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Employment, Hours of Work and the Optimal Design of Earned Income Tax Credits

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Abstract

This paper examines the optimal schedule of marginal tax rates and the design of earned income tax credits. The analysis is based on a structural labour supply model which incorporates unobserved heterogeneity, fixed costs of work and the detailed non-convexities of the tax and transfer system. An analytical framework is developed that allows explicitly for an extensive margin in work choices and also the partial observability of hours of work. This is contrasted to the standard case in which only earnings (and non-labour income) are observable to the government. The empirical motivation is the earned income tax credit reforms in Britain which include a minimum hours requirement at 16 hours per week and a further bonus at 30 hours. Our analysis examines the case for the use of hours-contingent payments and lends support for the overall structure of the British tax credit reforms. However, we also provide a strong case for a further reduction of marginal rates for lower earners but only those with school age children.

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1 Introduction

The empirical analysis of labour supply behaviour has strong implications for the design of tax policy. Our aim here is to use microeconometric estimates of labour supply responses to assess the design of earned income tax credit reforms. These reforms are directed towards addressing low labour market attachment and low wages of lower skilled workers. Over the last two decades these policies have grown substantially in the UK and in the US. Our objective is to examine the appropriateness of their design. In both the US and the UK, they are now one of the key programmes directed at low income working age families. In the US, for example, recipients grew from 6 million in 1985 to 19.2 million in tax year 2003, with the expenditure on the tax credit having risen in 2003 prices from $5 billion to $34 billion over the same period.[1] In the UK over the last decade there has been a similar emphasis on the expansion of earned income tax credit policies with the expenditure rising from around £1 billion in 2002 prices at the beginning of the 1990s to £2.68 billion in 1999, and further to £6.46 billion by 2002.

With increased interest in the labour supply responsiveness of individuals eligible for such tax-credits, certain common and robust features of estimated labour supply responses for lower skilled workers have emerged from recent empirical analysis. Specifically, the importance of distinguishing between the intensive margin where hours worked per week are chosen and the extensive margin where the work decision is made. In this research the labour supply elasticities appear to be much larger at the extensive margin, at least for certain types of individuals, see Blundell and MaCurdy (1999).

In parallel with the emergence of these empirical regularities, the literature on the design of tax and transfer systems has increasingly focussed on the use of work conditions, see Beaudry, Blackorby and Szalay (2006), Besley and Coate (1992), Chone and Laroque (2005), Laroque (2005), Moffitt (2006), Phelps (1994) and Saez

[1] Green Book, 2004, Joint Committee on Taxation, Ways and Means Committee, Washington, US.

(2001, 2002). Our analysis is closest in spirit to that by Saez who, building on earlier work by Diamond (1980), is able to show that tax credits can be optimal within a Mirrlees (1971) framework once the distinction between the extensive margin and intensive margin of labour supply is acknowledged. Indeed, Saez (2002) derives optimal design formula in terms of representative labour supply elasticities at the extensive and intensive margin. Recently, Immervol *et al.* (2006) implement this approach and suggest that for reasonable welfare weights, tax credits would be an optimal policy across a wide set of economies. As part of the Mirrlees Review, Brewer, Shephard and Saez (2008) use this approach to explore the taxation of families in the UK.

The contribution of this paper is twofold. First, we take the structural model of employment and hours of work seriously in designing the structure of taxes and transfers, allowing the distribution of earnings, fixed costs of work, demographic differences and unobserved heterogeneity to influence the choice of tax policy. Second, we consider the case where hours of work are partially observable to the tax authorities and contrast this to the case where only earnings and employment are observable.

This increasing reliance on tax-credit policies, especially in the UK and the US, reflects the secular decline in the relative wages of low skilled workers with low labour market attachment together with the growth in one-parent households (see Blundell (2001) and references therein). Figure 1(a) presents the historic time series of employment rates for women in Britain distinguished by demographic status. Single women and married women without children have maintained a strong attachment to the labour market since the late 1970s and display only small business cycle variation. The employment rate of married women with children showed a more marked impact of the early 1980s recession but then a strong secular increase in employment. Single mothers, on the other hand, showed little or no recovery from the 1980s recession until later in the 1990s.

It was this persistent low employment rate for single mothers in Britain that triggered the tax credit expansions of the late 1990s. The policy context for this paper is the resulting Working Families' Tax Credit (WFTC) reform in 1999.[2] This reform had the aim of creating a tax and transfer schedule for working families that reflected many of the key characteristics of earned income tax credit policies. It was targeted at low income families and had a work condition for eligibility. A novel feature of the UK system is that it makes use of hours conditions in addition to an earnings condition. Specifically WFTC is unavailable to parents who record less than 16 hours of work per week. Moreover there is a bonus for working 30 hours.

The evidence that tax credit policies encourage work is quite compelling (see Blundell and Hoynes (2004) for a review). The positive impact on employment has been found to be particularly strong for single mothers. This has been shown using a variety of evaluation methods, from the study of Eissa and Leibman (1998) which used a difference-in-differences strategy to examine the 1986 EITC expansion in the US, to a the experimental evidence on the Canadian Self Sufficiency Program (Card and Robins (1998)). In this paper we consider the optimal design of such tax credits and argue that structural labour supply models provide a natural framework for considering problems related to the optimality of the tax and transfer schedule.

To assess optimality we need robust estimates of elasticities at extensive (participation) and intensive (hours and weeks of work). These are structural parameters. However, structural models are necessarily based on a large set of economic and statistical assumptions. Quasi-experimental or experimental estimates can be argued to provide more robust estimates with fewer assumptions (see Blundell and Costa-Dias (2000), for example). The drawback of such approaches is that they recover particular treatment effects from specific policy reforms which bare only indirect relation to the parameters required for an optimal design problem of the type considered here. We use the comparison of average impact effects from the structural and quasi-experimental approaches to provide some evidence of the reliability of the structural

[2]In April 2003, support for families with children was reformed again when Child Tax Credit and Working Tax Credit were introduced, and WFTC, amongst other things, abolished. These new credits were more generous than the programmes they replaced, and more closely integrated with the annual income tax system.

model specification. We then use the resulting structural model to examine the optimality of tax credit design. The structural model we develop allows for discrete choices over non-linear budget constraints and fixed costs of work to reexamine the optimal design problem. The model specification builds on the earlier work of Hoynes (1996), Keane and Moffitt (1998), Blundell *et al.* (2000) and van Soest *et al.* (2002).

An interesting feature of the British tax and benefit system is the close interaction between means tested benefits, tax credits and taxes more generally. The level of tax credit receipt is based on net (rather than gross) family income. In comparison the US EITC depends on gross family income. Consequently, in the British system, the impact of a tax credit reform can be dulled by interaction with other taxes and benefits. These interactions change the overall shape of the budget constraint relative to a standard tax credit reform and force us to take an integrated view of the way *all* the elements of the tax and benefit system changes the incomes of families and the incentives to work. We show that this is important when assessing the impact and design of the reform to allow for the interaction with other benefits and taxes. Indeed our ex-ante structural evaluation results for the WFTC reform in Britain showed smaller effects than may have been expected. But we are able to show that the smaller impact is due to interaction of WFTC with other taxes/benefits and the rise in family allowances which are given without a work condition, rather than 'small' response elasticities.

