It also decreases slightly the guaranteed income level and decreases the phasing out rate.

The bottom panels of Figure 5 consider variations in the redistributive parameter ν. In the bottom-left panel, $\nu = 4$ which represents extremely strong redistributive tastes close to the Rawlsian case.[16] Relative to the top-left panel benchmark, the size of the guaranteed income is substantially higher (around \$12,000), the phasing out rates is very high (around 80%), and the EIC bubble has completely disappeared: the elasticity of participation η has little effect on the optimal schedule. In the bottom-right panel, $\nu = 0.25$ which represents a very low taste for redistribution.[17] Relative to the top-left panel, the guaranteed income is very small (less than \$2,000 for $\eta = 0.5, 1$). Both the EIC bubble and the phasing out rates are small.

Tables 1 and 2 summarize the optimal schedules for a wide range of parameters. Optimal schedules are summarized by 5 numbers. First, the guaranteed income level $-T(0)$ that is provided to the unemployed. Second, the average marginal tax rate from \$0 to \$6,000 ($[T(6000) - T(0)]/6000$) measures the tax distortion at the lowest end of the earnings distribution. Third, the average marginal tax rate from \$6,000 to \$15,000 ($[T(15000) - T(6000)]/[15000 - 6000]$) measures the phasing out rate of the transfer program. Fourth, the break-even point is the income level at which transfers are equal to zero ($T(w) = 0$) and the consumption schedule $c(w)$ crosses the 45^o line. Fifth, the average marginal tax rate from \$30,000 to \$100,000 measures the tax burden for middle and high income earners. Finally, the level of unemployment induced by the optimal transfer program is reported.

Table 1 focuses on the case where the redistributive taste parameter ν is equal to one. In the left side of the table (columns (1) to (6)), $\varepsilon_H = 0.25$ while in the right side, (columns (7) to (12)), $\varepsilon_H = 0.5$. Table 1 confirms the graphical results. Unsurprisingly, a higher elasticity ε_H reduces the optimal rates for high incomes and thus the size of the optimal transfer program.

[16] With $\nu = 4$, the government values 16 times less marginal consumption when disposa le income dou les.

[17] With $\nu = 0.25$, the government values only 2 times less marginal consumption when disposa le income is multiplied y 16.

The simulations show that, when η is high, the level of transfers affects significantly the unemployment rate and hence the cost of the transfer program. With $\eta = 1$, the optimal transfer program reduces the non-labor force participation rate to less than 3% which is only a fifth of the baseline level of non labor force participation. It is clearly unrealistic to assume that changing the parameters of the tax schedule can have such a large effect on labor force participation. Therefore, if the participation elasticity η evaluated around the current tax schedule is really equal to one, it seems likely that this elasticity is going to decrease as more and more people are induced to join the labor force and as only the individuals who really do not want to work are left in the pool of non-participants. In other words, though formula (8) is perfectly valid even if elasticities vary with the program parameters, it is no longer appropriate to use current elasticities estimates and apply them to a tax situation very different from the present one.[18]

Table 2 investigates the effect of the redistributive taste ν. The cases $\nu = 0.25$, $\nu = 1$ and $\nu = 4$ are considered in Panels A, B and C. Unsurprisingly, higher redistributive tastes lead to a larger guaranteed income level and higher phasing out rates and higher rates for middle and high incomes.

From the empirical literature, we can consider the case $\eta = 0.5$, $\varepsilon_L = 0.25$ and $\varepsilon_H = 0.25$ as a plausible benchmark. In that case with $\nu = 1$, the optimal transfer program should consist in a guaranteed income level with a modest tax rate for the first few thousands dollars of earned income (tax rate around 10% for the first $4,000 earned). The transfer income should then be taxed at fairly high rates further up the income distribution (tax rate around 60% from $4,000 to $15,000). Tax rates should then be lower (around 50%) for middle and high income earners. The size of the guaranteed income level is relatively large at $7,300. Therefore, the simulations suggest that combining a sizeable Negative Income Tax program with a tax exemption for the first five thousands dollars of annual earnings might be a desirable way to redistribute toward the disadvantaged. The guaranteed income provides income support for the really needy, and the earnings exemption does not discourage too severely work participation of people with low earnings potential.

- **Comparing Simulations to the Current Transfer System**

[18]This illustrates the well known difficulty to perform out of sample predictions using empirical estimates that are in principle valid only in the sample.

The model used in the paper is of course a crude approximation to the actual economic situation and therefore simulations should be regarded as illustrative only. It is nonetheless interesting to speculate what type of elasticity and redistributive parameters could justify the current structure of the U.S. transfer program policy. The current U.S. system applies very different tax schedules depending on the family status of the households. Two parents low income families are not in general eligible for welfare programs and thus can only collect EITC benefits implying that they face negative marginal rates of -32% (including Social Security Employee Payroll Taxes) over the first $10,000 dollars of household earnings and tax rates around 30% on the next $10,000 of earnings. However, the husband in a two parent family almost always work, thus the EITC is rarely effective in encouraging work participation for those families. As argued by Eissa and Hoynes (1998), the EITC program might well discourage female labor participation because of the extra tax rate in the phasing-out region.

