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ABSTRACT

A large literature evaluating the welfare effects of taxation has examined the role of the labor supply elasticity, and has shown that the estimated welfare effects are highly sensitive to its size. A common feature of this literature is its exclusive focus on hours worked and the associated marginal tax rate. An emerging consensus among public finance and labor economists, however, is that labor supply is more responsive along the extensive margin (participation) than along the intensive margin (hours worked). To understand the implications of the participation decision for the welfare analysis of tax reform, this paper embeds the extensive margin in an explicit welfare theoretic framework. It is shown that the participation effect on welfare is created by a different tax wedge than the marginal-tax wedge relevant for hours of work. This difference is due to non-linearities and discontinuities in tax-transfer schemes, features that are particularly important for the welfare evaluation of tax reforms affecting the bottom of the income distribution. We apply our framework to examine the labor supply and welfare effects for single mothers in the United States following four tax acts passed in 1986, 1990, 1993, and 2001. Our simulations show that each of the four tax acts reduced the tax burden on low-income single mothers, and created substantial welfare gains. We note three features of the welfare effects. First, we find that welfare gains are almost exclusively concentrated along the extensive margin of labor supply. Second, welfare effects along the extensive margin tend to dominate those along the intensive margin, even when the two labor supply elasticities are of similar size. This occurs because the welfare effect on each margin is created by a different tax wedge. Finally, ignoring the composition of the labor supply elasticity may reverse the sign of the welfare effect. In the welfare evaluation of tax reform, we conclude that the *composition* of the total labor supply elasticity is as important as its size.

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1 Introduction

The last two decades represent an unusually active period in the modern history of the United States tax system. A series of tax acts – passed in 1981, 1986, 1990, 1993, 2001 and 2003 – has dramatically changed the federal income tax code. These tax acts differed substantially in their scope and coverage, but all had important effects on the tax liabilities and incentives faced by taxpayers. The Tax Reform Act of 1986 (TRA86) represented the most fundamental change in the income tax system in nearly 40 years, and changed not only the rate schedule but also the basic definition of the tax base. By design, it had its largest effect on the highest income taxpayers, but TRA86 also included substantial benefits for lower-income taxpayers through lower marginal rates, increased personal exemptions and standard deduction. The Omnibus Budget Reconciliation Acts of 1990 and 1993, on the other hand, raised tax rates at the top of the income distribution and included even more significant benefits for lower income families by way of unprecedented expansions in tax-based transfers, but left untouched other elements of the tax code.

The primary effect of these tax changes for lower-income taxpayers has been to reduce tax liabilities. While lower tax burdens are the result of a combination of provisions, a central reason is the expansion of the Earned Income Tax Credit (EITC). A relatively modest program until 1986, the EITC has since evolved into the single largest cash transfer program for lower-income families at the federal level. In fact, the EITC now implies negative tax liabilities on labor income (including all federal, state, and social security taxes) for almost two-thirds of the population of single mothers.

This paper evaluates the welfare effects on single mothers from the tax acts passed in 1986, 1990, 1993, and 2001. We take note of recent empirical evidence that suggests strong labor force participation responses to the expansions of the EITC by female household heads. Of particular interest is the observation that these participation responses have not been matched on the hours-worked margin, even though incentives were substantial (Eissa and Liebman, 1996, Meyer and Rosenbaum, 2001). These empirical results are consistent with evidence from the earlier Negative Income Tax Experiments, where participation responses were found to be slightly larger than hours-worked responses for both single female heads and married women (Robins, 1985). The new findings are also consistent with indirect evidence showing larger estimated elasticities for *all* than for *working* married women (Mroz 1987, Triest 1990).

Recent work on optimal income taxation has shown that the policy recommendations change once participation responses are explicitly introduced (Saez, 2002). More precisely, it may be optimal to impose negative marginal tax rates at the bottom of the earnings distribution, similar to an EITC. By contrast, an EITC would be inefficient in a standard model with only intensive responses. These results on optimal taxation indicate that a correct modelling of labor supply behavior will also be important for tax reform analysis.

Our paper examines the impact of participation responses on the welfare evaluation of tax reforms. We set up a welfare theoretic framework accounting for labor supply responses along both the extensive (participation) and intensive (hours worked) margins. We model labor supply in a manner consistent with the empirical distribution of hours worked showing very few workers at low annual or weekly hours of work. To generate labor supply responses consistent with such a distribution, we drop the standard convex framework which imply that small increases in after-tax wages induce entry at infinitesimal hours of work. Our framework allows for discrete labor market entry by way of non-convexities in preferences and budget sets created by costs of work (as in Cogan, 1981; Heim and Meyer, 2004). We show that such non-convexities allow first-order welfare effects along the extensive margin. By contrast, with convex preferences and budget sets, small tax changes entail no first-order welfare effects along the extensive margin.

Our theoretical framework identifies parameters that are important for evaluating the welfare effects of tax reform. More precisely, welfare effects are shown to depend on labor supply elasticities along the intensive and the extensive margins; on the initial tax-benefit position of each individual; and on the reform-induced changes in tax rates. The distinction between the two margins of labor supply is crucial, because they imply distinctly different tax wedges. As in traditional analysis, the welfare effect on the intensive margin is related to the effective marginal tax rate on labor income (including the marginal phase-out rate applied to any benefits). On the other hand, the effect on the extensive margin is related to the effective average tax rate on labor income (including the average reduction rate on benefits). Our results show that conflating these two tax wedges in the welfare analysis can be fundamentally misleading. The reason is simple and intuitive. Features such as the EITC, TANF and Medicaid create significant non-linearities and discontinuities in the tax-transfer schedules and in turn lead to substantially different tax rates on participation than on hours worked, both in levels and in changes over time.

Our simulations account for all relevant changes to the federal income tax code introduced by the four tax acts. We therefore analyze more than just the EITC, although it does turn out to be the most important component for the population of interest. The tax simulations are based on Current Population Survey (CPS) data for the baseline years of each of the four reforms and NBER's TAXSIM model. Because of the central role of the public assistance system, we construct a benefit calculator that incorporates cash assistance as well as Food Stamps and Medicaid. We combine tax data from the NBER's TAXSIM model with our benefits data to characterize as precisely as possible the extensive and intensive tax wedges for each individual in the sample.

Based on a broad range of realistic labor supply elasticities, we find that all four tax reforms created substantial welfare gains for the population of single mothers. The effects are largest for the 1986 reform, both in terms of the total welfare gain as well as the gain per dollar spent. For all four reforms, we show that most of the welfare gains are generated along the extensive labor supply margin. For both the 1990 and the 1993 tax acts, these gains dominate welfare losses created by hours-of-work responses.

Consistent with empirical evidence, most scenarios assume that the participation elasticity is larger than the hours-of-work elasticity. However, this assumption does not drive our finding that the extensive responses account for most of the welfare gains. Even with identical elasticities, the welfare effects created along the extensive margin tend to dominate, especially for the 1990 and 1993 reforms. This occurs because non-linearities and discontinuities in the tax schedule create different distortions along the participation and hours margins, and because the tax acts had a stronger effect on the average tax rate (for example, -12.8 percent in 1993) than the marginal tax rate (-3.6 percent). These features of the tax schedule render the composition of the total labor supply elasticity a crucial element for the welfare evaluation of tax reform. In fact, we find that conflating the participation and hours elasticities may lead to the wrong sign on the welfare effect. The composition of the labor supply elasticity may then be more important than its size.

Our paper contributes to the large numerical literature on tax reform and the welfare costs of taxation, including those based on Computable General Equilibrium models (Ballard *et. al.*, 1985; Ballard, 1988), micro-simulation (Browning and Johnson, 1984; Triest 1994) as well as simple deadweight-loss calculations (Browning, 1987, 1995). A common feature of this literature is the assumption of a standard convex labor supply model, ruling out (discrete) participation responses. In addition to a more realistic model of labor supply behavior, we deviate from this literature by simulating the effects of *actual* rather than *hypothetical* reforms.

The organization of the paper is as follows. The next section describes some of the major changes in tax laws during the past two decades and reviews the empirical labor supply literature studying the impact of tax reforms. Section 3 presents a welfare theoretic framework that distinguishes explicitly between the intensive and extensive margins of labor supply response. Section 4 applies the theory to data from the Current Population Survey, and evaluates the welfare implications from the changes in the tax treatment of single mothers. Section 5 concludes.

2 Background

2.1 Two Decades of US Tax Reform

A worker filing a head of household tax return in 2004 would face a federal income tax schedule with six brackets, with rates ranging from 10 to 35 percent. These rates are applied to taxable income, the difference between gross income and deductions and exemptions. Her earnings would therefore be shielded from taxes by the standard deduction ($7,150) and by the personal exemption ($3,100 per person). If the taxpayer has two children, she would pay 10 percent in federal income taxes on earnings above $16,450. She would face either no state income tax (in Florida or Texas) or as much as a 5 percent state income tax (in Massachusetts or Oregon). Additionally, this taxpayer would also have paid payroll taxes of 7.65 percent on her first dollar of earnings.

A head-of-household tax filer could also be eligible for the earned income tax credit (EITC). To be eligible, her Adjusted Gross Income (AGI) must fall below some limit ($33,692 if she has more than one child). The size of the credit depends on the amount of earned income and the number of qualifying children who meet certain age, relationship and residency tests. Children must be under age 19 – or 24 if a full-time student – or permanently disabled and must reside with the taxpayer for more than half the year. Three regions in the credit schedule determine the size of the credit. The initial phase-in region transfers an amount equal to the subsidy rate (40 percent) times earnings. Over a range of earned income, she continues to receive the maximum credit ($4,204), after which the credit is phased out at a set rate (21 percent). The credit is refundable, so this taxpayer would receive the full amount of the credit if she had no federal tax liability.

Twenty years earlier, this taxpayer would have faced a very different tax scheme, with a much smaller EITC and 15 brackets – ranging from zero to 50 percent. A series of tax acts passed in the United States since the 1980's substantially changed the federal income tax structure and federal income tax liabilities. The 1986, 1990, 1993 and 2001 tax acts resulted in substantial changes to the tax liabilities of single women with children. With both the Tax Reform Act of 1986 and the Omnibus Budget Reconciliation Acts of 1990 and 1993, tax liabilities were changed primarily through expansions of the EITC – a refundable tax credit for low-income households with children. The 2001 tax act, on the other hand, did not affect the credit for single parents, but rather reduced the rates on the lowest income tax bracket and increased the size of tax credits. To outline the major features of the tax changes, Table 1 presents federal income tax parameters from 1984 to 2002. The table highlights the continuous and dramatic changes to the federal income tax schedule over the period. Tax liabilities are altered both because of changes to the rate schedule and to basic deductions and exemptions. Tax liabilities are also altered by tax credits. In that vein, the table also highlights the central role of the Earned Income Tax Credit in altering tax liability as well as the shape of the tax schedule for our population of interest, female household heads.

The 1986 expansion of the EITC, passed as part of the Tax Reform Act of 1986 (TRA86), increased the subsidy rate for the phase-in of the credit from 11 percent to 14 percent and increased the maximum income to which the subsidy rate was applied from $5,000 to $6,080. This resulted in an increase in the maximum credit from $550 to $851. The phase-out rate was reduced from 12.2 percent to 10 percent. The higher maximum credit and the lower phase-out rate combined to increase the upper limit in the phase-out region from $11,000 in 1986 to $18,576 by 1988.

The impact of the EITC expansion on the tax liability of eligible taxpayers was reinforced by other elements of TRA86. TRA86 increased the standard deduction for a taxpayer filing as head of household from $2480 in 1986 (included in the zero bracket) to $4400 in 1988. TRA86 further reduced the tax liability of taxpayers with children by increasing the deduction per dependent exemption from \$1080 in 1986 to \$1950 in 1988. Finally, the tax schedules were changed. The tax schedule changes were particularly beneficial to head of household filers because the increased standard deduction and exemption amounts meant that in 1988 the typical head-of-household did not jump from the 15 to the 28 percent tax bracket until her AGI exceeded \$33,565.

The Omnibus Budget Reconciliation Act of 1990 (OBRA90) further expanded the EITC for all eligible families, and introduced a different EITC schedule for families with two or more children. The phase-in rate of the EITC was increased from 14 percent to 18.5 for taxpayers with one-child and 19.5 percent for taxpayers with more children. OBRA90 also increased the maximum benefit, phased in over three years.

The largest single expansion of the EITC was contained in the budget reconciliation act of 1993 (OBRA93). OBRA93 further increased the additional maximum benefit for taxpayers with two or more children to \$1,400 by 1996 (\$3,556 versus \$2,152 in 1996), doubled the subsidy rate for the lowest-income recipients from 19.5 to 40 percent for larger families (18.5 to 34 percent for families with one child). These changes combined to dramatically expand eligibility for the EITC, such that by 1996 a couple with two children would still be eligible at incomes of almost \$30,000. Other than the expansions to the EITC there was little in the way of changes to the federal income tax for lower-income individuals in OBRA93.