Our empirical analysis suggests that lone parents with very young children are much less responsive to changes in financial work incentives than are lone parents with children of school age. In the former case - where the marginal value of leisure is high - it is better to offer reasonable levels of income support together with higher marginal tax rates when in work. In the latter case, where the children are older and where leisure is valued less highly, it is more desirable to have a lower level of income support and lower marginal tax rates to encourage them to work. Demographic heterogeneity is therefore important, and we argue that to the extent that individuals do differ in how responsive they are to changes in financial work incentives it may appear desirable from an optimality perspective to reflect this in the design of the tax and transfer system.

Motivated by the use of hours based eligibility criteria in the current British tax credit system, our simulations also explore the use of hours rules as an instrument to potentially improve the design of the tax and transfer system. While many theoretical models rule out the observability of hours of work, we assume that the tax authority is able to *partially* observe hours of work, and is therefore able to condition an additional payment on such information. When the tax authorities can only observe earnings, it is unable to infer whether an individual with a given level of earnings is low wage-high hours type, or high wage-low hours type. If such hours information is at least partially observable, the incentive compatibility constraints are relaxed which then allows the government to implement a tax schedule that improves social welfare. We begin by considering the case where the authorities can observe whether individuals are working at least 16 hours a week (but conditional on this, not how many hours). This minimum hours condition at 16 hours per week is used in the current British tax credit system. For lone parents with children who are of school age we obtain an optimal hours bonus that is sufficiently large such that it implies a negative participation tax rate at 16 hours provided that the lone parents' wage is not too high. However, the improvement in social welfare we obtain by this hours conditioning is found to be only very modest in size. We proceed to investigate where an optimal hours rule may be placed, and present an empirical case for an hours bonus for full time work. While this is found to be a more effective instrument, the welfare gains remain modest. Finally, we consider the structure of the constraint when the government can distinguish between full-time and part-time work.

The rest of the paper is as follows. In the next section we develop the analytical framework for optimal design within a stochastic structural labour supply model. In section 3 we outline the WFTC reform in the UK and its impact on work incentives. Section 4 outlines the structural microeconometric model with heterogeneity and fixed costs of work. In section 5 we describe the data and labour supply estimates. We also assess the robustness of the structural model estimates using a quasi-experimental comparison. Section 6 uses these model estimates to derive optimal schedules. We provide evidence for lowering the marginal rates at lower incomes and also document the importance of allowing the tax schedule to depend on the age of children. We also discuss how introducing hours rules affects tax credit design, and how important these are likely to be in terms of social welfare. Finally, section 7 concludes.

2 The Optimal Design Problem

The policy analysis here concerns the choice of a tax schedule in which the government is attempting to allocate a fixed amount of revenue R to a specific demographic group - single mothers - in a way which will maximise the social welfare for this group. Such a schedule optimally balances redistributive objectives with efficiency considerations for single mothers. Redistributive objectives are represented through the social welfare function defined as the sum of transformed individual utilities, where the transformation reflects the desire for equality.

In this section we develop an analytical framework for the design of tax and transfer policy that allows for two scenarios. In the first only earnings are observable by the tax authority, in the second we allow for partial observability of hours of work. Rather than assuming that individuals can freely choose their hours, we suppose that only a finite number of hours choices are available. With a total of J hours points available, we index these different hours h_j, or states, by $j \in \mathbf{J} = \{0, 1, \ldots, J\}$, with $j = 0$ representing non-employment.

The formulation of the optimal tax design problem will depend upon what information is observable to the government. We always assume that the government can observe earnings wh_j and worker characteristics X, and we shall also allow for the possibility of observing some hours of work information. Rather than necessarily observing the actual hours h_j that are chosen, the government is assumed to only be able to observe that they belong to the subset $\mathbf{h_j}$ with $h_j \subseteq \mathbf{h_j} \subseteq \mathbf{h} = \{h_1, \ldots, h_J\}$.[3] If we have $\mathbf{h_j} = \mathbf{h_{j'}}$ for $j \neq j'$ then the government is unable to distinguish between the distinct hours choices h_j and $h_{j'}$. Two important special cases are when $\mathbf{h_j} = h_j$ for all j (hours are perfectly observable), and when $\mathbf{h_j} = \mathbf{h}$ for all j (no hours information is conveyed). If hours of work are partially observable to the government within this framework then it will be optimal to condition on them.

Work decisions by individuals are determined by their preferences over labour hours and consumption, as well as the fixed costs of work they face and the tax and transfer system. Preferences are indexed by observable characteristics X, including the number and age of her children, and unobservable characteristics ε with distribution $dF(\varepsilon)$. We let $U(c, h_j; X, \varepsilon)$ represent the utility of a single mother who consumes c and works h_j hours. We will assume that she consumes her net income which comprises the product of hours of work h and the gross hourly wage w plus non-labour income and transfer payments, less taxes paid and fixed costs of work C.

Fixed costs of work are only paid if work takes place $j > 0$, and this is represented by the indicator function $1\{j > 0\}$. For the purposes of the discussion here we simplify this to $wh_j - T(wh_j, \mathbf{h_j}; X) - C \cdot 1\{j > 0\}$ where $T(wh_j, \mathbf{h_j}; X)$ is the net tax-transfer schedule which subsumes other income and is written as a function of the w, hours of work h_j and a set of observable characteristics X. Hours of work are then chosen by maximising $U(c, h_j; X, \varepsilon)$ subject to $c \equiv wh_j - T(wh_j, \mathbf{h_j}; X) - C \cdot 1\{j > 0\}$. Although we represent fixed costs of work through the single variable C, in the empirical analysis we will use a richer specification that allows for fixed costs to differ between part-time and full-time work and to depend on observable and unobservable characteristics.

In the empirical analysis individual utilities $U(c, h_j; X, \varepsilon)$ will be described by a parametric utility function and a parametric distribution of unobserved heterogeneity ε. The parameters of the utility function and the distribution of unobservables are identified up to some monotonic transformation through observed choices of single

[3]Since h_j is always contained in $\mathbf{h_j}$ we view the problem as one of partial observability rather than measurement error.

mothers. These parameters are estimated from a representative sample of single mothers from the UK described further below. Each single mother is assumed to choose the state $j \in \mathbf{J}$ that maximises her utility. Hours choices are such that (taking T and C as given) hours of work h_j are chosen to maximise their utility

$$h^* = \arg\max_{h_j} \{U(wh_j - T(wh_j, \mathbf{h_j}; X) - C \cdot 1\{j > 0\}, h_j; X, \varepsilon)\}^{j=0,1...J}.$$

Note that while ε is observed by the individual, it is not observable by the econometrician. In the empirical application we shall make a number of assumptions regarding its distribution.