Single parent families are also entitled to TANF and Food Stamps which are NIT type programs. This programs provide a basic support (around $10,000 but which large variations across states). The sum of Individual income taxation, EITC, TANF and food stamps generates tax rates around 20% for the first $9,000 of earnings but much higher rates, around 70%, for the next $9,000 of earnings. As discussed above, most estimates suggest that participation elasticities for these group are large (in excess of 0.5). It is striking to see how close this schedule is to our benchmark simulation result ($\eta = 0.5$, $\epsilon_H = \epsilon_L = 0.25$, and $\nu = 1$).

Finally, families or individuals with no children are entitled to very little benefits. This is a well-known gap in the U.S. welfare structure that is not justified in the type of model we have considered. Therefore, the current welfare U.S. comes fairly close to our simulation results only for single parents families. This group, however, represents a large fraction of the population in need of income support.

The logic of the U.S. transfer system is often explained as follows. The government provides NIT income transfers programs to those who cannot work such as the disabled with Disability Insurance, the old with Supplemental Security Income, and single mothers with TANF. The rest of the population is considered as able to work and is helped mostly with the EITC if they do work and support children. This coarse rule for redistribution can be justified theoretically if those deemed not able to work are indeed unresponsive to incentives, in which case a guaranteed income with a 100% rate is optimal. However, numerous empirical studies have suggested that labor supply in these groups is responsive to incentive. An EITC for those who can work is justified is they respond mostly through the extensive margin and if the "lazy" non-workers have low marginal social weights.

5 Conclusion

This paper has shown that the nature of labor supply responses to taxes and transfers is critical to design optimal income transfer programs. If the behavioral response is mainly along the intensive margin then the optimal program is a classical Negative Income Tax program with a large guaranteed income level which is taxed away at high rates. However, if the behavioral response is concentrated along the extensive or labor force participation margin then the optimal program is an Earned Income Credit with a smaller guaranteed income level and transfers that *increase* with earnings at low income levels. Formulas for optimal tax rates have been derived in terms of the behavioral elasticities and the redistributive tastes of the government.

The main lesson from the numerical simulations is that the optimal program is fairly sensitive to the size of the participation elasticity. When the participation elasticity is zero, the optimal program is a large Negative Income Program with a guaranteed income in excess of $10,000 and a high phasing-out rate (around 70%). However, if the participation elasticity is substantial, then the guaranteed income level should be lower but the first $5,000 to $7,000 should be exempted from taxation (or even slightly subsidized). The guaranteed income should then be taxed at a fairly high rate for incomes between $6,000 and $15,000. It is therefore critical to distinguish carefully participation and intensive elasticities in empirical studies. If the participation elasticity is large, then very strong redistributive tastes are needed to obtain an optimal guaranteed income level above the poverty level. The combined EITC and welfare U.S. system for single mothers is close to our optimal simulated schedules if, as evidenced by empirical studies, participation elasticities are substantial.

The present model could be extended in three directions. First, the paper considered a model of individual labor supply decisions. An important feature that is missing is the secondary earner labor supply decision. There is ample empirical evidence that the labor participation decision of wives is very elastic. This suggests that a tax on total household earnings as in the U.S. might be inefficient. At the same time, a tax on individuals, as in the U.K., is more efficient but also less equitable because total household income is a better indicator of well-being than individual income. The secondary earner problem raises an interesting and difficult optimal income tax problem which could be tackled using the methods developed in this paper. Note also that participation elasticities is likely to be correlated with fixed costs of work. As a result, single headed families with young kids for example are more likely to be very elastic on the participation margin and should be encouraged to work through EIC type programs.

Second, there is evidence in the labor literature that long term unemployment experiences may have an adverse effect on human capital and thus on subsequent wages. This problem is especially acute in Europe. This extra cost of unemployment has not been taken into account in the present paper. Plausibly, if this extra cost is high, then the optimal policy should be tilted even more toward EIC type programs and away from NIT programs. An important element to consider when designing the optimal policy in this case is whether individuals fully internalize the extra cost of unemployment.

Third, using empirical elasticities, it would be interesting to infer the social weights g_i that make the actual US tax and transfer system optimal. Even if the government does not explicitly maximize welfare, it may be interesting to know what are the implicit weights that the government is using. For example, if some of the weights appear to be negative then the tax schedule is not second-best Pareto efficient.[19]

Last, this study has been carried out in a timeless economy and has ignored the important question of the time period on which tax liability is computed. This implicit time period obviously affects the relative scope of extensive versus intensive margin. If the time period is a lifetime, then, as almost every person does some work over his lifetime, the extensive margin becomes irrelevant and the behavioral responses are necessarily intensive. On the other hand, if the time period is very short, such as a day or an hour, the extensive margin becomes prominent. Therefore, introducing time raises the important but difficult question on the optimal period that should be taken into account to compute tax liability. Relatively little work has been done

[19] This analysis has een used frequently in the commodity taxation literature where it is known as the inverse optimum pro lem (Ahmad and Stern (1984)) ut has never een applied to the transfer program pro lem.

on this subject.[20] It might be the case that the time dimension for assessing optimal tax and transfers programs is important and that applying EIC programs on a monthly or quarterly basis could be more effective than an annual basis. This largely under-explored issue is left for future research.