In June 2001, Congress passed the largest and most unusual tax cut in 20 years, the Economic Growth and Tax Relief Reconciliation Act of 2001 (EGTRRA). EGTRRA cut taxes by an estimated \$1.3 trillion dollars by 2010 and then sunsets, returning rates to their pre-EGTRRA levels (an event few expect to happen). Because female household heads typically have income in the lower end of the distribution, they benefit primarily from three provisions: reduction in the lowest income tax bracket from 15 to 10 percent, revisions to the Child Tax Credit, and to the Child and Dependent Care Tax Credit. The Child Tax Credit was increased from \$500 to \$1,000, and made refundable. The Dependent Care Tax Credit was increased from \$2,400 to \$3,000 starting in 2003. These features are likely to have similar effects on tax rates and liabilities for eligible taxpayers.

On the whole, the last two decades have been especially active for the tax system in the United States. As a consequence, this period has proven especially useful for understanding better labor supply behavior. We briefly review the empirical evidence on labor supply in the next section, and then present our framework for evaluating the welfare effects of these reforms.

2.2 Empirical Evidence on Labor Supply and Tax Reforms

The labor market participation of single mothers has changed significantly in recent years. Figure I presents the employment population rate for single mothers in the United States. The increase in the participation rates during a time coincident with reductions of tax liabilities is striking and difficult to dismiss. To focus the discussion, we review evidence that has attempted to explain this massive increase in the labor market participation of single mothers. The evidence on the labor supply responsiveness of female household heads to the tax reforms in the United States has used both quasi-experimental methods (Eissa and Liebman –EL– 1996, Eissa and Hoynes –EH– 2004, Hotz, Mullin and Scholz –HMS– 2002) as well more structural methods (Dickert, Houser and Scholz –DHS– 1995 and Meyer and Rosenbaum –MR– 2001). What is notable about this work is that the findings are consistent across the different methods and different reforms evaluated.

The first set of results come from studies that use quasi-experimental methods to examine the labor supply effects of the Tax Reform Act of 1986 on female heads (EL), the 1993 EITC expansion on married women (EH) and the EITC expansions in the 1990's on welfare recipients in California (HMS).[1] EL compare the change in labor force participation and hours worked by single mothers to that of single women without children, and find a sizeable labor force participation response of 2.8 percentage points (out of a base of 74.2). Their data (the Current Population Survey) also show no discernible hours of work response. It is interesting to note that EH also find important participation effects when examining the response of married women.

Exploiting the fact that states began implementing demonstration projects that altered the work incentive of welfare eligible families, HMS evaluate labor supply responses of larger welfare families to the marginal second child credit. Using administrative data on welfare recipients in four California counties, they find a dramatic increase in the employment rate of larger families -of 6 to 8 percentage points- relative to families with one child. These findings imply a range of labor force participation elasticities with respect to the net income of working parents, with 1.7 at the high end. Overall the evidence based on the difference-in-differences model is consistent and suggests fairly strong participation effects, especially for female household heads.

[1] More detailed information on eligibility and benefits are provided in Hotz and Scholz (2003).

A second set of studies exploits individual-level variation in after-tax wages and incomes to estimate the effect of EITC expansions on labor force participation. DHS use cross-sectional data from the 1990 Survey of Income and Program Participation (SIPP) and estimate a joint program and labor force participation model, identified by variations in the returns to part-time (or full-time) employment in different states. They estimate a labor force participation elasticity of 0.35. Because these results are based on cross-sectional data, one concern is the potential bias from correlations between unobserved state characteristics and labor supply incentives. MR address this concern by using state-time variation in labor supply incentives. They carefully model the complete set of welfare and tax systems at the federal and state level, and estimate a discrete participation model based on comparisons of utility in and out of the labor force. Using data from the 1985 to 1997 CPS, they find that the EITC accounts for about 60 percent of the increase in the employment of single mothers over the period. Their implied labor force participation elasticities are within the bounds of other studies, and reasonably large (about 0.7).

We should note that two other pieces of empirical evidence suggest that recent findings regarding the participation responses to tax reforms should not be surprising. This evidence comes from the Negatives Income Tax (NIT) Experiments in the late 1970's, and from the empirical labor supply literature. The randomized experiments, offering different guarantee and tax rates, suggested stronger employment effects than hours of work effects (see the reviews by Moffitt and Kehrer, 1981 and Robins, 1985). A careful review of the empirical literature suggests as well that participation is more sensitive to taxes than is hours worked (Triest, 1990; Mroz, 1987). Both papers show that excluding non-workers from the regressions generates much smaller labor supply elasticities than do regressions where non-workers are included, the suggestion being that it is the participation margin that is sensitive to the net-of-tax wage.[2]

Overall, the empirical evidence strongly suggests that the labor market entry decision is sensitive to taxes, and in fact much more sensitive than are hours worked. For single mothers, the empirical studies have found extensive margin responses to tax reforms which correspond to participation elasticities in the range from 0.35 to 1.7. Almost none of these studies find any significant hours of work effects.

[2] For other countries such as Canada, the United Kingdom, and France, there also exist experimental evidence on strong participation responses for single mothers (see Card and Robins, 1998; Blundell, 2001; Piketty, 1998).

3 A Framework to Evaluate Tax Reform

3.1 Welfare Analysis with Extensive Labor Supply Responses

Following Harberger (1964), several studies have attempted to measure the distortions to the labor-leisure choice induced by labor income taxes (e.g. Ballard *et al.*, 1985; Ballard, 1988; Triest, 1994; Browning, 1995). A common feature of these papers is the assumption that preferences and budget sets are convex. This assumption is problematic for two reasons. While a convex model features labor supply adjustments along both the intensive and the extensive margins, these adjustments occur in a continuous manner. Therefore, any individual entering the labor market following a small tax change will always choose to work an infinitesimal number of hours. The empirical distribution of hours worked, however, generally shows very few workers at low annual or weekly hours worked (see Figure II).

Second, the convex framework cannot provide a reasonable approximation for welfare analysis. To see the point, consider a standard labor supply model where individuals have identical preferences but heterogeneous productivities distributed continuously on an interval (such as Mirrlees, 1971). With a common reservation wage, individual productivity determines labor force participation. A tax reform that reduces the taxes of low-income individuals (i.e., around the reservation wage) would raise the number of workers by a small amount. In the convex model, these new entrants would work only a few hours. More precisely, a marginal change in the tax system would induce an infinitesimal number of individuals to join the labor market, at infinitesimal hours of work. By implication, the effect on tax revenue of these behavioral responses is second order. Since the welfare effect of tax reform is determined exactly by the behavioral effects on tax revenue (e.g., Immervoll *et al.*, 2004), adjustments in labor supply along the extensive margin create no first-order welfare effects. Thus, because it models entry-and-exit behavior incorrectly, the convex framework cannot provide a reasonable approximation of the welfare effects of tax reform.

To summarize then, the evaluation of tax reforms affecting entry and exit decisions requires a framework that explicitly distinguishes between the two margins of labor supply. In addition, some form of non-convexity is required to obtain both a realistic description of participation responses and the correct welfare effects. The next section sets up a framework along these lines.

3.2 The Model of Labor Supply Behavior

The most common explanation for discrete behavior along the extensive margin is the presence of non-convexities in preferences or budget sets due to fixed work costs (Cogan, 1981) or concave work cost functions (Heim and Meyer, 2004). These work costs may be monetary costs (child care, transportation, clothing, etc.) or they could come in the form of time losses (e.g., commuting time and the time used preparing for and recovering from work). Just as important perhaps are emotional costs due to stress and additional responsibilities associated with work. These work costs may be

fixed or they may depend in complex ways on working hours. But in general they tend to create economies of scale in the work decision, implying that very low working hours become non-optimal for the individual. We adopt a framework incorporating fixed work costs, denoted by q, which capture essential elements some of the factors mentioned above.[3]

For the fixed work costs, we adopt a stochastic formulation where each individual i draws a fixed cost q_i from a distribution $P_i(q_i)$ with density $p_i(q_i)$. As we shall see, this formulation implies that each individual in the population has a probability of labor market participation, which may be interpreted as an individual participation rate. The formulation is consistent with the empirical part of the paper, where we estimate the individual participation probabilities from a probit regression. The main advantage of the stochastic formulation is that it generates a smooth participation response at the individual level, where small changes in wages or taxes create small changes in the probability of participation. Hence we may capture the sensitivity of entry-exit behavior by setting elasticity parameters for each individual. Although the participation response is smooth in this way, it is also discrete in the sense that – conditional on entry – the individual never chooses very low hours of work. This aspect of the model is very important as pointed out in the previous section.

Individuals choose labor supply behavior after the realization of their fixed cost of working. The labor earnings of individual i is given by $w_i h$, where w_i is the individual productivity level while h denotes working hours. The tax system is described by a function $T(w_i h, \theta)$, where θ is an abstract parameter which we will use to capture policy reform. The tax function is a net payment to the public sector, embodying taxes as well as transfers. For our purpose,

[3] We incorporate as well non-convexities in the budget set due to the design of the tax-transfer system. These are mostly due to phase-outs and discontinuities in transfer programs.

it is important that the specification of the tax/transfer system retains sufficient flexibility for the empirical application. In particular, we allow for non-linearities and the possibility of discontinuities. Attention is restricted, however, to the case of piecewise linearity where individuals face marginal tax rates which are locally constant. This type of tax specification has also been used by Dahlby (1998) and Immervoll *et al.* (2004).

Individual utility is specified in the following way

$$u_i\left(c,h\right)=v_i\left(c,h\right)-q_i\cdot 1\left(h>0\right), \tag{1}$$

where c is consumption, $v_i\left(.\right)$ is a well-behaved utility function, and $1(.)$ denotes the indicator function. In contrast to some recent studies incorporating discrete participation behavior (Saez, 2002; Immervoll *et al.*, 2004), our formulation accounts for the presence of income effects. The fixed work cost is incurred only at positive hours of work ($h>0$), and it is assumed to be additively separable in utility. As we shall see below, the separability assumption simplifies the analysis considerably, since it implies that the decision about hours of work becomes independent of the fixed cost. More specifically, while the fixed cost will affect the choice to participate in the labor market, it will not affect the choice of working hours conditional on participation. For the welfare analysis of tax reform, which depends on labor supply elasticities, the substantive assumption we are making is that intensive labor supply elasticities do not depend on fixed costs. The elasticities may vary across individuals (due to heterogeneity of preferences and wage rates) but they will not vary with the realization of the fixed work cost for each individual. For the purpose of the simulation exercise, this assumption does not seem strong. One should bear in mind that fixed costs are very difficult to observe, implying that empirical evidence on the correlation between these costs and labor supply elasticities cannot easily be obtained. Hence we would not be able to make much use of the additional heterogeneity implied by the non-separability of fixed costs.[4]

The budget constraint is given by

$$c\leq w_ih-T\left(w_ih,\theta\right). \tag{2}$$

The household maximizes (1) subject to (2). The maximization may be solved in two stages. First, we solve for the optimal hours of work conditional on labor force participation and,

[4] The assumption of additive separability of fixed costs is stronger than we need. A specification with weak separability, where utility is given by $v_i\left(f\left(c,h\right),q_i\cdot 1\left(h>0\right)\right)$, would leave the analysis unchanged.

second, we consider the choice to enter the labor market at the optimal working hours. Given participation, $h > 0$, the optimum is characterized by the standard first-order condition

$$(1 - m_i) w_i \frac{\partial v_i (c_i, h_i)}{\partial c} = -\frac{\partial v_i (c_i, h_i)}{\partial h}, \tag{3}$$

where c_i and h_i denote consumption and hours of work at the optimum, while $m_i \equiv \partial T (w_i h_i, \theta) / \partial (w_i h_i)$ is the marginal tax rate on earnings. Since the T-function embodies transfers, the marginal tax rate includes the marginal claw-back on any benefits that the individual is receiving. The above expression confirms that the optimal solutions do not depend on the fixed cost q_i, and therefore the utility level (exclusive of fixed costs) $v_i = v_i (c_i, h_i) = u_i + q_i$ will also not depend on the fixed cost. This becomes useful later on.