Social welfare W is represented by the sum of transformed utilities

$$W = \int_{w,X} \int_{\varepsilon} \Gamma(U(wh^* - T(wh^*, \mathbf{h}^*; X) - C, h; X, \varepsilon))dF(\varepsilon)dG(X, w) \tag{1}$$

where hours of work are evaluated at their chosen value as a function of ε, X and w. For a given cardinal representation of U, the utility transformation function Γ in (1) determines the governments relative preference for the equality (or otherwise) of utilities.[4]

The government maximises W by choosing a tax schedule T. At the optimum, this tax schedule T must satisfy the government budget constraint:

$$\int_{w,X} \int_{\varepsilon} T(wh^*, \mathbf{h}^*; X)dF(\varepsilon)dG(X, w) = \overline{T}(\equiv -R). \tag{2}$$

In our application we will restrict T to belong to a particular parametric class of tax functions. This is discussed in section 6 when we examine the optimal design of the tax and transfer schedule.

3 Tax Credit and 'In Work' Benefit Reforms in the United Kingdom

Programmes to support low-income working families with children (originally labelled "in-work benefits", though the more recent programmes are officially designated tax

[4]Given the presence of preference heterogeneity, a more general formulation would allow the utility transformation function Γ to vary with individual characteristics.

credits) have a long history in the United Kingdom.[5] A peculiar feature of the UK's in-work benefits is that awards depend not just on the earned and unearned income and family characteristics, but also directly on (weekly) hours of work: since their inception, in-work benefits have only been available to families with children who usually work some minimum number of hours a week.

Two in-work benefits were in operation over the period of our sample: Family Credit (FC), which existed from April 1988 until September 1999, and the Working Families' Tax Credit (WFTC), which existed from October 1999 until March 2003. In April 1992, the minimum work requirement in FC fell from 24 to 16 hours a week. The impact of this reform on single parents' labour supply is ambiguous: those working more than 16 hours had an incentive to cut hours to (no less than) 16, while those previously working fewer than 16 hours had an incentive to increase their labour supply to (at least) the new cut-off. In 1995, there was another reform to Family Credit, in the form of an additional (smaller) credit for those adults working full time (defined as 30 or more hours a week). This reform affected the labour supply decisions of lone parents in obvious ways: there was an increased incentive for those working less than 30 hours to increase their hours to 30, but an income effect meant that those already working at least 30 hours had an incentive to cut their hours worked to no less than 30. The overall pattern of hours of work and employment over this period is presented in Figure 1(b). The growth in full time work after 1999 is evident. The distinct impact of the 16 hours incentive is seen clearly by a comparison of the hours distribution for single mothers and single childless women. This is presented in Figure 2 and shows a clear spike at 16 hours for single mothers.

The 1999 WFTC reform which is the focus of our analysis here had a more complicated impact on labour supply. WFTC was more generous than FC in three ways: it had higher credits, particularly those for young children, families could earn more before the benefit began to be withdrawn, and it had a lower withdrawal/taper rate. Table 1 shows the main parameters of FC and WFTC.

[5]For a more detailed discussion see Brewer *et al.* (2006).

Overall, the WFTC reform increased the attractiveness of working 16 or more hours a week compared to working fewer hours. But the last of the three aspects of the reform meant that the biggest income gains were experienced by families just at the end of the FC taper (i.e., families whose earnings had reduced their entitlement to FC just to zero), who tended to be working full time (Blundell *et al.*, 2000). The expected impact of the WFTC reform on lone parents' labour supply, conditional on working 16 or more hours, is as follows: (i) people receiving the maximum FC award will face an income effect away from work, but not below 16 hours a week; (ii) people working more than 16 hours and not on maximum FC will face an income effect away from work (but not below 16 hours a week), and a substitution effect towards work; (iii) people working more than 16 hours and earning too much to be entitled to FC but not WFTC ("windfall beneficiaries") will face income and substitution effects away from work if they claim WFTC (see Blundell and Hoynes, 2004; Brewer *et al.*, 2006).

WFTC, though, is by no means the whole story, when considering how labour supply is affected by tax and transfers. During the period under consideration, there were three other main ways that the UK tax and transfer system provided financial support to adults with dependent children: a flat-rate payment to all families unrelated to their income (known as child benefit); child allowances in welfare benefits (known as income support for lone parents, and income-related Jobseekers Allowance for couples); and a non-refundable income tax credit for parents (known as the children's tax credit), see Brewer (2003).

Many WFTC eligible families also received other means-tested benefits providing assistance with rental housing costs and local taxes (known as housing benefit and council tax benefit respectively), and these interacted with WFTC in a way that meant that families receiving these other benefits gained less from the WFTC reform that otherwise-equivalent families not receiving these benefits. Figure 3 provides a typical illustration of the way the various policies impact on the budget constraint of a low wage single parent.

The last of these is particularly important, and means that the recent UK experience of welfare reform affecting lone parents is very different from that of the US. Simplifying enormously, the US strategy in the 1990s combined an increased earned income tax credit with changes that made it harder for families to claim welfare (whether through time-limits, work requirements or sanctions) in order to produce a substantially stronger financial incentive for lone parents to work.[6] On the other hand, the UK increased welfare benefits and in-work benefits for lone parents by similar amounts, and made hardly any changes to the rules surrounding welfare benefits: in the UK, lone parents remain free to claim welfare benefits with no obligation to engage in job search, education or work-related activities until their youngest child reaches 16.

4 A Structural Labour Supply with Fixed Costs of Work

The labour supply specification develops from earlier studies of structural labour supply that use discrete choice techniques and incorporate non-participation in transfer programmes, specifically Hoynes (1996) and Keane and Moffitt (1998). Our aim is to construct a credible model of labour supply behaviour that adequately allows for individual heterogeneity in preferences and fixed costs. Individuals have preferences defined over consumption c and hours of work h. These preferences will vary with observable characteristics X and unobservable (to the econometrician) characteristics ε. Individuals are assumed to face a budget constraint, determined by a fixed hourly wage and the tax and benefit system, mirroring the optimal tax discussion in section 2. The model specification builds on previous work in Blundell *et al.* (2000) and Brewer *et al.* (2006). We later show that the simulation of the WFTC reform using this specification accords well with the observed employment of single mothers before and after the reform.

[6] see Dickens and Ellwood (2004).

To lay out the model specification in more detail we define $y_{h,P}$ to be the net income available to a particular woman who is employed for h hours and set this equal to consumption. This is computed as the product of hours of work h and the gross hourly wage w (assumed to be generated by a log-linear relationship of the form $\log w = X_w\beta_w + \varepsilon_w$) plus non-labour income and transfer payments, less taxes paid. Without loss of generality, net income can be written as $y_{h,P} = y_h + P \cdot \Psi_h$ where Ψ_h is the net financial gain from receiving in-work benefits, and P is an indicator variable for whether the individual is eligible and participates in the FC/WFTC programme at this choice of hours of work h.

In the estimation results reported here, preferences over hours and consumption are approximated by a second degree polynomial in hours of work and net income:

$$U(y_h, h; X, \varepsilon) = \alpha_{11}{y_h}^2 + \alpha_{22}h^2 + \alpha_{12}y_h h + \beta_1 y_h + \beta_2 h + \varepsilon_h$$

where for each choice of hours, ε_h is a state specific stochastic component assumed to follow a standard (Type-I) extreme-value distribution.[7] The optimal design results that we derive will necessarily depend upon the exact specification of the utility function. Later we present robustness results, showing how our main results are affected when we allow for a higher order approximation of the utility function.