[20]Vickrey is the economist who has studied the issue the most carefully. He advocated a system of life-time taxation (see Vickrey (1947)).

Appendix

- **Formal Model**

Individuals are indexed by $m \in M$ being a (possibly multi-dimensional) set of measure one. The measure of individuals on M is denoted by $d\nu(m)$. Individual $m \in M$ has a utility function $u^m(c_i, i)$ defined on after-tax income $c_i \geq 0$ and job choice $i = 0, .., I$. Each individual chooses i to maximize $u^m(c_i, i)$ where $c_i = w_i - T_i$ is the after-tax reward in occupation i. The labor supply decision of individual m is denoted by $i^* \in \{0, 1, .., I\}$. For a given tax and transfer schedule $(c_0, .., c_I)$, the set M is partitioned into $I + 1$ subsets, $M_0, .., M_I$, defining the sets of individuals choosing each of the occupations $0, .., I$. The fraction of individuals choosing occupation i, denoted by $h_i(c_0, .., c_I)$ is simply the measure of set M_i. It is assumed that the tastes for work embodied in the individual utilities are regularly distributed so that the aggregate functions h_i are differentiable.

The government chooses $(T_0, .., T_I)$ so as to maximize welfare

$$W = \int_M \mu^m u^m(w_{i^*} - T_{i^*}, i^*) d\nu(m)$$

where μ^m are positive weights and subject to the budget constraint (1). I denote by p the multiplier of this constraint. Even though the population is potentially very heterogeneous, as possible work outcomes are in finite number, the maximization problem is a simple finite dimensional problem. The first order condition with respect to T_i is

$$-\int_{M_i} \mu^m \frac{\partial u^m(c_{i^*}, i^*)}{\partial c_i} d\nu(m) + p \left[h_i - \sum_{j=0}^{I} T_j \frac{\partial h_j}{\partial c_i} \right] = 0. \qquad (10)$$

When obtaining (10), it is important to note that, because of the envelope theorem, the effect of a change in c_i has no first order effect on welfare for individuals moving in or out of occupation i and therefore there is no need to take into account, in the first term of (10), the effect of a change of c_i on the set M_i. I define the marginal social welfare weight for occupation i as

$$g_i = \frac{1}{p\, h_i} \int_{M_i} \mu^m \frac{\partial u^m(c_{i^*}, i^*)}{\partial c_i} d\nu(m). \qquad (11)$$

As explained in the text, this weight represents the dollar equivalent value for the government of distributing an extra dollar uniformly to individuals working in occupation i. Obviously, the weights g_i vary with the tax schedule $(c_0, .., c_I)$. In welfare economics, the primitive parameters are the utility functions u^m and weights μ^m, which generate an endogenous set of marginal weights $g_i(c_0, .., c_I)$. However, the weights g_i have a direct and more transparent interpretation than the primitive weights μ^m. That is why, in the simulations and as discussed in the text, we calibrate directly the weights functions as $g_i = g(c_i)/p$ without specifying the primitive weights μ^m. Obviously, it would be possible in each case to find a set of weights μ^m that generate weights g_i equal to the calibrated weights $g(c_i)/p$ at the optimum schedule. Using definition (11), the first order condition (10) can be rewritten as,

$$(1 - g_i)h_i = \sum_{j=0}^{I} T_j \frac{\partial h_j}{\partial c_i}. \tag{12}$$

With no income effects, $h_j(c_0 + R, .., c_I + R) = h_j(c_0, .., c_I)$, thus $\sum_i \partial h_j / \partial c_i = 0$, and therefore, summing equation (12) over all $i = 0, .., I$, one obtains equation (2).

- **The Extensive Model**

Within the general framework developed above, the extensive model can be obtained by assuming that each individual can only work in one occupation or be unemployed. This can be embodied in the individual utility functions by assuming that $u^m(c_j, j) = -\infty$ for all occupations except the one corresponding to the skill of the individual. This structure implies that the function h_i depends only on c_0 and c_i for $i > 0$. As a result, and using the fact that $\partial h_i / \partial c_i + \partial h_0 / \partial c_i = 0$, equation (12) becomes,

$$(1 - g_i)h_i = T_i \frac{\partial h_i}{\partial c_i} + T_0 \frac{\partial h_0}{\partial c_i} = (T_i - T_0) \frac{\partial h_i}{\partial c_i}.$$

Using the definition (3) of η_i, one immediately obtains (4) in Proposition 1.

- **The Intensive Model**

The intensive model can be obtained by assuming that each individual can only work in two adjacent occupations i and $i+1$ for a given i embodied in the individual utility u^m. This implies that the function h_i depends only on c_{i+1}, c_i, and c_{i-1}. Assuming no income effects, with a slight abuse of notation, h_i can be expressed as $h_i(c_{i+1} - c_i, c_i - c_{i-1})$. In that context, equation

(12) becomes,

$$(1-g_i)h_i = -T_{i+1}\frac{\partial h_{i+1}}{\partial(c_{i+1}-c_i)} - T_i\frac{\partial h_i}{\partial(c_{i+1}-c_i)} + T_i\frac{\partial h_i}{\partial(c_i-c_{i-1})} + T_{i-1}\frac{\partial h_{i-1}}{\partial(c_i-c_{i-1})}.$$

Using the fact that $\partial h_{i+1}/\partial(c_{i+1}-c_i) = -\partial h_i/\partial(c_{i+1}-c_i)$ and rearranging, we obtain

$$(1-g_i)h_i = -(T_{i+1}-T_i)\frac{\partial h_{i+1}}{\partial(c_{i+1}-c_i)} + (T_i-T_{i-1})\frac{\partial h_i}{\partial(c_i-c_{i-1})}.$$

Using the definition (5) of ζ_i, summing this equation over $i, i+1, .., I$, one obtains (6) in Proposition 2.