In the second stage, we solve for labor force participation. For the individual to enter the labor market, the utility from participation must be greater than or equal to the utility from non-participation. This constraint implies a cut-off for the fixed cost given by

$$\bar{q}_i = v_i (c_i, h_i) - v_i \left(c^0, 0\right), \tag{4}$$

where $c^0 \equiv -T (0, \theta)$ denotes consumption for those who are not working. Individuals with a fixed cost below the threshold-value $\bar{q}_i$ decide to enter the labor market at h_i hours, while those with a fixed cost above the threshold choose to stay outside the labor force. The threshold value determining the entry-exit choice reflects in part the difference between consumption for participants and consumption for non-participants. It is useful to write the consumption for participants in the following way

$$c_i = w_i h_i - T (w_i h_i, \theta) = c^0 + (1 - a_i) w_i h_i, \tag{5}$$

where $a_i \equiv [T (w_i h_i, z) - T (0, z)] / (w_i h_i)$ defines a tax rate on labor force participation. This tax rate is an effective *average* tax rate, including the benefit reduction from entry in proportion to earnings (i.e., the average claw-back rate). For a policy reform affecting only taxes and benefits for workers (such as an EITC), c^0 is constant and labor force participation is affected only through the change in the participation tax rate a_i. Changes in the marginal tax rate m_i will affect optimal working hours h_i, but these changes in h_i is of no consequence for the participation response due to the envelope theorem.

The welfare analysis of tax reform should be based on the dual rather than the primary approach to the individual's problem. In the dual approach, we minimize expenditures to obtain a given utility level. This problem is more involved than usual due to the non-convexity created by fixed work costs. The problem may be written in the following way

$$\min_{c,h} \{c - w_i h + T(w_i h, \theta)\} \text{ st. } v_i(c,h) - q_i \cdot 1(h > 0) \geq u_i, \tag{6}$$

where u_i is a fixed utility level. In the following, we let u_i denote the equilibrium utility level obtained from the primary problem. This implies that the solutions to the expenditure minimization problem (the compensated values of c and h) will be consistent with the solutions to the utility maximization problem (the uncompensated values of c and h).

Again, we may solve the problem in two stages. Conditional on participation, the problem simplifies to

$$\min_{c,h} \{c - w_i h + T(w_i h, \theta)\} \text{ st. } v_i(c,h) \geq u_i + q_i, \tag{7}$$

where q_i is now written on the right-hand side, since it is exogenous at this stage. The solution to this problem $\left(\tilde{c}_i, \tilde{h}_i\right)$ is characterized by the first-order conditions

$$(1 - m_i) w_i \frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial c} = -\frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial h} \quad \text{and} \quad v_i\left(\tilde{c}_i, \tilde{h}_i\right) = u_i + q_i. \tag{8}$$

From these equations, we obtain a function for compensated hours of work given by $\tilde{h}_i = \tilde{h}_i((1 - m_i) w_i, u_i + q_i)$, and a function for compensated consumption, $\tilde{c}_i = \tilde{c}_i((1 - m_i) w_i, u_i + q_i)$. By inserting these functions in eq. (7), we obtain the expenditure function conditional on participation

$$E_i^p(\theta, u_i + q_i) = \tilde{c}_i(\cdot) - w_i \tilde{h}_i(\cdot) + T\left(w_i \tilde{h}_i(\cdot), \theta\right). \tag{9}$$

We write $E_i^p(\cdot)$ as a function of θ to reflect that expenditures are evaluated at the current tax-benefit system. Notice that the θ-parameter enters directly (in the tax function) as well as indirectly, because the compensated variables are functions of the marginal tax rate. We suppress the wage rate w_i as a function argument in the expenditure function, because it is exogenous in the model. Notice finally that the expenditure function $E_i^p(\cdot)$ is increasing in the fixed cost q_i.

If the individual does not enter the labor market, the dual problem is to minimize $c + T(0, \theta)$ with respect to c and subject to $v_i(c, 0) \geq u_i$. The first-order condition is given simply by

$$v_i\left(\tilde{c}_i^0, 0\right) = u_i, \tag{10}$$

which defines a function $\tilde{c}_i^0 = \tilde{c}_i^0(u_i)$. Hence the expenditure function conditional on not working is given by

$$E_i^n(\theta, u_i) = \tilde{c}_i^0(u_i) + T(0, \theta). \tag{11}$$

At the given utility level, labor market participation is optimal if $E_i^p(\theta, u_i + q_i) \leq E_i^n(\theta, u_i)$ whereas non-participation is optimal if the opposite holds. Accordingly, we may characterize the expenditure function in the following way

$$E_i(\theta, u_i, q_i) = \min\left[E_i^p(\theta, u_i + q_i), E_i^n(\theta, u_i)\right]. \tag{12}$$

The comparison of expenditures at participation versus non-participation depends on the size of the work costs q_i. The higher the cost, the higher the value of $E_i^p(\cdot)$, and the less likely it becomes that the individual would want to participate. We may define a threshold value, denoted by $\tilde{q}_i$, where expenditures in the two states are equal, i.e. $E_i^p(\theta, u_i + \tilde{q}_i) = E_i^n(\theta, u_i)$. From eqs (9) and (11), this condition implies

$$\tilde{c}_i = \tilde{c}_i^0 + (1 - a_i) w_i \tilde{h}_i, \tag{13}$$

where a_i is the participation tax rate defined previously.

The participation decision in the dual approach should be consistent with the decision in primary approach in the sense that the solutions are the same at the actual utility level u_i. To see that this is indeed the case, notice that the first-order conditions (8) and (10) evaluated at $\tilde{q}_i$ implies

$$\tilde{q}_i = v_i\left(\tilde{c}_i, \tilde{h}_i\right) - v_i\left(\tilde{c}_i^0, 0\right). \tag{14}$$

Given the optimal hours of work $\tilde{h}_i$ and consumption for non-participants $\tilde{c}_i^0 = \tilde{c}_i^0(u_i)$, eqs (13) and (14) solve for the compensated threshold value $\tilde{q}_i$ and compensated consumption $\tilde{c}_i$. It is immediately clear that these equations are consistent with (4) and (5) in the primary approach.

Having described the individual's optimization, we are ready to write down aggregate (compensated) labor supply L. Each individual works $\tilde{h}_i((1 - m_i) w_i, u_i + q_i)$ hours if his realized fixed cost q_i is less than or equal to $\tilde{q}_i$. Otherwise he stays out of the labor market. As the probability distribution function for the fixed cost is denoted $p_i(q_i)$, we obtain

$$L = \sum_{i=1}^{N} \int_0^{\tilde{q}_i} \tilde{h}_i((1 - m_i) w_i, u_i + q_i) p_i(q_i) dq_i, \tag{15}$$

where N is the total number of individuals. At this point, we may use the separability of fixed costs to simplify the expression. As explained previously, the separability implies that the equilibrium utility level exclusive of fixed costs, i.e. $v_i = u_i + q_i$, is independent of the realization of the fixed cost. An increase in the cost leads to an offsetting decline in u_i. Hence working hours may be moved outside the integral in the above expression such that we get

$$L = \sum_{i=1}^{N} P_i\left(\tilde{q}_i\right) \tilde{h}_i\left(\left(1-m_i\right) w_i, v_i\right), \tag{16}$$

where $P_i\left(\tilde{q}_i\right) = \int_0^{\tilde{q}_i} p_i\left(q\right) dq$ is the individual probability of participation, which may be interpreted as an individual participation rate. The above expression emphasizes the joint role of the intensive and extensive margins in determining aggregate labor supply behavior, and it shows that the two margins are related to different tax/transfer parameters. While the choice of working hours depends on the effective marginal tax rate m_i, the participation rate is determined by the cut-off fixed cost $\tilde{q}_i$ which is related to the effective average rate of taxation a_i (the participation tax rate).

From eq. (16), the effect of tax reform on labor supply may be decomposed into its effect on hours of work for those who are working and its effect on labor force participation. As a measure of the sensitivity along the intensive margin, we define the compensated hours-of-work elasticity with respect to the *marginal* net-of-tax wage

$$\varepsilon_i \equiv \frac{\partial \tilde{h}_i}{\partial\left[\left(1-m_i\right) w_i\right]} \frac{\left(1-m_i\right) w_i}{\tilde{h}_i}. \tag{17}$$

The sensitivity along the extensive margin is captured by a participation elasticity, defined as the percentage change in the participation rate P_i created by a one percentage change in the *average* net-of-tax wage, i.e.

$$\eta_i \equiv \frac{dP_i\left(\tilde{q}_i\right)}{d\left[\left(1-a_i\right) w_i\right]} \frac{\left(1-a_i\right) w_i}{P_i\left(\tilde{q}_i\right)}. \tag{18}$$

Notice that each elasticity is defined with respect to the net-of-tax price which is relevant for the margin in question. For the purpose of empirical application, one should bear in mind that both elasticities are compensated. However, this matters mostly for the hours-of-work elasticity. In fact, for the participation elasticity, one can show that the compensated elasticity η_i is identical to the uncompensated elasticity as long as we are considering a change in wages or taxes for workers only (such that $T\left(0, \theta\right)$ is constant). As shown in Appendix A, the reason for this result is that the derivative of the cut-off $\tilde{q}_i$ (obtained from eqs 13 and 14) is the same as the derivative of $\bar{q}_i$ (obtained from eqs 4 and 5) when non-participants are unaffected. These derivatives are identical because out-of-work consumption ($\tilde{c}_i^0$ and c^0, respectively) is constant in both cases, and due to the fact that changes in optimal hours of work ($\tilde{h}_i$ and h_i, respectively) envelope out in the participation decision. This insight is important, since it implies that participation elasticities estimated from tax-benefit reform affecting only workers (say the EITC) can be interpreted as compensated elasticities and may be used as an input in the welfare analysis.

3.3 The Welfare Analysis of Tax Reform

To study the relationship between tax reform and efficiency, we start by defining the excess burden of taxation on a single individual. Several different measures involving consumers' surplus or Hicksian variations have been proposed in the literature (cf. Auerbach and Rosen, 1980, and Auerbach, 1985). We adopt a measure based on the equivalent variation, defining the excess burden as the amount – in excess of government revenue – that the individual would be willing to pay to get rid of all taxes and transfers. In other words, how much additional revenue could be collected, with no loss in utility for the individual, if the distortionary tax were to be replaced by a lump sum tax. Hence, the excess burden on individual i from a tax-benefit system θ is given by

$$EB_i\left(\theta, u_i, q_i\right) = E_i\left(\theta, u_i, q_i\right) - E_i\left(0, u_i, q_i\right) - R\left(\theta, u_i, q_i\right), \tag{19}$$

where $E_i\left(\theta, u_i, q_i\right)$ denote expenditures at the existing tax-benefit system, $E_i\left(0, u_i, q_i\right)$ denote expenditures in the absence of taxes and transfers, while u_i has been defined above as the post-tax level of utility. The net tax payment of individual i, $R\left(\theta, u_i, q_i\right)$, is equal to $T\left(w_i\tilde{h}_i\left(\cdot\right), \theta\right)$ conditional on working ($q_i \leq \tilde{q}_i$) and $T\left(0, \theta\right)$ conditional on not working ($q_i > \tilde{q}_i$).

The aggregate excess burden is defined as the sum of the individual excess burdens (Auerbach, 1985), i.e.,

$$EB = \sum_{i=1}^{N} \int_0^{\infty} \left[E_i\left(\theta, u_i, q_i\right) - E_i\left(0, u_i, q_i\right) - R\left(\theta, u_i, q_i\right)\right] dP_i\left(q_i\right). \tag{20}$$

Because of heterogeneity in wages, tax rates, tastes, and fixed costs, individual excess burdens of taxation vary across the population. Thus, the aggregate excess burden measure compares the revenue from individual lump sum taxes, keeping each individual at her post-tax level of utility, to the actual revenue collected by the distortionary tax system.[5]

By using eq. (12) and the definition of $R(\theta, u_i, q_i)$, we may rewrite the aggregate excess burden to

$$\begin{aligned} EB &= \sum_{i=1}^{N} \left[\int_0^{\tilde{q}_i} \left(E_i^p(\theta, u_i + q_i) - T\left(w_i \tilde{h}_i(\cdot), \theta \right) \right) dP_i(q_i) \right. \\ & \left. + \int_{\tilde{q}_i}^{\infty} \left(E_i^n(\theta, u_i) - T(0, \theta) \right) dP_i(q_i) - \int_0^{\infty} E_i(0, u_i, q_i)\, dP_i(q_i) \right]. \end{aligned} \tag{21}$$

To derive the consequences of a tax reform, we consider the effect on EB of a marginal change in the θ-parameter. Because of the envelope theorem, any changes in behavior induced by the reform does not affect the expenditure functions. Thus, from eqs (9) and (11), the changes in expenditures are given simply by the *mechanical* changes in taxes and benefits, $\partial E_i(.)/\partial\theta = \partial T(.)/\partial\theta$. Using this relationship, we may differentiate eq. (21) to obtain

$$\frac{dEB}{d\theta} = -\sum_{i=1}^{N} \left[m_i w_i \frac{d\tilde{h}_i}{d\theta} P_i(\tilde{q}_i) + a_i w_i \tilde{h}_i \frac{dP_i(\tilde{q}_i)}{d\theta} \right], \tag{22}$$

where we have also used the definition of the participation tax rate a_i and the fact that $E_i^p(\theta, u_i + q_i) = E_i^n(\theta, u_i)$ at the threshold level $\tilde{q}_i$. This equation shows that the marginal deadweight burden of tax reform is given by the effect on government revenue from behavioral responses. The expression reflects that the behavioral revenue effect is related to the two different margins of labor supply response. The first term captures the revenue effect from the change in the optimal hours of work for those who are working. The second term gives the effect on revenue brought about by the tax-induced change in labor force participation. While the second effect on efficiency is related to the tax rate on labor force participation a_i, the efficiency effect from changed working hours depends on the tax burden on the last dollar earned m_i.[6]

The equality of the welfare effect with the behavioral effect on government revenue reflects a general insight from models with no externalities besides those created by taxes and transfers.