In addition to this state specific heterogeneity term we allow β_1 and β_2, that partially determine the marginal rate of substitution between work and consumption, to depend on observed and unobserved heterogeneity (the latter are denoted by ε_y and ε_l respectively). The α parameters are also allowed to vary with observed heterogeneity. As described in section 2 individuals are assumed to choose from a small subset of hours $\mathbf{h} = \{0, 10, 19, 26, 33, 40\}$, corresponding to the hours ranges 0, 1-15, 16-22, 23-29, 30-36 and 37+ respectively.[8]

[7] This assumption is common: see for example, Blundell *et al.* (1999) and Keane and Moffitt (1998).

[8] Blundell and MaCurdy (1999) give the arguments for modelling labour supply with a discrete choice model. One key advantage is that it easily permits the highly non-convex budget constraints created by welfare benefits and in-work support.

4.1 Fixed Costs of Work

Fixed work-related costs are a key component in the analysis of labour supply and provide an important wedge that separates the intensive and extensive margin. They reflect the actual and psychological costs that an individual has to pay to get to work. We model work-related costs as a fixed, one-off, weekly cost subtracted from net income at positive values of working time, with an additional cost of full-time work (corresponding to thirty or more hours). These unobserved work-related costs (WRC_1 and WRC_2 respectively) are defined by:

$$\begin{aligned} WRC_1 &= X_{f1}\beta_{f1} + \varepsilon_f \\ WRC_2 &= X_{f2}\beta_{f2} \end{aligned}$$

and are modelled to depend on observed characteristics X_{f1} and X_{f2}, together with the random component ε_f: the parameter vectors β_{f1} and β_{f2} are to be estimated.

A full consideration of childcare costs would require that the decision to use childcare and how much to spend is modelled jointly with employment choices. Given that the focus of this paper is on tax credit design, we follow Blundell *et al.* (2000) by allowing for childcare costs explicitly, but also assuming that the relationship between maternal employment and childcare use is fixed and known, and integrating out the choice of childcare quality. In particular, we assume a deterministic relationship between hours of childcare per child h_{cc} and hours of work h, represented by:

$$h_{cc} = G(h|X_{cc})$$

In practice, this is estimated as a linear relationship, with the intercept and slope coefficients allowed to vary with the number and age of children X_{cc}. The relationship is fitted from those individuals observed working and using childcare without controlling for any sample selection bias, and non-working women are assumed not to use childcare, because our data does not tell us about the childcare use of these women. To estimate the childcare price per child p_c, we compute the empirical distribution of hourly child-care costs for various groups of working mothers defined by their family status and number and age of children, without accounting for any sample selection bias. We have therefore implicitly assumed that those parents observed not working would require the same hours of childcare per child per hour of maternal employment as those observed working, and would face the same prices; results that vary these assumptions would be desirable. We have also estimated the relationship from data before and after the WFTC reform, which is effectively assuming that the fall in the effective price of childcare implied by the childcare tax credit had no impact on those families' use of childcare, nor on the market-clearing the price of childcare.

At price p_c for an hour of childcare per child, the full cost $C = C(h; X_f, X_{cc}, p_c, \varepsilon_f)$ of working is given by the following expression:

$$\begin{aligned} C(h; X_f, X_{cc}, p_c, \varepsilon_f) &= I_{h1} WRC_1 + I_{h2} WRC_2 + p_c h_{cc} \\ &= I_{h1}(X_{f1}\beta_{f1} + \varepsilon_f) + I_{h2}(X_{f2}\beta_{f2}) + p_c G(h|X_{cc}) \end{aligned}$$

where $I_{h1} = 1(h > 0)$ is an employment indicator, $I_{h2} = 1(h \geq 30)$ is a *full-time* employment indicator. Defining $\widetilde{y}_h = y_h - C$, net income in the presence of unobserved fixed work-related costs and childcare expenditure costs, is given by $\widetilde{y}_{h,P} = \widetilde{y}_h + P \cdot \Psi_h$. Note that y_h contains the value of the childcare disregard (under FC) or the childcare tax credit (under WFTC).

4.2 Programme Participation and Take-Up

With the exception of FC and WFTC we assume that all other transfer programmes have complete take-up. We rationalize incomplete take-up of the tax credit programme by assuming the presence of some 'stigma' or 'hassle' cost. This cost is subtracted from the utility of all claimants, and is assumed to be given by $\eta = X_\eta \beta_\eta + \varepsilon_\eta$, where X_η reflects demographic and other household characteristics, and ε_η unobserved heterogeneity. Incorporating this in to the model, utility is now given by:

$$u(\widetilde{y}_{h,P}, h, P; X, \varepsilon) = U(\widetilde{y}_{h,P}, h; X, \varepsilon) - P\eta.$$

With the net financial gain from receiving in-work benefits at a given choice of hours h_j given by Ψ_{h_j}, individuals who are entitled to in-work benefit at this level of hours will claim if the utility gain derived from the higher income exceeds this utility cost. This is equivalent to the condition $\varepsilon_\eta < \Omega_U$, where:

$$\Omega_U = U(\widetilde{y}_h + \Psi_h, h; X, \varepsilon) - U(\widetilde{y}_h, h; X, \varepsilon) - X_\eta \beta_\eta$$

4.3 Choice Probabilities and the Likelihood Specification

Observed heterogeneity affects all the α and β parameters, the childcare expenditure costs, and the fixed work-related costs. Unobserved heterogeneity affects the linear income and hours terms, childcare expenditure costs, and work-related costs, denoted by ε_y, ε_l, ε_{cc} and ε_f respectively.

As in section 2, we let h_j represent a discrete hours choice. Given our assumptions concerning the distribution of the additive state specific error ε_h we are able to derive an explicit expression for the choice probabilities. For given random components $\epsilon = (\varepsilon_w, \varepsilon_y, \varepsilon_l, \varepsilon_{cc}, \varepsilon_f)$ this is given by:[9]

$$\Pr(h = h_j, P = p | X, \epsilon) = \frac{\exp\{u(\widetilde{y}_{h_j} + p \cdot \Psi_{h_j}, h_j, P = p; X, \epsilon)\}}{\sum_{k=0}^{J} \max\left[\exp\{u(\widetilde{y}_{h_k}, h_k, 0; X, \epsilon)\}, E_{h_k} \exp\{u(\widetilde{y}_{h_k} + \Psi_{h_k}, h_k, 1; X, \epsilon)\}\right]}$$

where E_h is an indicator equal to one if the individual is entitled to in-work support when working h hours.