- **Optimal Tax Formula in the General Model**

The optimal tax formula can be derived as in Section 3.3 by considering a small change dT in the tax rates for jobs $i, i+1, .., I$: $dT_i = dT_{i+1} = .. = dT_I = dT$. This tax change raises $[h_i + h_{i+1} + .. + h_I]dT$ additional taxes through the mechanical effect which are valued $[(1-g_i)h_i + (1-g_{i+1})h_{i+1} + .. + (1-g_I)h_I]dT$ by the government.

As in Section 3.3, this tax change decreases $c_i - c_{i-1}$ by dT and leaves unchanged all the other differences $c_j - c_{j-1}$ which induces $dh_i = -h_i\zeta_i dT/(c_i - c_{i-1})$ individuals in job i to switch to job $i-1$ reducing tax revenue by $(T_i - T_{i-1})dh_i = -(T_i - T_{i-1})h_i\zeta_i dT/(c_i - c_{i-1})$.

This tax change also changes all the differences $c_j - c_0$ for $j \geq i$ and thus induce a number $-h_j\eta_j dT/(c_j - c_0)$ of individuals in each occupation $j \geq i$ to become unemployed. Therefore the total behavioral cost due to movements in and out unemployment is equal to $-dT\sum_{j\geq i}(T_j - T_0)h_j\eta_j/(c_j - c_0)$. At the optimum, the sum of these effects is zero, implying equation (8) in the text.

- **Relating ζ_i and ε_i**

Consider as seen in Section 3.3, a small change dT in all tax levels T_j for $j \geq i$. By definition of the implicit marginal tax rate τ_i, this tax change is equivalent to a change in the marginal rate τ_i equal to $d\tau_i/(1-\tau_i) = dT/(c_i - c_{i-1})$.

Using the mobility elasticity ζ_i, this small tax change induces a loss in tax revenue equal to,

$$-(T_i - T_{i-1})h_i\zeta_i\frac{dT}{c_i - c_{i-1}} = -\tau_i h_i(w_i - w_{i-1})\zeta_i\frac{d\tau_i}{1-\tau_i}. \tag{13}$$

In the classic labor supply supply model, by definition of the earnings elasticity ε_i, this tax change reduces earnings of the individuals with income w_i by $dw = -\varepsilon_i w_i d\tau_i/(1-\tau_i)$. As there are h_i individuals with income w_i, the total effect on tax revenue is equal to $\tau_i h_i dw$ which can be written as,

$$-\tau_i w_i h_i \varepsilon_i \frac{d\tau_i}{1-\tau_i}. \tag{14}$$

Therefore, comparing (13) and (14), we see that the two models produce the same behavioral response when $\zeta_i(w_i - w_{i-1}) = \varepsilon_i w_i$.

- **Numerical Simulations**

The numerical simulations are performed using the empirical earnings distribution. The data used to calibrate the earnings distribution is annual individual earnings data from the March 1997 Current Population Survey. The simulations are performed using the discrete model of Section 3.3. Therefore, the empirical earnings distribution is approximated using a discrete grid. The vector of discrete values for earnings levels is reported in Table A1. The vector of density weights h_i^0 estimated using data on the empirical distribution is also reported in Table A1. The non labor force participation rate is equal to 15%.

The system consists in $I+2$ simultaneously equations (2), (1), (8) for $i = 1, .., I$. The welfare weights are $g_i = 1/(p \cdot c_i^\nu)$ where p is the marginal value of public funds and ν is the redistributive tastes parameter. There are $I+2$ unknowns, the tax levels T_i for $i = 0, 1, .., I$ and the marginal value of public funds p. The system has $I+2$ equations and $I+2$ unknowns and thus yields in practice a unique solution.

The main complication of simulations comes from the endogeneity of the density weights h_i. The density weights h_i are endogenous because the distribution of earnings and the unemployment level are affected by taxes and transfers. Formally, Section 3.3 has shown that the functional form of the density weights is $h_i(c_i - c_0, c_{i+1} - c_i, c_i - c_{i+1})$. In principle, the weights h_i should satisfy two conditions. First, the functional form of the weights h_i should be chosen so as to be compatible with the structure of behavioral elasticities η_i and ζ_i defined in equations (3), and (5)). Second, the weights h_i should coincide with the empirical weights h_i^0 when the tax schedule $(T_i, i = 0, 1, .., I)$ is equal to the actual schedule $(T_i^0, i = 0, 1, .., I)$.