[5] With heterogeneous agents, aggregation problems can arise (see Auerbach 1985). In particular, any measure of aggregate excess burden will depend on the initial distribution of income. To generate a distribution-neutral measure of excess burden, one would have to impose strict conditions on preferences-such as no income effects [quasilinear utility] or constant income effects [Gorman Polar form].

[6] Using expression (22), we can confirm that the welfare effects from extensive reponses disappear in a convex framework (see Section 3.1). The reason is that new labor- market workers enter at infinitesimal hours, $\tilde{h}_i \approx 0$, with the consequence that $T\left(w_i \tilde{h}_i, \theta\right) - T(0, \theta) = a_i w_i \tilde{h}_i \approx 0$ for these individuals. The revenue effect created by such participation responses (the second term in eq. 22) equals zero to a first order.

In the present context, one should bear in mind that the model features no imperfections in the labor market. Thus, since non-employment is voluntary, the marginal entrant is indifferent between working and not working. If a small tax reform induces additional entry, the new entrants obtain no first-order utility gains, but they create a positive externality on everybody else through the government budget. Likewise, the hours-of-work responses for those who are employed create no direct utility gains, but they give rise to an externality through the government budget.

The effect of the reform on working hours may be obtained from the compensated labor supply function, $\tilde{h}_i\left(\left(1-m_i\right)w_i, v_i\right)$. The participation response depends on the change in the threshold value $\tilde{q}_i$, which may be derived from total differentiation of eqs (13) and (14). By inserting the derivatives in (22) and using the elasticity definitions (17) and (18), the marginal excess burden in proportion to aggregate income may be written as (see Appendix B)

$$\frac{dEB/d\theta}{\sum_{i=1}^{N} w_i \tilde{h}_i P_i\left(\tilde{q}_i\right)} = \sum_{i=1}^{N} \left[\frac{m_i}{1-m_i}\frac{\partial m_i}{\partial \theta}\cdot \varepsilon_i + \frac{a_i}{1-a_i}\frac{\partial a_i}{\partial \theta}\cdot \eta_i\right] s_i, \tag{23}$$

where $s_i \equiv w_i \tilde{h}_i P_i\left(\tilde{q}_i\right) / \left(\sum_{i=1}^{N} w_i \tilde{h}_i P_i\left(\tilde{q}_i\right)\right)$ is the (expected) wage share of individual i, and where $\partial a_i/\partial\theta \equiv \left[\frac{\partial T\left(w_i \tilde{h}_i, \theta\right)}{\partial \theta} - \frac{\partial T(0,\theta)}{\partial \theta}\right] / \left(w_i \tilde{h}_i\right)$ is the impact on the effective average tax rate (the participation tax) from the reform. The first term in the bracketed expression looks familiar, since it reflects a classic Harberger-style formula for the marginal deadweight burden of taxation. It shows that the welfare loss created on the intensive margin depends on the level of the marginal tax rate, the change in the marginal tax rate due to the reform, and the elasticity of hours of work. The second component in the expression reflects the deadweight loss due to changed labor supply behavior along the extensive margin. This effect is related to the level of the participation tax rate, the change in the participation tax as well as the sensitivity of entry-exit behavior as measured by the participation elasticity. Hence, the welfare effects created on the two margins of response may be expressed in similar ways, except that they are related to different tax and elasticity parameters. Finally, since the individual effects are weighted by individual earnings shares, the initial income distribution matters for the marginal excess burden of the reform.

A priori one might have wondered whether the standard convex framework could be saved by a reinterpretation of the labor supply elasticity. Following this interpretation, one would introduce extensive responses into the framework simply by using estimates of the *total* labor supply elasticity including both margins of response. The above analysis demonstrates that, in general, this approach is not correct, since labor force participation is related to a different tax wedge than are working hours. The analysis also shows that the size of the error made by the conventional model depends on the degree to which the observed variation in aggregate labor supply is concentrated on the extensive margin.

Having said that, it should be noted that there is one special case for which a reinterpretation of the conventional model is valid. This is the case of a linear Negative Income Tax (NIT), which grants a lump sum transfer B to all individuals in the economy (participants and non-participants) and then imposes a constant marginal tax rate on labor income, $m_i = m \; \forall i$. In this case, the tax burden on labor market entry for individual i becomes $T\left(w_i \tilde{h}_i, \theta\right) - T(0, \theta) = m w_i \tilde{h}_i$, which implies a participation tax rate $a_i = m$. Moreover, if the tax reform is simply a change of tax/transfer parameters within the framework of the NIT, we would have $\frac{\partial a_i}{\partial \theta} = \frac{\partial m}{\partial \theta}$. Inserting in eq. (23), we get

$$\frac{dEB/d\theta}{\sum_{i=1}^{N} w_i \tilde{h}_i P_i(\tilde{q}_i)} = \frac{m}{1-m} \frac{\partial m}{\partial \theta} \cdot (\varepsilon + \eta), \tag{24}$$

where $\varepsilon \equiv \sum_{i=1}^{N} \varepsilon_i s_i$ and $\eta \equiv \sum_{i=1}^{N} \eta_i s_i$ are weighted averages of individual elasticities. This corresponds to a standard Harberger-type formula, with the intensive and extensive elasticities being lumped in a total labor supply elasticity $\varepsilon + \eta$.[7]

Although the above special case is interesting, its practical applicability is limited. It requires that the entire tax and welfare system is a linear NIT, which is never satisfied in reality. For example, it does not apply to situations with gradual phase-out of benefits (as with cash benefits and food stamps in the US) and/or if there are discontinuities in benefits (as with medicaid). Nor will it apply if the income tax system involves in-work benefits like the EITC and/or increasing marginal rate structures. Our empirical application will account for all these factors in the simulation of tax wedges on the two margins.

[7] In this special case, it does not cause problems that the intensive and extensive elasticities were defined with respect to different prices (marginal and average net-of-tax wages, respectively). With an NIT, the average and marginal net wages are identical, i.e. $(1 - m_i) w_i = (1 - a_i) w_i$ for $\forall i$.

4 Evaluating Tax Reforms: The Case of Single Mothers

4.1 Simulation Methodology

In this section, we apply the theoretical framework to evaluate the welfare effects of four federal tax reforms in the United States passed in 1986, 1990, 1993, and 2001. We focus on the case of single mothers, because they experienced substantial tax changes and because empirical evidence suggests strong participation responses. For each observation, we simulate the effects of actual changes in federal taxes due to the tax change. In this sense, our methodology differs from most numerical studies of tax reform which consider simple hypothetical reforms.[8]

Our simulation procedure consists of the following steps. First, we estimate participation probabilities and earnings for each individual in a baseline year (usually the year prior to the tax change). For nonparticipants, the imputation of earnings is necessary to calculate labor income and tax liability if they choose to enter following a reform. To be consistent, we also use imputed earnings for workers. The imputation of earnings is based on a simple earnings regression, where we control for self-selection into the labor force using a propensity score correction. The regression equation is specified as:

$$\log(y_i) = X_i\alpha + \hat{P}_i\beta + \nu_i,$$

where y is earned income (for the sample of workers), and X represents demographic characteristics, including age, education, age-education interactions, race, and state of residence. To control for self-selection, we include the predicted probability of labor force participation $\hat{P}_i$ as a regressor in the earnings equation. This probability is estimated from a first-stage probit:

$$P(lfp_i = 1) = \Phi(Z_i\gamma),$$

where lfp is labor force participation and Z includes all demographic characteristics *and* the number of children. Hence the selection term is identified by the number of children.[9]

[8] Papers considering hypothetical tax reforms include Browning and Johnson (1984), Ballard (1988), Triest (1994), Browning (1995), Liebman (2002), and Immervoll *et al.* (2004). A recent paper by Preston and Walker (1999), on the other hand, does consider actual policy reform. However, this is not a tax but a policy reform in the United Kingdom affecting the child support payments of absent fathers. Interestingly, their empirical analysis allows for discrete participation responses.

[9] A more appropriate approach may be to identify the selection effect using young children (under the age of 6). When we estimate such models, we generate very similar predicted earnings distributions and essesntially identical welfare effects.

We then use predicted earnings to simulate individual marginal and average tax rates, as well as changes in *federal* tax rates implied by the reforms. Section 4.3 describes this imputation in detail.

To simulate welfare benefits, we create a benefit calculator that includes the major programs of the welfare system (cash assistance, food stamps, and medicaid). Our benefit calculator accounts for the main features of these programs, including the income-dependent reduction rates, state, and number of dependent children.

Using simulated tax and benefit rates, we calculate effective marginal and average tax rates for each individual (both baseline levels and reform-induced changes). Finally, we compute welfare effects based on assumed elasticities and the formulae derived in Section 3.

Since the results from Section 3 were based on a small reform methodology, the computed welfare effects represent first-order approximations to the true effects. For each reform, we evaluate the entire labor supply response at the pre-reform tax wedge. Since the reforms under consideration reduced tax wedges, this method may overstate the size of the welfare effects somewhat.[10] While the four tax reforms under consideration were substantial, it seems unlikely that second-order effects would significantly change our simulation results. Indeed, even for TRA86, the total tax burden was reduced by less than 8 percent of wage income for the population of single mothers.

The big advantage of the small reform methodology is its simplicity and transparency. To evaluate the reforms, we need only to estimate earnings and tax rates and to set elasticities based on the empirical literature. In particular, we do not need to specify utility functions or estimate (or calibrate) utility parameters. Our approach is therefore very nonstructural.

4.2 Data and Regression Results

The data for the simulations come from the 1986, 1991, 1994 and 2001 March Current Population (CPS) Surveys. The March CPS is an annual demographic file of nearly 60,000 households, with information on labor market and income outcomes for the previous year. Therefore, the data we use are for tax years 1985, 1990, 1993 and 2000.

The CPS reports income and demographic information on households, families and individid-

[10] Of course, since we compute the welfare effects of each of the four reforms separately (changing the baseline each time), all second-order effects *across* reforms are accounted for. These second-order effects are presumably more important than second-order effects *within* reforms.

uals. We note this fact because families and households may be different from the relevant unit of observation for our exercise - the tax-filing unit - if there are subfamilies (children and/or grandchildren). We base our tax-filing units on CPS families, and allocate subfamilies (both related and unrelated) to separate tax-filing units from the primary family. We consider any member of the tax-filing unit who is under the age of 19 (or less than 24 and a full-time student) to be a dependent child for tax purposes. We also assume that any taxpayer with a child meeting the age criteria also meets both the dependent child and EITC child requirements.

The sample includes unmarried females (widowed, divorced, and never-married) who are between 18 and 49 years old and have children. It does not include older women, primarily to avoid complications related to modeling retirement decisions. Nor does it include any female who was ill or disabled, in the military, or reported herself retired during the previous year. Finally, we exclude observations with negative earned income (due to negative self-employment income), negative unearned income, or with positive earned income but zero hours of work. The resulting sample sizes are in the range of 4,000 to 5,000 individuals across the years.

Summary statistics of the characteristics of the data (shown in Table A1) suggest that the typical unmarried mother looks only slightly different from 1985 to 2000. While she is between 32 and 33.5 years old, she is clearly aging over the 15-year period, and has fewer children by the end of the period. With high school education, her earnings amount to $7,922 in 1985 ($12,674 in 2000 dollars). Over time, she has slightly more education and a much higher earnings, due primarily to more hours worked.

Table A2 presents results for the first-stage probits and the earnings regressions. The results are very consistent for 1985, 1990 and 1993, and show that the propensity score adjustment for selection into the labor market is significant in the earnings regressions. The propensity score correction for selection into the labor force is quite a bit weaker in 2000, however. One reasonable explanation of this finding could be the success of welfare reform in encouraging mothers into the labor force. Nonetheless, we find that the distribution of predicted relative to actual earnings looks similar for all years.

4.3 Tax and Benefit Calculations

This section describes our method of calculating tax and benefit parameters. To start, we note that the appropriate measure of the tax wedge encompasses the entire effect of behavioral responses on revenue, and therefore must include all taxes and transfer (benefits). Our computations of individual effective tax rates include federal, state and payroll taxes, as well as cash assistance, food stamps and medicaid. Individual tax rates are computed using predicted earnings, CPS-measures of non-labor income (including social insurance benefits and unemployment insurance benefits) and demographic characteristics such as number of children and state of residence. Because the CPS does not ask about itemized deductions, we make the reasonable assumption that all female heads take the standard deduction.