Letting $\epsilon_{-\epsilon_\eta} = (\varepsilon_w, \varepsilon_y, \varepsilon_l, \varepsilon_f, \varepsilon_{cc})$, the log-likelihood contribution for any sample individual is given by:

[9] The distinction between the vectors ε and ϵ is that the latter does not contain the state specific error ε_h.

$$\log l = \log \int\limits_{\epsilon_{-\epsilon_\eta}} \left\{ \int\limits_{\epsilon_\eta < \Omega_U} \prod_{j=0}^{J} \Pr(h = h_j, P = 1|X, \epsilon)^{1(h=h_j, E_{h_j}=1, P=1)} f(\epsilon_\eta) d\epsilon_\eta \right.$$

$$+ \int\limits_{\epsilon_\eta > \Omega_U} \prod_{j=0}^{J} \Pr(h = h_j, P = 0|X, \epsilon)^{1(h=h_j, E_{h_j}=1, P=0)} f(\epsilon_\eta) d\epsilon_\eta$$

$$\left. + \int\limits_{\epsilon_\eta} \prod_{j=0}^{J} \Pr(h = h_j, P = 0|X, \epsilon)^{1(h=h_j, E_{h_j}=0)} f(\epsilon_\eta) d\epsilon_\eta \right\} f(\epsilon_{-\epsilon_\eta}|\epsilon_\eta) d\epsilon_{-\epsilon_\eta}.$$

Note that we make use of the preference consistent bounds on ε_η, derived earlier: this requires that the random participation cost ε_η is integrated over a range that guarantees that the observed programme participation choice remains the most preferred outcome. With no entitlement to FC/WFTC at the observed hours h_j, then we have no information on the value of FC/WFTC participation cost, and the likelihood contributions are instead be integrated over the unrestricted range of ε_η.

5 Data and Labour Supply Estimates

5.1 Data

We use eight repeated cross-sections from the Family Resources Survey (FRS), from the financial year 1995/6 through to 2002/3. The FRS is a cross-section household-based survey drawn from postcode records across Great Britain: around 30,000 families with and without children each year are asked detailed questions about earnings, other forms of income and receipt of state benefits. Our sample is restricted to lone mothers who are aged between 18 and 45 at the interview date. Dropping families with missing observations of crucial variables, and those observed during the phase-in period of October 1999 to March 2000 inclusive, restricts our estimation sample to 12,390 lone mothers. Table A1 presents the key sample statistics. The FRS is the data set most often used to micro-simulate tax and benefit reforms in Britain.

5.2 Estimation

In estimation, the integrals in the log-likelihood are approximated using simulation methods (see Train, 2003), integrating out the random preferences by drawing a number of times from the distribution (we use 10 draws), and computing the mean pseudo-likelihood across these realisations. With the exception of the state specific errors, all the unobserved preference heterogeneity terms are assumed to be normally distributed, with both ε_y and ε_l correlated with wage equation residual ε_w. Having conditioned on a first-stage estimation of the wage rate, the standard deviation of the wage disturbance is fixed at the first-stage estimate σ_w, with the covariance matrix of the unobserved heterogeneity then estimated. The extreme value errors ε_h do not require simulating, and the scale of utility is fixed by the standard deviation of these errors. The distribution of childcare prices is approximated with six discrete mass points.

Identification comes from the changes to the tax and benefit regimes over time and the varying eligibility status to FC/WFTC. Unobserved costs of working are identified as they are common to the 5 states with positive hours of work; FC/WFTC participation costs are identified separately from fixed work-related costs since some lone mothers are not entitled to FC/WFTC at certain levels of hours.

5.3 Labor Supply Estimates

As explained above, there are three first stage regressions: a wage equation, a function describing childcare use, and a childcare price distribution. Explanatory variables in the wage equation included proxies of human capital and demand-side factors and year dummies. The selection term includes the age of the youngest child, together with the net income that would be received if the lone parent were not working (the results are shown in Table A2, with plausible coefficients on years of education in the wage equation, and age of youngest child and modelled out-of-work income in the selection equation).

The unobserved fixed costs of working are assumed to vary by the number of children, age of youngest child, region and ethnicity. For childcare costs, we defined 6 groups according to the number of children (1, 2, 3 or more), whether any of their children were aged under 3. For each group, we regressed hours of childcare use per child on maternal hours of work and a dummy for whether the father worked, and we used these equations to predict childcare use at all choices of hours worked for all mothers: results are available on request. To estimate the price distribution, we created six price bands (including zero cost), and calculated the empirical frequency in each band for each group (number of children, whether any aged under 3): results are also available on request.

The parameter estimates for the labour supply model are presented in Table A3. The unobserved fixed costs are found to be greater with the presence of younger children, increasing in the number of children, and to be much higher for non-white individuals and London residents. However, full-time work reduces both the London and the ethnic effect (the total full-time fixed cost becomes lower for non-whites). Unsurprisingly, these work-related costs (other than childcare) are found to be higher on average for individuals who do not work compared to those who do.

The vector of variables that affects the linear income and hours terms are: the number of dependent children, dummies for the youngest child being under 2, under 5, or under 10, functions of age, a dummy for education being completed at age sixteen or above and ethnicity (sample means of these variables are given in Table A1 in the Appendix). Additionally, the age of youngest child dummies enter through the quadratic terms. Unsurprisingly, there is greater preference for income, and less for hours of work, the greater the number of children. Interpreting the impact of the age of the youngest child is more difficult because it enters both the linear and quadratic terms of the utility function.

The utility cost of participating in FC/WFTC is found to be significantly different from zero, and higher for more highly-educated parents. It is also higher for non-white single mothers than white single mothers. Using the point estimates, we find that

98% of lone mothers have positive marginal utility of net income at their observed state, and 80% have negative marginal utility of work.

Table 2 presents the simulated labour supply elasticities at the extensive and intensive margins across a range of earnings and household types. The extensive elasticities are generally much larger than the intensive elasticities at all earnings levels. The participation elasticities are larger for single mothers with older children.

5.4 Simulating the WFTC Reform

To further understand the properties of the structural model and to assess its performance we first use the estimated parameters to simulate the impact of the WFTC reform (together with the other contemporaneous changes discussed in section 3) on single mothers. The initial step is to estimate a choice probability distribution (over the combination of hours and programme participation) for each individual under a given tax and transfer system: we do this by numerically averaging over the unobserved components in the model.[10] To simulate the impact of a change in the tax and benefit system, we use the same numerical draws to compute the choice probabilities under both tax and benefit systems, and combine these into a matrix of transition probabilities over the choices. This gives us the (estimated) expected value of the transition matrix given the parameter estimates, where the expectation is over all random components.

The results of this simulation for the employment impacts of the WFTC reform are presented in the first row of results in Table 3. These show a 3.68 percentage point increase in the overall employment of single parents (from a base of around 45%). The second column displays the simulated impact for the tax credit expansion alone without the coincident additional changes to income support. The 5.95 percentage

[10]State specific errors are drawn from the extreme value distribution using an accept-reject procedure to ensures that the predicted hours choice under the tax system at the interview date correspond to hours of labour actually supplied. We use 1000 accepted draws from the distribution in the simulation of policy reforms. See, for example, Creedy and Kalb (2005) for a discussion of this calibration procedure.

point increase showing an almost double impact and highlighting the importance of allowing for all reforms that influence the labour supply incentives.

5.5 A Comparison with a Difference-in-Differences Estimate

To assess the reliability of this model it would be useful to compare the results with an experimental baseline. However, typically there do not exist experimental evaluations for targeted tax credits of this kind. A popular alternative approach has been to use the difference-in-differences method (see Eissa and Liebman (1996), for example). Even if the assumptions behind the difference-in-differences approach are strong if a causal interpretation is the objective, we take a more limited objective. The idea is to use the quasi-experimental estimates to validate the structural model. For this we use the difference-in-differences methodology to evaluate the impact of the WFTC reform in 1999.