However, it is impossible to find functions $h_i(c_i - c_0, c_{i+1} - c_i, c_i - c_{i+1})$ that satisfy equations (3), and (5) for constant elasticities η_i, ζ_i and δ_i for all possible values of c_0 and $c_i, i = 0, 1, .., I$. Therefore, in the simulations, I ignore the effect of the intensive behavioral response on h_i. The density weights are taken as,

$$h_i = h_i^0 \cdot \left(\frac{c_i - c_0}{c_i^0 - c_0^0} \right)^{\eta_i},$$

where $c_i^0, I = 0, 1, .., I$ is the actual after-tax schedule. The schedule c_i^0 used in simulations is a very simplified approximation of the real schedule. The real schedule is approximated with a linear tax schedule with constant tax rate of 40% and a guaranteed income $c_0^0 = \$6,000$. Sensitivity analysis shows that the optimal schedules are not significantly affected when other assumptions for the actual schedule c_i^0 are made.

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FIGURE 1

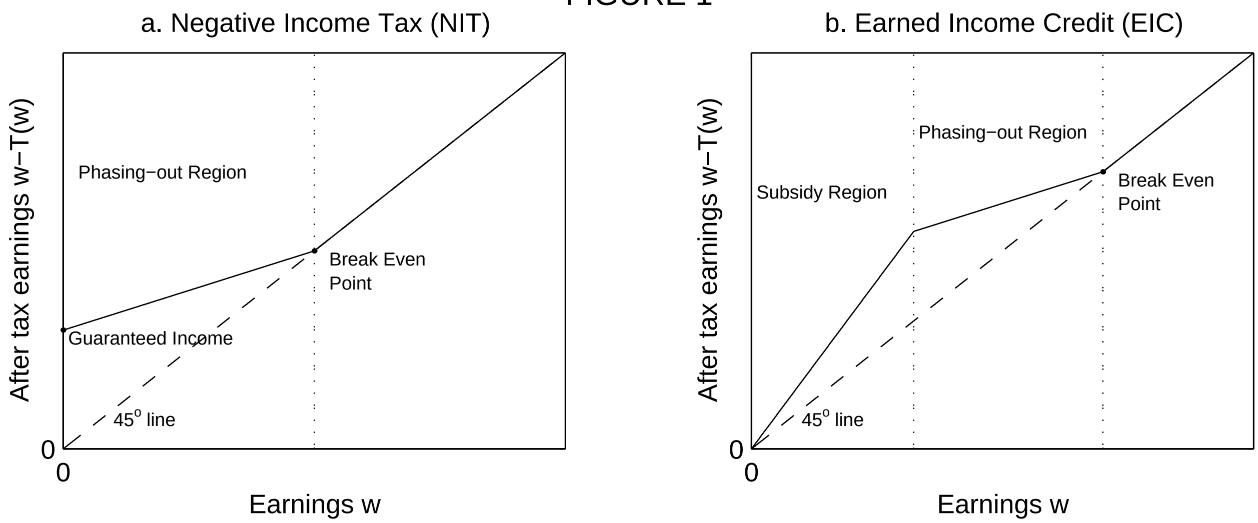
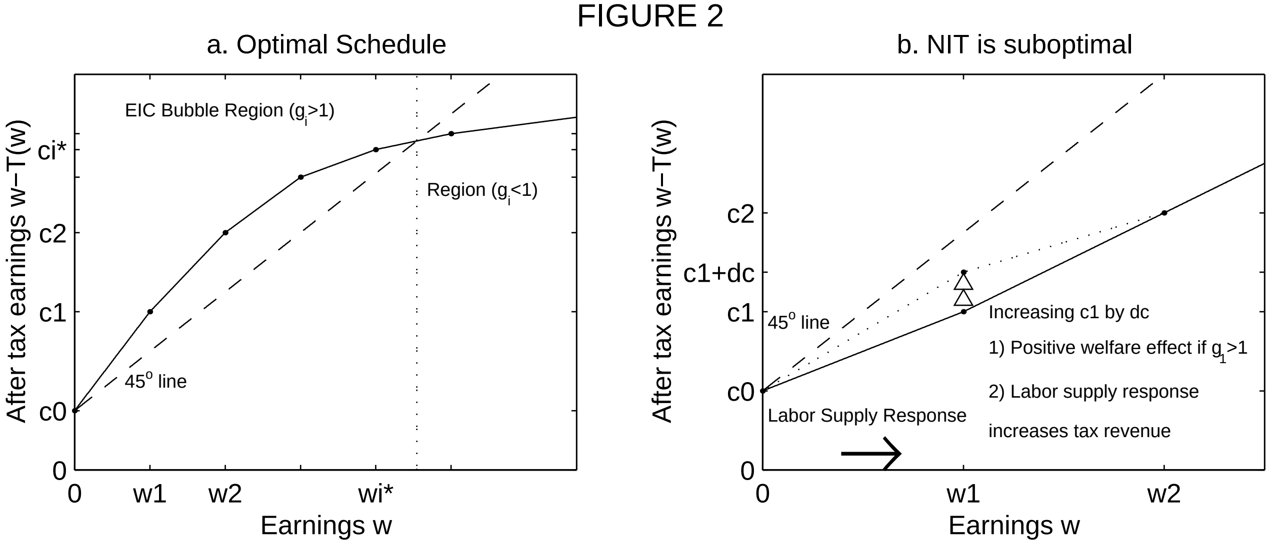

a. Negative Income Tax (NIT)
After tax earnings w−T(w)
Phasing−out Region
Break Even
Point
Guaranteed Income
45^{o} line
0
0
Earnings w
b. Earned Income Credit (EIC)
After tax earnings w−T(w)
Phasing−out Region
Subsidy Region
Break Even
Point
45^{o} line
0
0
Earnings w