The tax parameters for the sample of female heads are calculated using the Tax Simulation Model (TAXSIM) of the National Bureau of Economic Research (NBER)[11]. To compute pre-reform marginal and average tax rates on labor income,[12] we use estimated earnings $(\hat{y}_i)$ and other CPS-data relevant for tax liability (I_i). TAXSIM calculates marginal tax rates as the tax owed on an additional 10 cents of earnings, i.e. $\left[T\left(\hat{y}_i + 10 \text{ cents}, I_i\right) - T\left(\hat{y}_i, I_i\right)\right]/(10 \text{ cents})$. It also calculates total liabilities, which may be used to derive an average tax rate relevant for participation. This average tax rate is defined as the difference between tax liability at predicted earnings $T(\hat{y}_i, I_i)$ and at zero earnings $T(0, I_i)$ in proportion to predicted earnings, i.e. $[T(\hat{y}_i, I_i) - T(0, I_i)]/\hat{y}_i$.

TAXSIM-generated tax rates do not include any transfer components. In the United States, lower-income families are eligible to receive cash assistance from the Temporary Assistance to Needy Families (TANF), previously Aid to Families with Dependent Children (AFDC) program. In addition, eligible families may receive in-kind benefits in the form of food vouchers (Food Stamps) and health insurance (Medicaid). To incorporate benefits, we augment tax data from TAXSIM with information on AFDC, Food Stamps and Medicaid. Because transfer programs have differing eligibility and benefit structures at the federal and state levels, we treat each program separately. In particular, the benefit calculations account for the dependence of benefits on the state of residence and on the number of dependent children.

Calculations of effective average tax rates account for benefits lost with labor market entry, including AFDC (TANF), Food Stamps, and Medicaid - if entry is predicted above the eligibility threshold. Where appropriate, calculations of effective marginal tax rates account for

[11] see Feenberg and Coutts (1993) for an introduction to TAXSIM.

[12] With the exception of TRA86, pre-reform tax rates are calculated for the year in which the reform was enacted. We use the previous year as baseline for TRA86 to account for the fact that the reform was extensively discussed and largely anticipated.

TANF/AFDC and Food Stamps benefit reduction rates. A concern that arises here is the bias that occurs from less than 100 percent take-up of welfare benefits (see Moffitt, 1992). Because not all eligibles receive benefits, our calculations as such would overestimate of "true" benefits on average. To correct this bias we apply an "empirical" take-up rate, calculated from our CPS data as the share of the eligible population that reports positive benefits during the year. We apply a take-up rate of 54 percent, calculated using our 1993 March CPS data. This take-up rate is consistent with empirical evidence in the welfare literature (Moffitt, 1992).

Table II reports sample means and standard deviations for the marginal and average tax rates in the four pre-reform years (1985, 1990, 1993, 2000). The numbers illustrate the dramatic changes in the tax treatment of single mothers. Most notable is the decline in the overall tax burden – captured by the average tax rate – from 1985 to 2000. The benefit-adjusted average tax rate drops from 57 percent to 32 percent over the period. The marginal tax rate shows a more moderate and less systematic decline than the average tax rate. This pattern is not surprising given the large expansions of the EITC during this period. An expansion of the EITC reduces unambiguously the tax burden, whereas its impact on the marginal tax rate depends on the distribution of individuals on the different income intervals of the EITC (phase-in, plateau, and phase-out). The table also shows that accounting for benefits and transfers is fundamentally important. In fact, the pattern showing greater marginal than average tax rates is *reversed* when the impact of benefits and transfers is included. We report as well tax ratios used in the welfare calculations. These ratios are calculated for each individual as $t/(1-t)$, where t denotes the marginal or average tax rate (benefit-inclusive) for the intensive or extensive margin.

In Table II, the changes in tax rates across the different pre-reform years reflect all changes in the tax and welfare system taking place at the federal and state levels over the period, and they incorporate as well any behavioral responses to these tax and benefit changes as well as macro/time effects on income variables. To isolate the impact of the federal tax reforms on tax rates (exclusive of behavioral responses feeding back into tax liabilities), we measure the difference between imputed post-reform tax rates and pre-reform rates. The post-reform tax rate is imputed by using federal tax rules applying after the reform have been fully phased in. The post-reform years for the four tax acts we consider are 1988, 1993, 1996 and 2002. Using the TAXSIM model, we combine post-reform federal tax rules with pre-reform earnings (adjusted for inflation) to obtain new federal tax liabilities. The post-reform tax rates to be used in the simulations are then constructed from the new federal taxes combined with the pre-reform state taxes, payroll taxes and benefits.

Table II confirms that the decrease in effective tax rates over the 15-year period has been driven to a large extent by tax changes at the federal level. This was particularly the case for the 1986 and 1993 reforms, which reduced the average tax rate by 8 and 13 percentage points, respectively.

As a final note, we point out the heterogeneous effects of the tax laws on single mothers. Substantial variation in the tax parameters is shown by the size of the standard deviation of different tax rates. This heterogeneity highlights the need for using micro-simulations to evaluate the tax reforms. Large errors may occur in more aggregate studies because of the correlation between earnings, tax rates and tax changes.

4.4 The Welfare Effects of Tax Reform

In this subsection, we present simulated welfare effects for all four tax reforms. Our simulations are based on assumptions about the elasticities along the two margins of labor supply response. Given existing empirical evidence, we assume that participation is more elastic than hours worked. In our benchmark scenario, we set the participation elasticity equal to 0.40 and the (compensated) hours-of-work elasticity equal to 0.10, implying a total labor supply elasticity equal to 0.50. Subsequently, we carry out a sensitivity analysis where we alter the size of the total elasticity, as well as its composition.

Table III summarizes the welfare effects for all four reforms under the benchmark scenario. The total welfare gain as a percentage of aggregate labor income is reported in column (3), and can be decomposed into the effect created along the intensive margin (column 1) and along the extensive margin (column 2). We find substantial welfare gains for all the reforms, especially for the 1986 reform, which created a welfare gain of 7.09 percent of labor income. The effects are also high for the 1993 reform (2.33 percent), which contained the largest single expansion of the EITC. For the 1990 and 2001 reforms, the welfare gains are not quite as large. But, as shown in column (5), these reforms were also smaller in terms of the total tax cut for single mothers, and this makes the welfare gains difficult to compare across reforms. To facilitate comparison, we therefore report the welfare gain per dollar spent in column (6) and the extensive welfare gain per dollar spent in column (7). These numbers confirm that TRA86 created much larger efficiency gains than the other subsequent reforms.

For all four reforms, most of the total welfare gain is generated on the extensive margin. While more than 3/4 of the gain from TRA86 is created by labor market entry, essentially all of the positive effect from OBRA90 is driven by labor force participation. For this reform, the intensive welfare effect is around zero because negative effects in the phase-out region cancel out positive effects in the phase-in region of the EITC. For OBRA93, the welfare gain is a result of the extensive margin dominating welfare losses created on the intensive margin. With EGTRRA in 2001, the difference between the intensive and extensive welfare effects are less pronounced. This occurs for two reasons. First, the 2000 tax cuts reduced average tax rates only slightly. More interesting is that by 2000, previous reforms seem to have eliminated much of the inefficiency along the extensive margin (cf. Section 4.3).

One might argue that our findings regarding the relative sizes of the extensive and intensive welfare effects were to be expected under the assumed elasticity scenario. Notice, however, that the difference between extensive and intensive welfare effects cannot be explained exclusively by elasticities, since the two kinds of welfare effects are related in different ways to the tax-transfer system. For example, for the tax act of 1990, increasing the hours-of-work elasticity would leave the intensive welfare effect more or less unchanged since the losses in the phase-out region would continue to cancel out the gains created in the phase-in region. For OBRA93, increasing the intensive elasticity would simply exacerbate the welfare loss along that margin, thereby reinforcing the point regarding the difference of welfare effects along the two margins.

Our finding that the extensive responses drive most of the welfare effects for the four reforms reinforces the relevance of this margin of labor supply. Having said that, one should be careful not to conclude that the large extensive effects reflect the size of the error committed by the standard (convex) policy simulation. There are other important differences. First, previous studies considered hypothetical – typically quite crude – reforms. The error made by leaving out the participation margin depends crucially on the details of the tax reform and the tax-transfer system in place at the time of the reform. Second, it is not always clear how to interpret elasticities used in the studies that do not model the participation margin. A common approach in the literature was to set labor supply parameters based on total elasticities, hence ascribing all of the extensive response to the intensive margin. We explore the consequences of this approach in column (4), called 'traditional' for lack of a better word. The numbers demonstrate clearly the large error made by ascribing an empirical response to the wrong margin in policy analysis. In fact, the error thus committed may be larger than ignoring the response altogether.

These errors reflect that the two margins of labor supply response depend on taxes and transfers in different ways. While the intensive margin depends on the effective marginal tax rate, the extensive margin is related to the effective average tax rate. By implication, the size of the error depends crucially on the properties of the tax-transfer programs being analyzed. For example, if one was to consider a change in a proportional tax rate, and if the existing tax-transfer system is also proportional, lumping margins together would create no error in the welfare analysis. Likewise, one would create no error in the case of a linear NIT system (cf. Section 3.3). However, linear taxation is not a realistic description of the actual tax-transfer policies which involve non-linearities as well as discontinuities. The discrepancy between the numbers in columns (3) and (4) reflects the importance of these aspects for the welfare analysis.

In Table IV we explore the sensitivity of the results to alternative elasticity assumptions. The scenario considered above ('Middle') is compared with 'Low' and 'High' scenarios to get a range for the likely effects. In the Low scenario, the intensive elasticity ε is set equal to 0.05 while the extensive elasticity η is equal to 0.20, implying a total elasticity equal to 0.25. In the High scenario, the intensive and extensive elasticities are 0.15 and 0.60, respectively, such that the total elasticity is 0.75. Notice that the Low, Middle, and High scenarios all reflect the same composition of labor supply responses, with the intensive elasticity being one-fifth of the total elasticity. Finally, we compare the Middle scenario to one with identical elasticities along the intensive and extensive margins ($\varepsilon = \eta = 0.25$). The Identical scenario has the same total elasticity as the Middle scenario (0.50) so as to isolate the effect of composition.

As we would expect, the size of the welfare effect is quite sensitive to the size of elasticities. From the welfare theory, we know that the sensitivity of marginal excess burden functions with respect to elasticities depends on the level of tax rates at the time of the implementation of the reform. The higher the initial tax rate, the greater the sensitivity of the results to the elasticities. Therefore, one would expect the sensitivity to be highest for the 1986 reform. To see that this is indeed the case, one should compare the welfare gains per dollar spent across reforms to account for the different sizes in the revenue costs. For TRA86, it is interesting to note that a total elasticity of 0.75 – not out of bounds of the empirical estimates – implies Laffer curve effects. In this scenario, the large tax reductions granted to single mothers were recouped entirely from the labor supply responses created by the reform.[13]

An advantage of our approach is that it allows a sensitivity analysis with respect to the composition of the total elasticity, not just its size. The results in Table IV demonstrate very clearly that welfare effects may be very sensitive to the composition of the elasticity. The sensitivity will be especially high for reforms that affect the two margins of response in very different ways. In particular, this was the case for OBRA90 and OBRA93 which introduced big improvements in the returns to entry from the EITC, while at the same time worsening the incentives along the intensive margin for many people due to the phase-out of the credit. Consequently, the composition of the elasticity becomes crucial for the welfare effects of these two reforms. For the 1993 reform, changing the benchmark composition ($\varepsilon = 0.10$; $\eta = 0.40$) to one with identical elasticities ($\varepsilon = \eta = 0.25$) reduces the welfare gain from 2.33 percent of labor income to 0.79 percent. This reduction in the welfare gain is quite a bit larger than what would be obtained by halving the total labor supply elasticity without changing composition, i.e., going from the Middle scenario to the Low scenario.

Despite the sensitivity of the results with respect to both size and composition of the elasticity, Table IV displays significant gains across all elasticity scenarios and for all four reforms. In every scenario, the welfare gain per dollar spent is larger than one. This implies that the tax cuts to single mothers are generating pure efficiency gains. That is, if one were to finance the tax cuts through lump sum taxation, which involves a marginal cost of funds (MCF) less than or equal to one, the reforms would increase aggregate utilitarian welfare.[14] In reality, the EITC is financed, not by lump sum taxes, but through higher distortionary taxes on middle- and high-income earners, which implies a marginal cost of funds above one. For the EITC to create efficiency gains in this case, the marginal cost of funds would have to be lower than the welfare gains per dollar spent reported in the table. This is difficult to say something about because MCF estimates are highly sensitive to the design of the tax increases (Browning, 1987; Dahlby, 1998). However, it is interesting to note that if MCF is 1.4, a reasonably high value

[13] A randomized social experiment in Canada also indicates that Laffer effects may occur at the bottom of the income distribution. The Canadian Self-Sufficiency Project (SSP) provides a time-limited earnings supplement to single parents who find full-time work after having been on welfare for at least a year. The analysis by Michalopoulos *et al.* (2005) show that, at the end of the period examined, the SSP program was paying for itself through increased tax revenues.