We divide our sample into two periods: April 1995 to September 1999 which we label FC, April 2000 to the end of the sample labelled WFTC.[11] Our difference-in-differences estimator compares outcomes of eligibles versus those who are not eligible in both periods. Our estimator will identify the impact of WFTC on eligibles assuming (i) common trends for eligible and non-eligible groups and (ii) invariance in group heterogeneity over time conditional on a set of matching covariates. The matching covariates in our analysis include a number of dummy variables, including those indicating the presence of children, WFTC period, "treatment group" (the former two dummies interacted), age of youngest child, region, housing tenure, quarter of the year, and education. Continuous variables include an age polynomial, and time trend polynomial, together with a time trend polynomial interacted with educational groups. Our difference-in-differences estimator and its relationship to our structural model is discussed in more detail in Appendix A.

The results of this exercise presented in the second row of results in Table 3. The

[11] Our analysis here uses the Labour Force Survey data due to the considerably larger sample size that it offers relative to the Family Resources Survey dataset.

simulated parameter estimate from the structural evaluation model does not differ significantly from the difference-in-differences estimate. This provides some basis for confidence in proceeding to use this structural stochastic model to examine the optimal design of tax policy towards single mothers labour supply.

6 The Optimal Tax Results

In this section we use our structural parameters to examine the design of the tax and transfer schedule. We show the importance of allowing the tax schedule to depend on the age of children. One of the key results is that marginal rates should be lower at the start of the earnings distribution for families with older children. Given the use of hours conditions in the current British tax credit system, we also consider the case where hours can be partially observed. Our analysis suggests that may be an incentive to introduce an hours rule for lone mothers with children who are of school age, but the social welfare gains do not appear to be large. The extent to which the government may wish to include other observable characteristics in the tax base is discussed elsewhere. For example Banks and Diamond (2008) point out that if hours cannot be monitored accurately then there is an argument against the use of an hours rule. Here we assume partial observability and design the tax schedule so there is no incentive to manipulate actual hours above the hours condition. Before detailing these results, we first turn briefly to discuss the further parametric specifications adopted in our optimal tax analysis, together with other considerations.

6.1 Optimal Tax Specification

We have shown that using parameter estimates from a structural model of labour supply, the labour supply behaviour of individuals can be simulated as the parameters of the tax and transfer system are varied. With these endogenous and heterogenous labour supply responses allowed for, the structural model provides all the necessary information to maximise an arbitrary social welfare function, subject to a government budget constraint. Note that our analysis here makes no distinction between the tax and transfer system, and so corresponds to our structural model of section 4 with no programme participation costs. Furthermore, we also abstract from non-labour income sources.

To implement the optimal design analysis we parametrically specify the tax schedule. While in principle this can be made arbitrarily close to the fully non-parametric schedule by choosing a sufficiently flexible specification, we shall adopt a piecewise linear tax schedule with the tax schedule characterized by a level of out-of-work income (income support), and four different marginal tax rates. These marginal tax rates, which are restricted to lie between -100% and 100%, apply to weekly earnings of up to £80, between £80 and £140, between £140 and £220, and £220 and above respectively. When we later allow for partial observability of hours we introduce additional payments that are received only if the individual fulfills the relevant hours criteria.

The optimal tax schedule is solved separately for three different groups on the basis of the age of youngest child: under 4, aged 5 to 10 and 11 to 18.[12] In all cases, we have conditioned upon the presence of a single child. For each of these groups we set the value of government expenditure equal to the actual expenditure on this group within our sample.[13] Conditioning upon this level of expenditure we calculate the tax schedule that maximizes social welfare in each of these groups. We adopt the following the utility transformation function:

$$\Gamma(u|\theta) = \frac{1}{\theta} \times \{(\exp u)^{\theta} - 1\}. \tag{3}$$

which controls the preference for equality by the one dimensional parameter θ and also permits negative utilities. When θ is negative, the function (3) favours the equality of utilities; when it θ is positive the reverse is true. By L'Hôpital's rule

[12] For sample size reasons, age groups 0 to 2, and 3 to 4 have been aggregated in the derivation of the tax schedule.

[13] We make no attempt to calculate what the optimal division of overall expenditure is between these three groups. This therefore makes an implicit assumption regarding the value that the government attaches on the welfare of these groups.

$\theta = 0$ corresponds to the additive case, i.e. $\Gamma(u|\theta = 0) = u$. We solve the schedule for a set of parameter values $\theta = \{-0.2, 0.0, 0.1\}$ and then derive the social weights that characterise these redistributive preferences.[14]

Numerically, we solve the maximisation problem by using a hierarchy of discretizations, with the results from a coarse search used to reduce the parameter space to be searched at the next finer discretized level. At each point in the discretized parameter space we calculate the preferred labour market choice of each individual using the structural model as detailed above. The results of these simulations then allow us to evaluate both the government budget constraint and social welfare function. In our finest parameter space discretization we allow for single percentage point marginal rate increments, and £1 increments in out-of-work income (and if applicable, hours contingent payments).[15]

6.2 Implications for the Tax Schedule

The underlying properties from the labour supply model, together with the choice of social welfare weights, are the key ingredients in the empirical design problem. We have seen from Table 2 that the intensive and extensive labour supply responses differ substantially. They also vary with the age of the youngest child.[16] As expected this is reflected strongly in the optimal tax results. For the choice of social welfare function we examine the impact of alternative θ values in (3). In Figures 4(a)-(c) we present the underlying social welfare weights evaluated at the optimal schedule (discussed below) across the different child age groups according to these alternative θ values.

[14]Labour supply responses also differ by characteristics other than the age of children, but we do not attempt to incorporate these in the design problem.

[15]The state specific errors that we integrate over are consistent with observed behaviour under the actual tax and transfer system with complete take-up. If these errors are drawn from the unrestricted Type-I extreme value distribution, then the integral over state specific errors has an analytical form given our choice of utility transformation function Γ and so does not require simulating. See Shephard (2007) for details.

[16]While these are treated as separate groups in our analysis they can also be considered as the same group at different points in time. The ageing of children introduces dynamic considerations in the design problem, which are necessarily absent from our static structural model.

For all three values of θ considered here the weights are broadly downward sloping. For the most part we focus our discussion here on the -0.2 value, although we do provide a sensitivity of our results to the choice of θ and find the broad conclusions are robust to this choice.

In Figures 5(a) we present the optimal schedule across the alternative θ values for single mothers with a child between 5 and 10 years of age. Table 4(a) presents the corresponding marginal rate schedule. Overall we generally find that there is an increasing marginal rate structure with lower rates at lower earnings. As the value of θ increases (less redistributional concern) the level of out-of-work income falls, with the main impact on the marginal rate structure coming through a decrease in the rate applied to earnings between £140 and £220 per week. As we shall see below, while the former effect is common to lone mothers with children of all ages, the latter effect is more unusual and contrasts with the broader reductions in marginal rates that are observed for parents with both younger and older children. Note that compared to the current schedule facing single parents this analysis points to lower rates at lower incomes (see Figure 3 earlier).