FIGURE 2



a. Optimal Schedule
EIC Bubble Region (g_i>1)
Region (g_i<1)
45° line
After tax earnings w−T(w)
ci*
c2
c1
c0
0
0
w1
w2
wi*
Earnings w
b. NIT is suboptimal
After tax earnings w−T(w)
c2
c1+dc
c1
c0
0
45° line
Increasing c1 by dc
1) Positive welfare effect if g_1>1
2) Labor supply response
increases tax revenue
Labor Supply Response
0
w1
w2
Earnings w

FIGURE 3

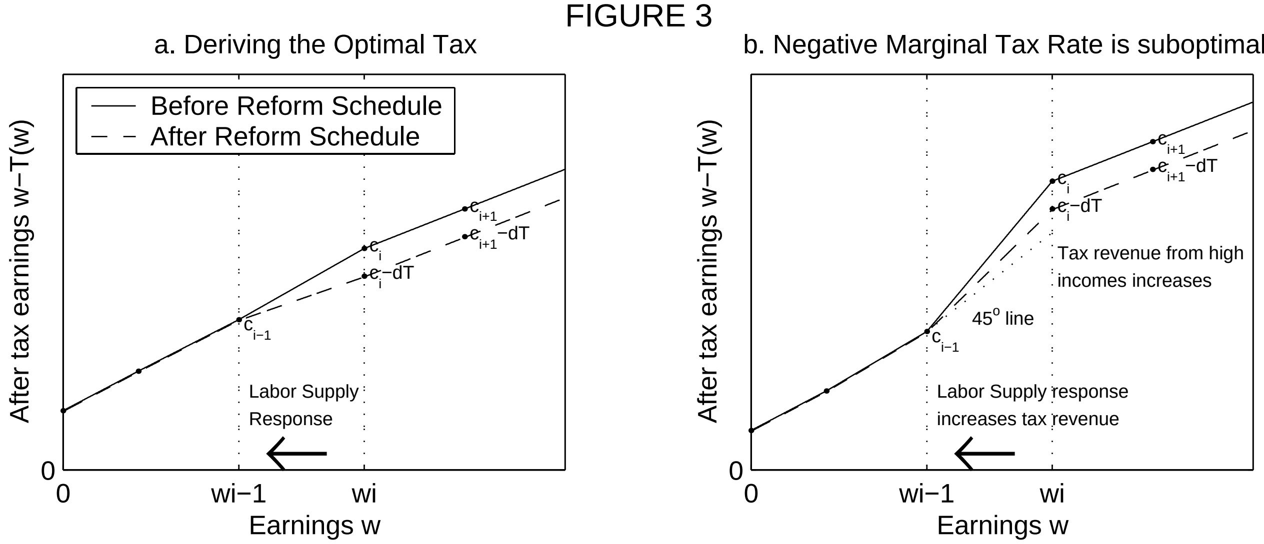

a. Deriving the Optimal Tax
Before Reform Schedule
After Reform Schedule
After tax earnings w−T(w)
Earnings w
0
wi−1
wi
c_{i+1}
c_{i+1}−dT
c_i
c_i−dT
c_{i−1}
Labor Supply
Response
b. Negative Marginal Tax Rate is suboptimal
Tax revenue from high
incomes increases
45° line
Labor Supply response
increases tax revenue