[14] The marginal cost of funds for lump sum taxation is generally below 1 because, assuming that leisure is a normal good, such taxes make individuals work more (Ballard and Fullerton, 1992). In the absence of income effects (quasi-linear utility), the marginal cost of funds is exactly 1.

given the existing estimates, then the tax cuts to single mothers are creating pure efficiency gains for all reforms in our benchmark scenario. This is a strong result since it indicates that one does not even have to rely on higher social welfare weights for the EITC recipients (single mothers) than for the rest of population to justify the reforms.

To explore the role of heterogeneity for the results, Tables V through VIII show tax/benefit parameters and welfare effects by earnings groups for the four reforms. In each table, the grouping of individuals is made according to the income ranges in the EITC program (phase-in, plateau, phase-out and beyond) prevailing at the time of the implementation of the reform. The disaggregation is based on predicted earnings from the regression described in Section 4.2.

A general conclusion emerging from the four tables is that the total welfare gains are generated mostly in the phase-out interval (although not for the 1993 reform). To be more precise, the effects are created by the extensive responses of individuals with predicted earnings in the pre-reform phase-out interval. For the 1986 reform, 43% of the total welfare gain is driven by this effect, while for the 1990 and 2001 reforms the share is more than half. These results are easily grasped by recalling that welfare effects reflect behavioral effects on government revenue, and are therefore positively related to levels of tax rates, reductions of tax rates and predicted earnings shares. If all these magnitudes are large for a certain income group and for a given margin of labor supply response, the welfare effects will be large for this group on that margin. This applies for example to TRA86 where the phase-out group faced high average tax rates prior to the reform (58%), got large reductions in these rates (10%-points), and constituted a large share of predicted earnings (46%). These factors correlated so as to create an extensive welfare effect for the phase-out group equal to 3.07 percent of the 7.09 percent total.

The disaggregated tables show that the extensive welfare effects are positive for all income groups across all four reforms. The intensive welfare effects, however, are negative for the phase-out group after OBRA90 and OBRA93, reflecting the higher phase-out rate introduced by these reforms. We also obtain negative intensive effects for the beyond group in 1990 and 1993 as well as for the plateau group in 1993. This occurs because the reforms expanded the size of the phase-out region for the EITC, combined with the fact that we group individuals according to pre-reform EITC intervals. In the 1993 reform, the negative intensive effects due to the increased claw-back rate and the expanded phase-out region dominate the positive intensive effects created by a higher phase-in rate. This may seem surprising given the very large increases in the subsidy rate introduced by this reform. Indeed, as Table II shows, the population of single mothers as a whole got lower effective marginal tax rates following the 1993 reform. However, the marginal rate reductions from a steeper phase-in of the EITC were relatively unimportant for efficiency because they were occurring at low wage levels, where only small behavioral revenue effects can be generated. Indeed, Table VII shows that the phase-in group constituted a very small proportion of aggregate earnings at the time of the 1993 reform.

In all of the scenarios considered so far, elasticities were uniform across the population of single mothers. It is difficult to evaluate the empirical validity of this assumption, since empirical evidence on labor supply elasticities across the income distribution is extremely limited and only suggestive at best. Eissa and Liebman (1996), for example, find that behavioral responses were strongest for the least educated (i.e. lowest potential earnings). We relax the assumtpion of uniform participation elasticity and instead allow it to decline with predicted income: women who are predicted to enter the labor market at higher incomes (phase-out region) should be less sensitive to a given change in tax-transfer schemes than women predicted to enter at lower incomes (say the phase-in region). Table IX presents welfare effects with a decreasing profile for the participation elasticity, keeping the assumption of uniform hours-of-work elasticities. The results show that our conclusions are robust to the introduction of heterogeneous participation elasticities. In particular, total welfare gains are substantial and are created mostly along the extensive margin. While total gains are somewhat lower for the 1986, 1990, and 2001 reforms, the gains created by the 1993 reform are higher compared to the uniform-elasticity scenario. These results reflect offsetting effects. Concentrating on the extensive response at low earnings means that labor-market entry generates less government revenue and, therefore, lower welfare gains. On the other hand, more of the responsiveness is concentrated along the margin most affected by those tax acts that expanded the EITC and reduced participation taxes (OBRA1990 and OBRA1993). For OBRA1993, the latter effect dominates the dampening effect of the earnings-elasticity correlation, creating larger gains.

5 Concluding Remarks

This paper has examined the welfare effects of tax reform in the United States using a welfare theoretic model incorporating both the intensive and the extensive margins of labor supply.

We find that large efficiency gains have been generated by the participation responses of single mothers. The welfare gains per dollar spent are substantially larger than one for all reforms and all elasticity scenarios, implying that the tax cuts have created pure efficiency gains. These pure gains suggest that the tax cuts could potentially be justified even with distortionary financing and without incorporating social welfare weights that are higher for single mothers than for the rest of the population.

Our analysis has demonstrated the need to distinguish explicitly between labor supply responses along the intensive and extensive margins, and to account for the difference between the associated tax wedges. Because the welfare effects created on the two margins are related to different tax rates and different tax rate changes, the composition of the labor supply elasticity becomes crucial for the effects of tax reform. Recent empirical literature has reinforced the view that participation responses are larger than hours-of-work responses. On the other hand, papers on the effect of marginal tax rates on taxable income suggest that intensive responses may be important once they are interpreted more broadly than hours worked (Feldstein, 1995). Our study demonstrates the need for empirical research to pin down the composition of the labor supply elasticity into the two types of response.

Related to our work, Liebman (2002) uses a micro-simulation model calibrated to 1999 CPS data to illustrate the trade-offs in the design of an EITC-including the optimal maximum credit, phase-in and phase-out rates- with fixed costs and participation effects. Liebman therefore extends on the work of Saez (2002) on optimal income taxation. This paper takes a different approach by analyzing actual tax reforms rather than optimal design. Moreover, since the four tax reforms we consider changed several different components of the federal tax code – including exemptions, deductions, and marginal tax rates – the estimated effects reflect more than just the EITC.

Recent work by Fullerton and Gan (2004) argues for incorporating directly the stochastic nature of estimated labor supply models when calculating the welfare effect of tax changes. The expected welfare effect from a tax change (accounting for the uncertainty about the location on the budget set) will be different from the welfare cost at the expected point, due to the fact that welfare cost functions are convex in tax rates. Our empirical application follows the standard approach of using point estimates, and hence does not incorporate such uncertainty in the welfare analysis. While the Fullerton-Gan framework incorporates discrete labor supply choices along both the intensive and extensive margin, their empirical applications exclude the participation margin by looking at married women working full time. Our main concern has instead been with the participation response which we believe is more important, especially for the population of single mothers.

Although our paper has focused exclusively on tax reform in the United States, the results may carry implications for welfare reform in other countries as well. In particular, many European countries are characterized by large taxes and transfers creating significant disincentives to labor market entry for low-wage earners. The findings of Immervoll *et al.* (2004) show these distortions, and suggest that in-work benefits may be good policy to alleviate work distortions. Indeed, a number of European countries, including the United Kingdom and France, have introduced various forms of in-work benefits.

A Derivation of Compensated and Uncompensated Participation Elasticities

In this appendix, we relate the compensated participation elasticity defined in eq. (18) to the primitives of the model. This relationship is important for the derivation of the marginal excess burden of taxation in Appendix B. In addition, we prove that the uncompensated participation elasticity is equal to the compensated elasticity as long as we consider a change in the price of participation, $(1-a_i)\,w_i$, which keeps the tax-transfer position of a non-participant, $T(0,\theta)$, fixed. That is, the change in the price of participation is generated by a change in the wage or tax-transfer payment for workers.

The definition of the participation elasticity in eq. (18) may be written as

$$\eta_i = p_i(\tilde{q}_i)\,\frac{d\tilde{q}_i}{d\left[(1-a_i)\,w_i\right]}\,\frac{(1-a_i)\,w_i}{P_i(\tilde{q}_i)}, \tag{25}$$

which relates the elasticity to the change in the fixed cost cut-off value. The change in the cut-off value may be found by differentiating eqs (13) and (14) which gives

$$\frac{d\tilde{c}_i}{d\left[(1-a_i)\,w_i\right]} = (1-m_i)\,w_i\frac{d\tilde{h}_i}{d\left[(1-a_i)\,w_i\right]} + \tilde{h}_i, \tag{26}$$

$$\frac{d\tilde{q}_i}{d\left[(1-a_i)\,w_i\right]} = \frac{\partial v_i\left(\tilde{c}_i,\tilde{h}_i\right)}{\partial\tilde{c}_i}\frac{d\tilde{c}_i}{d\left[(1-a_i)\,w_i\right]} + \frac{\partial v_i\left(\tilde{c}_i,\tilde{h}_i\right)}{\partial\tilde{h}_i}\frac{d\tilde{h}_i}{d\left[(1-a_i)\,w_i\right]}, \tag{27}$$

where we have used eq. (10) implying that the consumption level of a non-participant is fixed. By substituting (26) into (27) and using the first-order condition (8), we obtain the change in the fixed cost cut-off:

$$\frac{d\tilde{q}_i}{d\left[(1-a_i)\,w_i\right]} = \frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial \tilde{c}_i}\tilde{h}_i. \tag{28}$$

After inserting this relationship into the definition (25), we have the following expression for the participation elasticity

$$\eta_i = \frac{p_i\left(\tilde{q}_i\right)}{P_i\left(\tilde{q}_i\right)}\frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial \tilde{c}_i}\left(1-a_i\right)w_i\tilde{h}_i. \tag{29}$$

This relationship is used in the derivation of the marginal excess burden of taxation in Appendix B.

To compare the compensated and uncompensated participation elasticities, notice that the uncompensated elasticity may be obtained from the definition (25) by replacing the compensated change in the fixed cost threshold, $d\tilde{q}_i$, with the uncompensated change, $d\bar{q}_i$. The uncompensated change in the threshold may be found by differentiating eqs (4) and (5) with respect to $(1-a_i)\,w_i$. This gives

$$\frac{dc_i}{d\left[(1-a_i)\,w_i\right]} = (1-m_i)\,w_i\frac{dh_i}{d\left[(1-a_i)\,w_i\right]} + h_i, \tag{30}$$

$$\frac{d\bar{q}_i}{d\left[(1-a_i)\,w_i\right]} = \frac{\partial v_i\left(c_i, h_i\right)}{\partial c_i}\frac{dc_i}{d\left[(1-a_i)\,w_i\right]} + \frac{\partial v_i\left(c_i, h_i\right)}{\partial h_i}\frac{dh_i}{d\left[(1-a_i)\,w_i\right]}, \tag{31}$$

where we have assumed that $c_i^0 = T\left(0, z\right)$ is fixed, i.e., the change in the price of participation is generated by a change in the wage or tax-transfer payment for workers. After substituting (30) into (31) and using the first-order condition (3), we obtain

$$\frac{d\bar{q}_i}{d\left[(1-a_i)\,w_i\right]} = \frac{\partial v_i\left(c_i, h_i\right)}{\partial c_i}h_i.$$

This uncompensated change in the fixed cost threshold is equal to the compensated change in eq. (28) because both changes are evaluated at the actual utility level where $(c_i, h_i) = \left(\tilde{c}_i, \tilde{h}_i\right)$. Thus, the uncompensated participation elasticity is equal to the compensated elasticity as long as we are considering a change in $(1-a_i)\,w_i$, which is generated by a change in the wage or tax-transfer payment for workers.

B Derivation of the Marginal Excess Burden in Eq. (23)

We start by deriving the effect of the reform on the number of working hours, $d\tilde{h}_i/d\theta$, and on the labor market participation rate, $dP_i\left(\tilde{q}_i\right)/d\theta$. The impact on the number of working hours is found by differentiating the compensated labor supply function $\tilde{h}_i\left(\left(1-m_i\right)w_i, v_i\right)$. This gives

$$\frac{d\tilde{h}_i}{d\theta} = -\frac{\partial \tilde{h}_i\left(\left(1-m_i\right)w_i, v_i\right)}{\partial\left[\left(1-m_i\right)w_i\right]} w_i \frac{\partial m_i}{\partial\theta} = -\frac{1}{1-m_i}\tilde{h}_i \frac{\partial m_i}{\partial\theta}\cdot\varepsilon_i, \qquad (32)$$

where the last equality follows from the definition of the hours-elasticity in eq. (17).