In Figures 5(b) and 5(c) we show the corresponding optimal schedules calculated for lone mothers with older (11 and over) children and with younger (under four) respectively. Relative to the above group, lone mothers with older children have similar marginal tax rates at low earnings, and lower levels of out-of-work income. Marginal rates in the highest earnings bracket are lower for this older group, however, and decreasing in θ, while marginal rates in the earnings bracket immediately below this are higher. In contrast, the schedule for mothers with younger children comprises similar levels of out-of-work income, but with higher marginal tax rates for low earnings. Marginal rates for high earners are also decreasing in θ, again coming as part of a broader reduction in marginal rates across the earnings distribution.

Under WFTC, most lone parents with earnings in our upper bracket would face a combined tax and credit withdrawal rate of slightly over 69%. This is lower than the rates we obtain when $\theta = -0.2$, and for all values of θ considered here for single mothers with a child between 5 and 10 years of age. Since there may be important reasons why marginal rates should not be as high in this range as we calculate above (for example, political economy considerations and the importance of responses at other margins than hours of work) we also consider how imposing this as an upper limit on marginal rates over this range affects the overall structure of marginal rates.[17] This is presented in Figure 5(d) for the $\theta = -0.2$ case. It is clear that this restriction has very limited impact for the structure at lower earnings but does serve to smooth out the marginal rate schedule at higher earnings.

Table 4(b) describes the marginal rate schedules by age of the youngest child. In this table we present the results with the marginal rate at higher earnings left unrestricted and with the 69% maximum rate imposed. The lower panel also presents the net income values evaluated at various earnings points. A key conclusion to be obtained from this is that marginal rates are lower at lower earnings but this is mainly for families with older children. In terms of the schedule at lower earnings the biggest 'jump' in earnings is for families with children aged between 5 to 10 years. This produces a low marginal tax rate and suggests there are big gains to improving the incentives to work among this group. Indeed the largest climb in net income across all earnings occurs for this group.[18]

Before proceeding further, we consider the robustness of our main results to the utility function parameterization. Specifically, we re-estimate our structural model using a third order polynomial expansion in income and hours as our utility function

[17]Our whole analysis has centered around a static, hours-of-work labour supply model. While this is an important margin of response for this group, in practice there may be other margins along which these individuals can respond (for example, effort at work, and the intensity at which they search for better jobs). If these margins are important, then we would expect that explicitly allowing for them would lower marginal rates especially for relatively high earnings (since once individuals reach the highest level of hours there is no further margin along which these individuals can respond in our model). See Goolsbee (2000) and Gruber and Saez (2000), for example.

[18]We have said nothing about the precision of our results. The optimal schedules have been calculated conditional on *estimated* labour supply behaviour and so are uncertain. While standard errors can be calculated using the bootstrap, it remains computationally difficult.

and use these new parameter estimates as inputs into the optimal design problem.[19] Across all the different age groups, we find that the schedules are very similar to those arrived at using our original utility representation. Figure 5(e) shows how the schedules compare for the middle age group with $\theta = -0.2$.

6.3 Introducing an Hours Rule

For several decades the UK's tax credits and welfare benefits have made use of rules related to weekly hours of work. As discussed in section 3, individuals must work at least 16 hours a week to be eligible for in-work tax credits, and receive a further credit when working 30 or more hours. While many theoretical models rule out the observability of any hours information, this design feature motivates us to explore the optimal structure of the tax and transfer system when hours can be partially observed as set out in section 2. We begin by assuming that the tax authority is able to observe whether individuals are working 16 hours or more. This matches the placing of the main hours condition in the British tax-credit system. In this case the tax authority is able to condition an additional payment on individuals working such hours. When the tax authority is only able to observe earnings, it is unable to infer whether an individual with a given level of earnings is low wage-high hours, or high wage-low hours. Since the government may value redistribution more highly in the former case, it may be able to better achieve its goals by introducing an hours rules into the system.

The results are presented in Figures 6(a)-(c). A clear picture emerges. There is little requirement for an hours bonus for families with children aged below 5. But as the children age the optimal schedule changes quite dramatically with a strong move towards an hours bonus.[20] Figure 6(d) shows the impact on the marginal rates for

[19] Observable and unobservable heterogeneity continue to enter the model as described in section 4. All the additional higher order terms depend on age of youngest child.

[20] The analytical framework we developed in section 2 does not allow for any form of measurement error. While earnings may not always be perfectly measured, it seems likely that there is more scope for mis-measurement of hours as they are conceivably harder to monitor and verify. Indeed, the

families with youngest child aged 11-18. Relative to the optimal system when such a rule is not implementable, the hours bonus increases marginal rates in the part of the earnings distribution where this hours rule would roughly come into effect while marginal rates further up the distribution are essentially unchanged. As a result of this, some low hours individuals will either not work or increase their hours, while some high earnings individuals will reduce their hours. While the level of out-of-work income remains effectively unchanged, the hours bonus is sufficiently large that it implies a negative participation tax rate at 16 hours provided that the lone parents' wage is not too high. In Figures 6(e)-(g) we consider the impact of imposing a 69% maximum marginal rate at higher earnings. As before, this restriction has very little impact on the overall shape of the budget constraint, and does not lead to large changes in the size of the hours bonuses at 16 hours.

Before investigating the size of the welfare gains achieved through partial hours observability, we explore the impact that varying the redistributive taste parameter θ has on the size of the hours bonus and on the overall structure of the budget constraint. This is presented in Figure 6(h) for lone mothers with children aged 11 to 18. The figure shows that the size of the bonus is falling monotonically with θ so that the use of hours contingent payments is potentially more valuable when the government values redistribution more highly. The same pattern is also observed for the younger two age groups.

Although there are some notable changes in the structure of the constraint when hours information is partially observable, it does not follow that it necessarily leads to a large improvement in social welfare. Indeed, in the absence of the hours conditioning, there were very few individuals working less than 16 hours (see Figures

presence of hours rules in the tax and transfer system presents individuals with an incentive to not truthfully declare whether they satisfy the relevant hours criteria. Relative to when hours are always truthfully reported, this would seem to weaken the case for introducing a measure of hours in the tax base but does not necessarily remove it. While we do not explore this issue further, it seems plausible that allowing for this form of systematic measurement error will reduce the size of the hours contingent payment.

7(d)-7(f)) so the potential that it offers to improve social welfare appears limited. We now attempt to provide some guidance concerning the size of the welfare gain from introducing hours rules. The exact experiment we perform is as follows: we take the optimal schedule when only earnings were observable to the tax authorities, maintain the marginal rate structure, and ask what size lump sum transfer would be required such that the same level of social welfare (under the use of hours contingent payments) is obtained.[21] While this is unlikely to be the cost minimizing way of achieving the necessary level of social welfare (because further welfare gains can be realized by changing the marginal rate structure as expenditure varies) it does serve as a useful indicative exercise.

The results of this analysis are presented in Table 5 for the case when $\theta = -0.2$. Unsurprisingly, when children are aged less than 5 the size of the transfer required to achieve the level of social welfare obtained under the 16 hour rule is negligible. However, even when children are of school age, the size of the required transfer is found to be small (and even smaller for the less redistributive preferences considered). It follows that unless the costs of partial hours observability is sufficiently low, it would appear difficult to advocate the use of a 16 hours rules based upon this analysis.