FIGURE 4: Extensive versus Intensive Responses

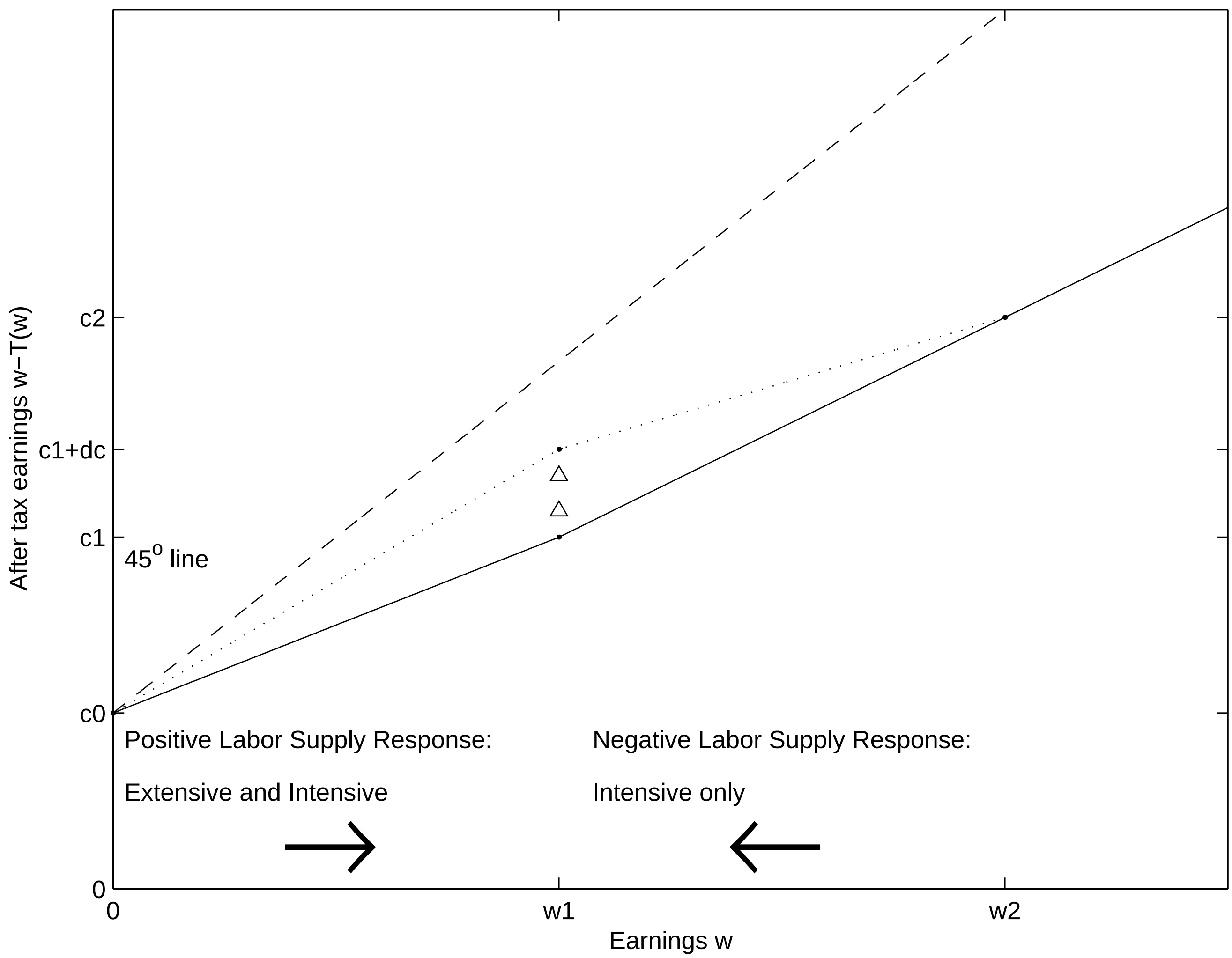


FIGURE 5. Optimal Tax Schedules

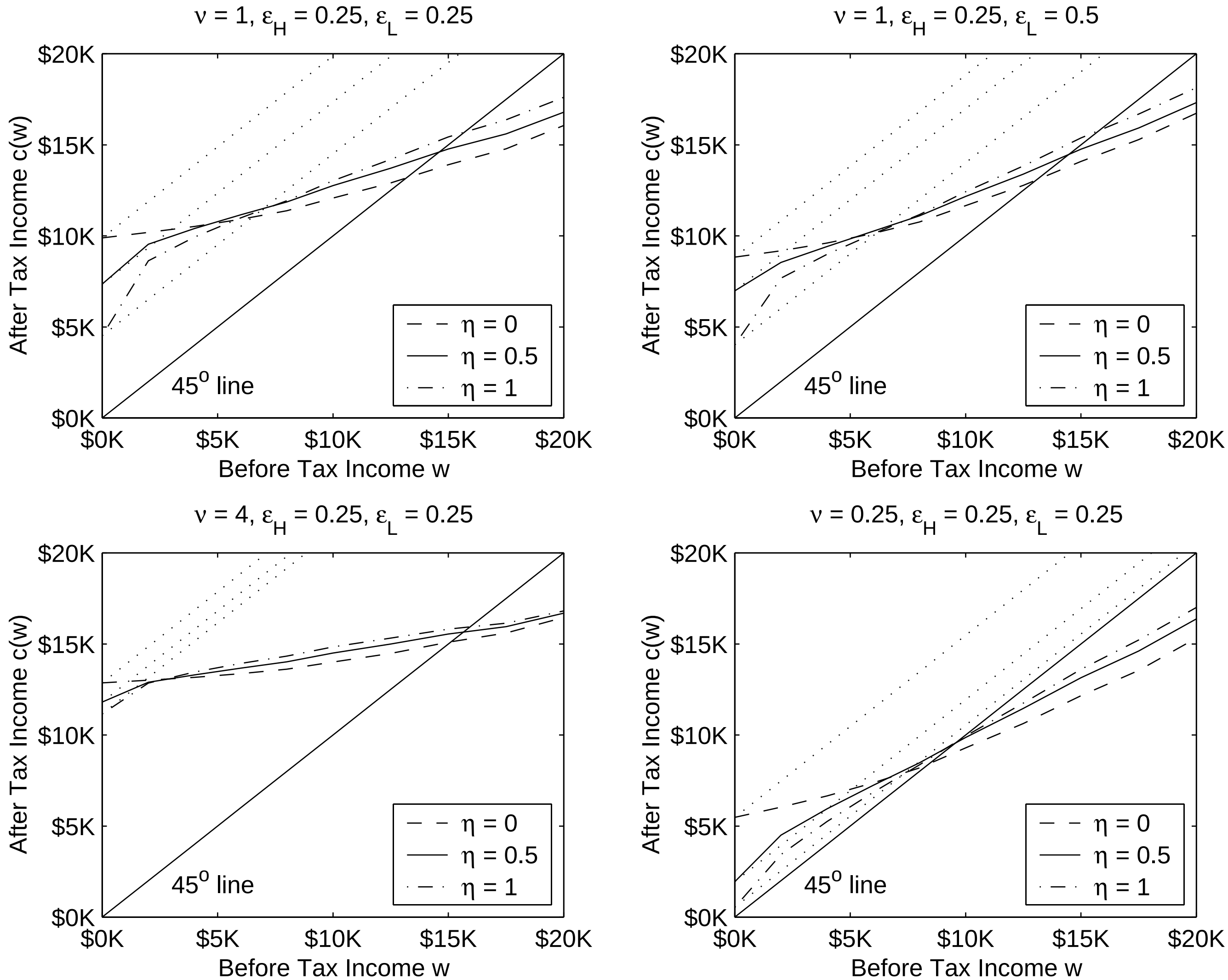


Table 1: Numerical Simulations with redistributive tastes parameter ν = 1.

	Middle-High Income Elasticity $\varepsilon_H = 0.25$						Middle-High Income Elasticity $\varepsilon_H = 0.5$					
	Guaranteed Income Level	Average M.T.Rate \$0-\$6K	Average M.T.Rate \$6K-\$15K	Break-Even Point	Average M.T.Rate \$30K+	Unemployment rate	Guaranteed Income Level	Average M.T.Rate \$0-\$6K	Average M.T.Rate \$6K-\$15K	Break-Even Point	Average M.T.Rate \$30K+	Unemployment rate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Low Income Participation Elasticity η												
PANEL A: Intensive Elasticity for low incomes e_L = 0												
η = 0	$11,600	82	90	$14,100	42	15.6	$10,500	85	92	$10,700	31	15.7
η = 0.5	$7,700	7	84	$12,900	46	11.8	$6,900	15	87	$14,600	34	13.5
η = 1	$5,400	-23	71	$17,000	48	2.6	$4,300	-23	76	$13,800	35	2.9
PANEL B: Intensive Elasticity for low incomes e_L = 0.25												
η = 0	$9,900	83	67	$14,300	46	15.2	$8,800	85	69	$11,400	34	15.3
η = 0.5	$7,300	37	60	$12,900	49	13.8	$6,500	42	64	$10,300	36	14.2
η = 1	$4,500	-8	51	$16,800	50	2.5	$3,500	-7	55	$14,400	37	2.8
PANEL C: Intensive Elasticity for low incomes e_L = 0.5												
η = 0	$8,800	78	56	$14,400	48	15.0	$7,800	80	59	$11,800	35	15.0
η = 0.5	$7,000	45	50	$13,000	51	13.9	$6,200	51	54	$10,900	38	14.0