To derive the impact on labor market participation, we first analyze how the fixed cost cut-off value is affected by the reform. The change in the cut-off may be found by differentiating eqs (13) and (14) which gives

$$\frac{d\tilde{c}_i}{d\theta} = \left(1-m_i\right)w_i\frac{d\tilde{h}_i}{d\theta} - w_i\tilde{h}_i\frac{\partial a_i}{\partial\theta}, \qquad (33)$$

$$\frac{d\tilde{q}_i}{d\theta} = \frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial\tilde{c}_i}\frac{d\tilde{c}_i}{d\theta} + \frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial\tilde{h}_i}\frac{d\tilde{h}_i}{d\theta}, \qquad (34)$$

where we have used eq. (10) and the definition $\partial a_i/\partial\theta \equiv \left[\frac{\partial T(w_i h_i,\theta)}{\partial\theta} - \frac{\partial T(0,\theta)}{\partial\theta}\right]/\left(w_i h_i\right)$. By substituting (33) into (34) and using the first-order condition (8), we obtain

$$\frac{d\tilde{q}_i}{d\theta} = -\frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial\tilde{c}_i} w_i\tilde{h}_i\frac{\partial a_i}{\partial\theta}.$$

This change in the fixed cost threshold may be converted into a change in the participation rate through the relationship $dP_i\left(\tilde{q}_i\right)/d\theta = p_i\left(\tilde{q}_i\right)\cdot d\tilde{q}_i/d\theta$. This implies

$$\frac{dP_i\left(\tilde{q}_i\right)}{d\theta} = -p_i\left(\tilde{q}_i\right)\frac{\partial v_i\left(\tilde{c}_i, \tilde{h}_i\right)}{\partial c_i} w_i\tilde{h}_i\frac{\partial a_i}{\partial\theta} = \frac{1}{1-a_i}P_i\left(\tilde{q}_i\right)\frac{\partial a_i}{\partial\theta}\cdot\eta_i, \qquad (35)$$

where the last equality follows from the relationship (29).

Finally, the expression for the marginal excess burden in (23) may be obtained by substituting eqs (32) and (35) into (22) and dividing by aggregate labor income.

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TABLE 1
FEDERAL INCOME TAX AND EITC PARAMETERS, 1984-2002

Year	Federal Income Tax Parameters		EITC Parameters			
	[lowest, highest marginal tax rate)] (number of brackets)	Personal Exemption, Standard Deduction[a/, b/]	Phase-In Rate	Maximum Credit	Phase-Out Rate	Maximum Earnings
			(family with one child; family two or more children)			
1984	[0.000; 0.500] (15)	$1,000 ; $0	0.100	$500	0.125	$10,000
1985	[0.000; 0.500] (15)	$1,040 ; $0	0.110	$550	0.122	$11,000
1986	[0.000; 0.500] (15)	$1,080 ; $0	0.110	$550	0.122	$11,000
TRA86						
1987	[0.110; 0.390] (5)	$1,900 ; $2,540	0.140	$851	0.100	$15,432
1988	[0.150; 0.330] (2)	$1,950 ; $4,400	0.140	$874	0.100	$18,576
1989	[0.150; 0.330] (2)	$2,000 ; $4,550	0.140	$910	0.100	$19,340
1990	[0.150; 0.330] (2)	$2,050 ; $4,750	0.140	$953	0.100	$20,264
OBRA90 [c/]						
1991	[0.150; 0.310] (3)	$2,150 ; $5,000	0.167; 0.173	$1,192; $1,235	0.119; 0.124	$21,250
1992	[0.150; 0.310] (3)	$2,300 ; $5,250	0.176; 0.184	$1,324; $1,384	0.126; 0.130	$22,370
1993	[0.150; 0.396] (5)	$2,350 ; $5,450	0.185; 0.195	$1,434; $1,511	0.132; 0.139	$23,050
OBRA93 [d/]						
1994	[0.150; 0.396] (5)	$2,450 ; $5,600	0.263; 0.300	$2,038; $2,526	0.160; 0.177	$23,755; $25,296
1995	[0.150; 0.396] (5)	$2,500 ; $5,750	0.340; 0.360	$2,094; $3,110	0.160; 0.202	$24,396; $26,673
1996	[0.150; 0.396] (5)	$2,550 ; $5,900	0.340; 0.400	$2,152; $3,556	0.160; 0.211	$25,078; $28, 495
1997	[0.150; 0.396] (5)	$2,650 ; $6,050	0.340; 0.400	$2,210; $3,656	0.160; 0.211	$25,750; $29,290
2000	[0.150;0.391] (5)	$2,900; $6,650	0.340; 0.400	$2,353; $3,888	0.160; 0.211	$27,450; $31,152
EGTRRA2001						
2001	[0.100; 0.386] (5)	$3,000 ; $6,900	0.263; 0.300	$2,428; $4,008	0.160; 0.211	$28,250; $32,100
2002	[0.100; 0.386] (6)	$3,050 ; $7,000	0.340; 0.360	$2,547; $4,204	0.160; 0.211	$30,200; $33,150

a/ The standard deductions are given for head of household tax return.
b/ In 1984-1986, there were no standard deductions because of the zero bracket. The 15 brackets include the zero bracket.
c/ Basic EITC only. Does not include supplemental young child credit or health insurance credit.
d/ Introduced a small benefit for taxpayers with no qualifying children, phased-in at 0.0765 up to a maximum credit of $306.

Source: The Green Book and authors' calculations from Internal Revenue Service (IRS) forms and publications.

TABLE II

Tax-benefit parameters: sample averages and standard deviations for the group of single mothers

Tax-benefit parameters	1986 reform	1990 reform	1993 reform	2001 reform
Marginal tax rate				
- without benefits	0.259 (0.164)	0.221 (0.176)	0.185 (0.211)	0.236 (0.284)
- with benefits	0.500 (0.161)	0.426 (0.141)	0.443 (0.169)	0.370 (0.200)
Average tax rate				
- without benefits	0.145 (0.105)	0.089 (0.088)	0.043 (0.099)	-0.040 (0.177)
- with benefits	0.566 (0.094)	0.492 (0.092)	0.455 (0.094)	0.318 (0.144)
Tax ratio				
- intensive margin	1.945 (6.034)	0.941 (2.102)	1.088 (3.580)	0.779 (1.346)
- extensive margin	1.578 (3.204)	1.067 (1.491)	0.896 (0.389)	0.577 (1.742)
Effect of Tax Act				
- marginal tax rate	-0.059 (0.095)	-0.016 (0.052)	-0.036 (0.143)	-0.033 (0.065)
- average tax rate	-0.076 (0.029)	-0.054 (0.015)	-0.128 (0.077)	-0.023 (0.014)

Note: The marginal tax rates, average tax rates, and tax ratios are calculated for pre-reform years (1985, 1990, 1993, 2000). Tax parameters without benefits are calculated using NBER's tax simulation model (TAXSIM). The marginal tax rate includes federal, state and social security payroll rates. The average tax rate is derived by first calculating the TAXSIM federal, state and social security tax liability when an individual is working and not working, respectively. Afterwards, we derive the average tax rate by calculating the difference in tax liabilities between working and not working and divide the difference by earnings. The tax rates with benefits include cash assistance (AFDC), food stamps and medicaid adjusted for an empirical 54% take-up rate. Each parameter is calculated as an average for all individuals in the sample. The tax ratios are derived by calculating the average over the individuals of $t/(1-t)$ where t is the relevant tax rate of the individual. The tax ratios include benefits. The changes in the marginal and average tax rates reflect only changes at the federal level. These changes are calculated as the difference between the post and pre reform rates. The post reform tax rate is imputed for federal tax rules that apply in 1988, 1993, 1996 and 2002, respectively, to allow for the phase-in of the reforms. The data come from the March Current Population Survey. Numbers in parentheses are standard deviations.

TABLE III

Welfare effects from the changed taxation of single mothers

Hours-of-work elasticity equal to 0.1 and participation elasticity equal to 0.4

	The welfare gain from tax reform				Reduction in	Welfare gain per $ spent	
Tax reform	Intensive	Extensive	Total	"Traditional"	tax burden	Total	Extensive
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1986 reform	1.64	5.45	7.09	8.19	7.94	9.38	3.19
1990 reform	0.02	1.91	1.94	0.11	4.47	1.76	1.75
1993 reform	-0.36	2.68	2.33	-1.78	7.93	1.42	1.51
2001 reform	0.35	0.78	1.12	1.73	2.75	1.69	1.39

Note: The welfare gain is measured in percentage of wage income and is calculated using equation (23) in the text. The total welfare gain is calculated as the sum of the intensive and extensive gains. The "traditional" welfare gain is calculated assuming that the total labor supply elasticity is entirely along the intensive margin. The reduction in tax burden measures the decrease in tax liabilities in percentage of wage income and before any behavioral responses. The welfare gain per dollar spent equals RTB/(RTB-EG) where EG is the efficiency gain and RTB is the reduction in tax burden. Data come from the March Current Population Survey.

TABLE IV
Welfare effects from the changed taxation of single mothers
Different scenarios for the size and composition of elasticities

	Elasticity scenario			The welfare gain from tax reform				Welfare gain
	ε	η	Total	Intensive	Extensive	Total	"Traditional"	per $ spent
1986 reform								
Low	0.05	0.20	0.25	0.82	2.73	3.54	4.09	1.81
Middle	0.10	0.40	0.50	1.64	5.45	7.09	8.19	9.38
High	0.15	0.60	0.75	2.46	8.18	10.63	12.28	Laffer
Identical	0.25	0.25	0.50	4.09	3.41	7.50	8.19	18.27
1990 reform								
Low	0.05	0.20	0.25	0.01	0.96	0.97	0.06	1.28
Middle	0.10	0.40	0.50	0.02	1.91	1.94	0.11	1.76
High	0.15	0.60	0.75	0.03	2.87	2.91	0.17	2.85
Identical	0.25	0.25	0.50	0.06	1.20	1.25	0.11	1.39
1993 reform								
Low	0.05	0.20	0.25	-0.18	1.34	1.16	-0.89	1.17
Middle	0.10	0.40	0.50	-0.36	2.68	2.33	-1.78	1.42
High	0.15	0.60	0.75	-0.53	4.02	3.49	-2.67	1.79
Identical	0.25	0.25	0.50	-0.89	1.68	0.79	-1.78	1.11
2001 reform								
Low	0.05	0.20	0.25	0.17	0.39	0.56	0.86	1.26
Middle	0.10	0.40	0.50	0.35	0.78	1.12	1.73	1.69
High	0.15	0.60	0.75	0.52	1.17	1.68	2.59	2.57
Identical	0.25	0.25	0.50	0.86	0.49	1.35	1.73	1.96

Note: The welfare gain is measured in percentage of wage income and is calculated using equation (23) in the text. The parameter ε denotes the hours-of-work elasticity with respect to the net-wage, while η is the participation elasticity with respect to the net-income gain of participation. The total welfare gain is calculated as the sum of the intensive and extensive gains. The "traditional" welfare gain is calculated assuming that the total labor supply elasticity is entirely along the intensive margin. The welfare gain per dollar spent equals RTB/(RTB-EG) where EG is the efficiency gain and RTB is the reduction in tax burden in Table II. A Laffer curve effect arises if EG>RTB implying that the reduction in tax burden creates a net-tax revenue. Data come from the March Current Population Survey.

TABLE V
Tax/benefit parameters and welfare effects by income groups: 1986 reform
Hours-of-work elasticity equal to 0.1 and participation elasticity equal to 0.4

	Phase-in <5000	Plateau 5000-6500	Phase-out 6500-11000	Beyond >11000	Aggregate
Group shares					
Population	0.34	0.14	0.37	0.15	1.00
Wage income	0.10	0.09	0.46	0.35	1.00
Tax/benefit parameters					
Marginal tax rate	0.52	0.54	0.52	0.38	0.50
Average tax rate	0.55	0.54	0.58	0.59	0.57
Change in marginal tax rate	-0.05	-0.11	-0.07	0.01	-0.06
Change in average tax rate	-0.06	-0.08	-0.10	-0.06	-0.08
Welfare gain					
Intensive	0.08	0.34	1.19	0.02	1.64
Extensive	0.31	0.40	3.07	1.67	5.45
Total	0.40	0.74	4.26	1.69	7.09

Note: The marginal tax rate and the average tax rate incorporate benefits. See notes to Table II and III for explanation of calculations. The decomposition into different income groups is determined by the income thresholds in the Earned Income Tax Credit in 1985. Data come from the March Current Population Survey.