η = 1	$4,000	-2	42	$16,700	51	2.3	$3,000	0	45	$10,100	38	2.5

Notes: Simulations performed using redistributive taste parameter ν=1. No income effects included.

Table 2: Numerical Simulations with varying redistributive tastes

	Elasticity $\varepsilon_H = 0.25$, Elasticity $\varepsilon_L = 0.25$					
	Guaranteed Income Level	Average M.T.Rate \$0-\$6K	Average M.T.Rate \$6K-\$15K	Break-Even Point	Average M.T.Rate \$30K+	Unem-ployment rate
Low Income Participation Elasticity η	(1)	(2)	(3)	(4)	(5)	(6)
	PANEL A: Low Redistributive tastes parameter n = 0.25					
$\eta = 0$	\$5,500	68	47	\$9,600	27	14.6
$\eta = 0.5$	\$1,900	12	34	\$8,500	30	7.7
$\eta = 1$	\$540	-5	25	\$8,300	31	2.7
	PANEL B: Medium Redistributive tastes parameter n = 1					
$\eta = 0$	\$9,900	83	67	\$14,300	46	15.2
$\eta = 0.5$	\$7,300	37	60	\$12,900	49	13.8
$\eta = 1$	\$4,500	-8	51	\$16,800	50	2.5
	PANEL C: High Redistributive tastes parameter n = 4					
$\eta = 0$	\$12,900	92	81	\$17,400	62	16.0
$\eta = 0.5$	\$11,800	69	79	\$16,800	63	26.0
$\eta = 1$	\$11,200	54	79	\$16,600	64	27.2

Notes: Simulations performed using low income intensive elasticity $\varepsilon_L = 0.25$ and high income elasticity $\varepsilon_H = 0.25$.

Table A1: Empirical Earnings Distribution Calibration

Income Levels	Density weights (in percent)
(1)	(2)
$0	14.2
$2,000	3.3
$4,000	2.7
$6,000	2.8
$8,000	3.0
$10,000	4.8
$12,500	5.2
$15,000	6.5
$17,500	4.7
$20,000	8.2
$25,000	9.8
$30,000	16.4
$50,000	14.5
$100,000	3.9