TABLE VI

Tax/benefit parameters and welfare effects by income groups: 1990 reform

Hours-of-work elasticity equal to 0.1 and participation elasticity equal to 0.4

	Phase-in <6810	Plateau 6810-10730	Phase-out 10730-20264	Beyond >20264	Aggregate
Group shares					
Population	0.34	0.28	0.33	0.04	1.00
Wage income	0.12	0.24	0.51	0.13	1.00
Tax/benefit parameters					
Marginal tax rate	0.43	0.41	0.45	0.35	0.43
Average tax rate	0.50	0.45	0.52	0.50	0.49
Change in marginal tax rate	-0.05	-0.01	0.01	0.01	-0.02
Change in average tax rate	-0.07	-0.06	-0.04	-0.02	-0.05
Welfare gain					
Intensive	0.05	0.02	-0.04	-0.01	0.02
Extensive	0.30	0.52	0.98	0.11	1.91
Total	0.35	0.54	0.94	0.11	1.94

Note: The marginal tax rate and the average tax rate incorporate benefits. See notes to Table II and III for explanation of calculations. The decomposition into different income groups is determined by the income thresholds in the Earned Income Tax Credit in 1990. Data come from the March Current Population Survey.

TABLE VII
Tax/benefit parameters and welfare effects by income groups: 1993 reform
Hours-of-work elasticity equal to 0.1 and participation elasticity equal to 0.4

	Phase-in <7750	Plateau 7750-12200	Phase-out 12200-23050	Beyond >23050	Aggregate
Group shares					
Population	0.41	0.28	0.27	0.04	1.00
Wage income	0.14	0.25	0.46	0.15	1.00
Tax/benefit parameters					
Marginal tax rate	0.36	0.41	0.59	0.48	0.44
Average tax rate	0.44	0.40	0.51	0.54	0.46
Change in marginal tax rate	-0.14	0.04	0.05	0.03	-0.04
Change in average tax rate	-0.19	-0.13	-0.05	-0.02	-0.13
Welfare gain					
Intensive	0.11	-0.11	-0.32	-0.04	-0.36
Extensive	0.80	0.88	0.88	0.11	2.68
Total	0.91	0.77	0.57	0.07	2.33

Note: The marginal tax rate and the average tax rate incorporate benefits. See notes to Table II and III for explanation of calculations. The decomposition into different income groups is determined by the income thresholds in the Earned Income Tax Credit in 1993. Data come from the March Current Population Survey.

TABLE VIII
Tax/benefit parameters and welfare effects by income groups: 2001 reform
Hours-of-work elasticity equal to 0.1 and participation elasticity equal to 0.4

	Phase-in <6950	Plateau 6950-12700	Phase-out 12700-27413	Beyond >27413	Aggregate
Group shares					
Population	0.13	0.32	0.48	0.07	1.00
Wage income	0.04	0.21	0.58	0.17	1.00
Tax/benefit parameters					
Marginal tax rate	0.14	0.27	0.50	0.40	0.37
Average tax rate	0.24	0.21	0.39	0.48	0.32
Change in marginal tax rate	0.00	-0.05	-0.04	0.00	-0.03
Change in average tax rate	-0.01	-0.01	-0.03	-0.03	-0.02
Welfare gains					
Intensive	0.00	0.09	0.25	0.01	0.35
Extensive	0.00	0.04	0.57	0.17	0.78
Total	0.01	0.13	0.82	0.17	1.12

Note: The marginal tax rate and the average tax rate incorporate benefits. See notes to Table II and III for explanation of calculations. The decomposition into different income groups is determined by the income thresholds in the Earned Income Tax Credit in 2000. Data come from the March Current Population Survey.

TABLE IX
Welfare Effects with a Decreasing Profile for the Participation Elasticity

	Phase-in	Plateau	Phase-out	Beyond	Aggregate
Elasticities					
Hours	0.10	0.10	0.10	0.10	0.10
Participation	0.60	0.40	0.30	0.10	0.40
Welfare gain of 1986 reform					
Intensive	0.08	0.34	1.19	0.02	1.64
Extensive	0.47	0.40	2.30	0.42	3.59
Total	0.55	0.74	3.49	0.44	5.22
Welfare gain of 1990 reform					
Intensive	0.05	0.02	-0.04	-0.01	0.02
Extensive	0.45	0.52	0.74	0.03	1.73
Total	0.50	0.54	0.70	0.02	1.76
Welfare gain of 1993 reform					
Intensive	0.11	-0.11	-0.32	-0.04	-0.36
Extensive	1.21	0.88	0.66	0.03	2.78
Total	1.31	0.77	0.35	-0.01	2.43
Welfare gain of 2001 reform					
Intensive	0.00	0.09	0.25	0.01	0.35
Extensive	0.00	0.04	0.43	0.04	0.51
Total	0.01	0.13	0.67	0.05	0.86

Note: The decomposition into different income groups is determined by the income thresholds in the Earned Income Tax Credit before the reform. The 'aggregate' labor supply elasticities in the last column measure the average over the population and over the four reforms.

Figure I
Labor Force Participation of Unmarried Females: 1989-2000

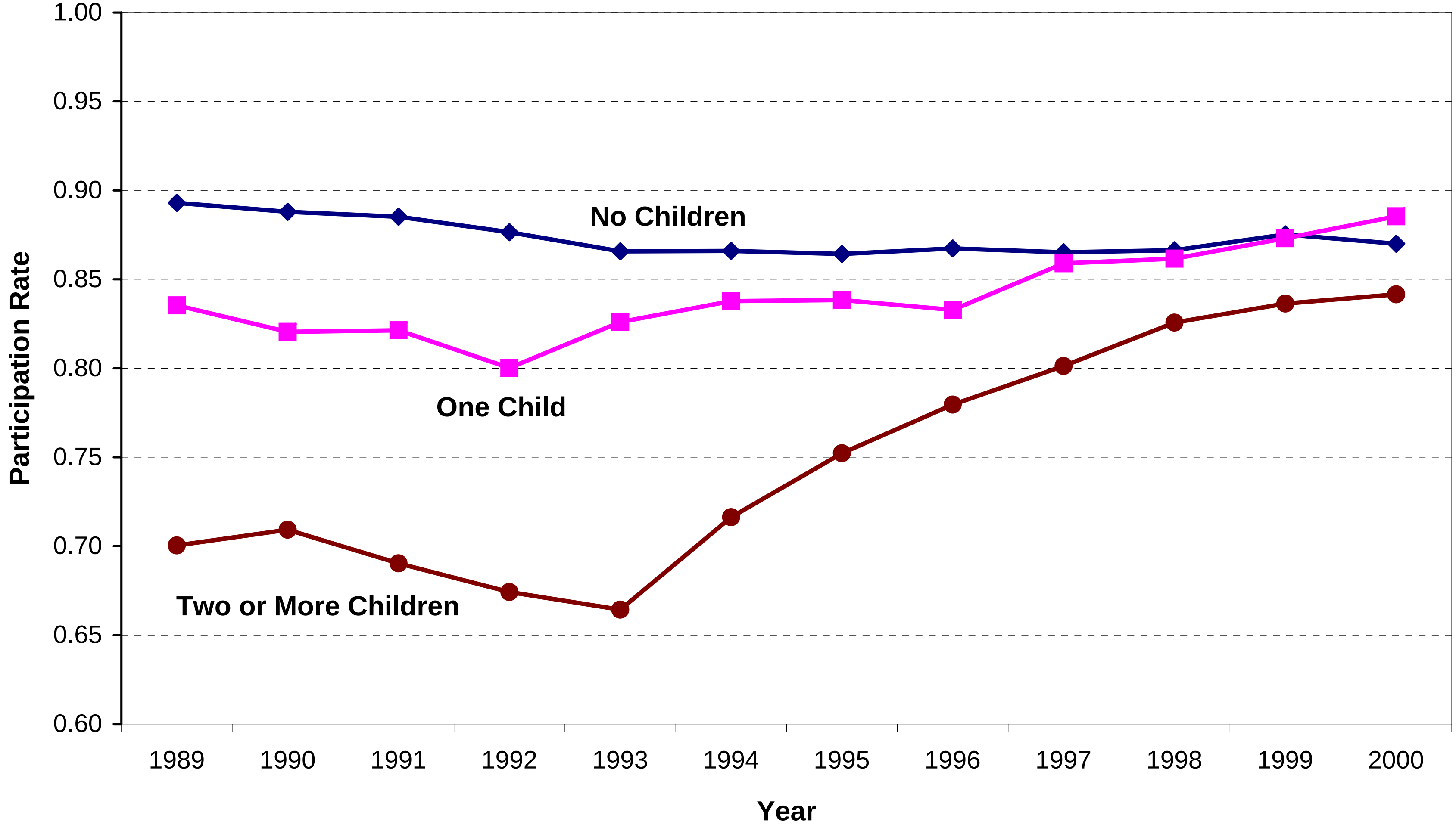
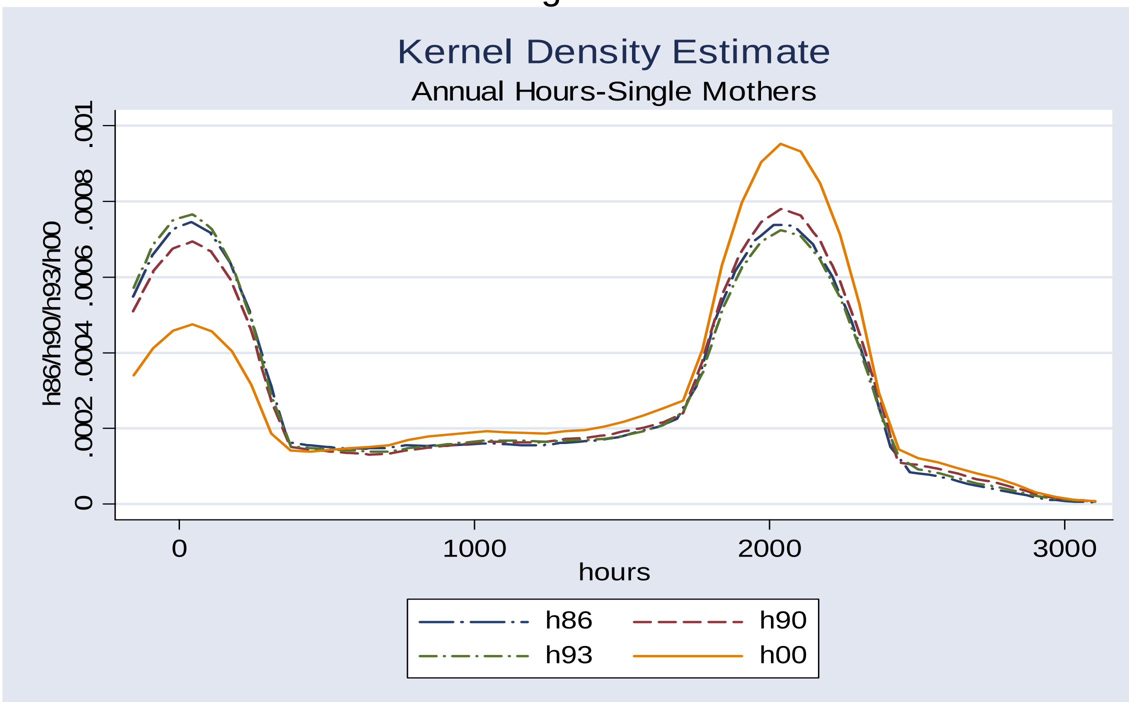


Figure II



Kernel Density Estimate
Annual Hours-Single Mothers
h86/h90/h93/h00
0
.0002
.0004
.0006
.0008
.001
0
1000
2000
3000
hours
h86
h90
h93
h00

TABLE A1
Summary statistics: single mothers in the United States

	1986 reform	1990 reform	1993 reform	2001 reform
Age	32.04 (7.75)	32.91 (7.77)	32.98 (7.79)	33.44 (8.15)
Education	12.96 (2.38)	12.31 (2.36)	39.05 (2.31)*	39.32 (2.32)*
Black	0.321 (0.467)	0.345 (0.475)	0.338 (0.473)	0.315 (0.464)
Non-white	0.021 (0.142)	0.023 (0.151)	0.031 (0.172)	0.037 (0.188)
Number of children	1.94 (1.10)	1.77 (0.99)	1.78 (1.0)	1.74 (0.93)
Labor force participation	0.707 (0.455)	0.72 (0.447)	0.697 (0.459)	0.830 (0.376)
Annual hours worked	1142 (961)	1219 (969)	1148 (970)	1426 (903)
Wage and salary income	$7,922 (9,210)	$10,390 (11,642)	$10,572 (12,740)	$16,430 (19,526)
Non-labor income	$2,756 (4,605)	$3,277 (5,742)	$3,553 (5,912)	$3,961 (7,740)
Gross hourly wage	$6.53 (4.43)	$7.85 (5.49)	$8.68 (7.00)	$11.24 (10.68)**
Observations	4,498	4,850	5,011	4,072

Note: Authors' tabulations of the March Current Population Survey. Sample includes unmarried mothers age 18-49. See text for further sample selection. Non-labor income is calculated as the difference between total income and earnings, and therefore includes income for various sources such as welfare assistance, capital income, social security income and workers' compensation. The wage is defined for workers only. Standard errors are in paranthesis. All monetary amounts are in nominal dollars. * Eduction recode in CPS-need to edit; ** wage topcoded at $200.