6.3.1 An Optimal Hours Rule?

The social welfare gains from introducing a 16 hours rule appear to be only very modest in size. In this section we explore whether there are potentially larger gains by allowing the choice of the point at which the hours rule becomes effective to be part of the optimal design problem. Figures 7(a)-(c) show the schedules separately for the different age groups and for $\theta = -0.2$. In all cases, we get an optimal hours rule at the fifth (out of six) discrete hours point, i.e. at around 30 hours per week. We also note that the size of the optimally placed hours bonus always exceeds that calculated when the hours rule became effective at 16 hours per week. Introducing an

[21] The presence of income effects in our model implies that the actual cost will exceed the size of the transfer.

hours rule further up the hours distribution allows the government to become more effective in distinguishing between high wage/low effort and high effort/low wage individuals than at 16 hours to the extent that few higher wage individuals would choose to work very few hours. Relative to the schedule when the hours rule is set at around 16 hours, this alternative placement tends to make people with low and high earnings better off, while people in the middle range lose. Again, very little happens to out of work income levels, with the hours rule again having its largest impact on the budget constraint in the region where the hours rule roughly comes into effect. Figures 7(d)-(f) show the resulting impact on the hours distribution.

As before, we attempt to quantify the benefits from allowing for hours conditioning. Performing the same experiment as we conducted under the 16 hours rule with $\theta = -0.2$ we find that the required transfer is somewhat larger than that obtained under the 16 hours rule, but the welfare gains are still unlikely to be considered "large" (again, see Table 5). For lone parents with school aged children the size of the required transfer corresponds to roughly 1% of the expenditure on these groups. While it is unclear whether the benefits from introducing an hours contingent payment that rewards full-time work would exceed the cost of operating such a scheme, if the government wishes to maintain the use of hours conditional eligibility, the analysis here suggests that it may be able to improve design by shifting towards a system that primarily rewards full-time rather than part-time work.

6.3.2 Introducing a Part-time and Full-time Hours Rule

We now turn to the possibility of allowing a further hours point. Here we do not consider the optimal placement of these points, but rather restrict them to be at the second and fifth discrete hours points (around 16 and 30 hours per week). The purpose here is to mimic the general structure of the British tax credit system, and the results of this exercise are displayed in Figures 8(a)-(c).

Across all groups, the optimal schedules make use of hours bonuses at both hours points that are roughly equal in magnitude to those obtained when introducing each of them in isolation, with very high marginal tax rates in the middle range of the earnings distribution. This broad structure looks close to the current overall structure of the tax-credit system facing single parents in Britain. However, here marginal rates are lower at lower incomes and there is much greater emphasis placed on rewarding full-time work through the use of appropriate hours contingent payments.

Finally, we note that relative to the earlier results, the implementation of such a system is even more informationally demanding and provides more individuals an incentive to manipulate their declared hours of work. The extent to which the government may wish to introduce further hours contingent payment will therefore crucially depend upon its ability to distinguish between different hours of work.

7 Conclusions

The aim of this paper has been to examine the optimal schedule of marginal tax rates and design of earned income tax credits. The question we wish to pose is: what is the form of an optimal income transfer for low income individuals? To implement this we developed a structural labour supply model which incorporated unobserved heterogeneity, the non-convexities of the tax and welfare system as well as allowing for fixed costs of work. We have explicitly allowed for different labour supply responses at the intensive and extensive margins. We also developed an analytical framework for the design of tax and transfer policy that explicitly allows for the partial observability of hours of work, so mirroring design features of the British system. We then contrast this to standard case in which only earnings (and employment) are revealed to the tax authority.

The analysis has focused exclusively on single mothers. The empirical results suggest that lone parents with very young children are much less responsive to changes in financial work incentives than are lone parents with children of school age. In the former case - where the marginal value of leisure is high - it is better to offer high levels of income support together with high marginal tax rates when in work. In the latter case, where leisure is valued less highly, it is more desirable to have a lower level of income support and lower marginal tax rates to encourage them to work. We have shown that there is evidence to support the overall structure of the British tax credit programmes but there is also a strong case for reducing marginal rates for lower earners but only for those with school age children.

The UK's tax credits and welfare benefits have a long history of rules related to weekly hours of work. This motivated us to consider how incorporating such hours information affects the structure of the constraint. We explored the implications of introducing a 16 hour rule in the system, much like in the current British tax credit system, and found that for lone parents with children who are of school age we obtain an hours bonus that is sufficiently large that it implies a negative participation tax rate at 16 hours provided that the lone parents' wage is not too high. However, the improvement in social welfare we obtain by this hours conditioning is found to be only modest in size. If the tax authorities are able to choose the lower limit on working hours that trigger eligibility for such families, then we find an empirical case for using a *full-time* work rule. While this is found to be a more effective instrument, the welfare gains remain modest in size. The form of these minimum hours rules highlight an optimal 'dynamic incentive' that enhances the financial reward to work as children age.

Finally, we found that if was thought to be possible to accurately distinguish between full-time and part-time work - much as in the existing British tax credit system - then we find support for this two point structure but provide a case for placing greater emphasis on rewarding full-time work. As in the situation without hours conditioning there remains a strong case for reducing marginal rates for lower earners with school age children.

Appendix A

Here we discuss our difference-in-differences estimator, which we implement in section 5.5, and its relationship to our structural model of labour supply. Throughout this section we let Y denote the employment state: $Y = 1$ denotes employment, and $Y = 0$ denote non-employment states. Similarly we define $t = 1$ if the time period is after the reform and $T = 1$ if the individual is eligible to receive WFTC (in our application this means that they are a single parent). In this case the difference-in-differences estimator replaces the four conditional means in the following expression with their empirical analogs:

$$\alpha_{DD}(X) = [E(Y|X, T = 1, t = 1) - E(Y|X, T = 1, t = 0)] \\ - [E(Y|X, T = 0, t = 1) - E(Y|X, T = 0, t = 0)]$$

and then integrates over the (empirical) distribution of X in the treatment group ($T = 1$) in period $t = 1$. We denote this distribution as F_X

The choice model described above attempts to estimate the impact of WFTC on employment in the treatment group - the average treatment effect on the treated. This parameter can be directly recovered from the structural model. Note that $Y = 1$ if and only if $h > 0$. As in our earlier exposition, we let ε represent the vector of all unobserved heterogeneity in the structural model and let F_ε be its joint distribution. We also define $D = 1$ to indicate the WFTC policy reform so that $D = 1 \equiv \{T = 1, t = 1\}$. The structural model then specifies the conditional probability of employment as a function of observable covariates, the policy parameters D and the distribution of unobserved heterogeneity ε:

$$\Pr[h > 0|X, D] = \int_\varepsilon f(X, \varepsilon, D) dF_\varepsilon$$

The structural model then defines the average impact of the policy on the treated as:

$$\alpha_{SEM}(X) = \Pr[h > 0|X, D = 1] - \Pr[h > 0|X, D = 0]$$

which when integrated over the distribution of X can be written as:

$$\alpha_{SEM} = \int_X \int_\varepsilon f(X, \varepsilon, D = 1) dF_\varepsilon dF_X - \int_X \int_\varepsilon f(X, \varepsilon, D = 0) dF_\varepsilon dF_X.$$

which can be computed by simulation. For difference-in-differences to recover this parameter it has to be that:

$$\int_\varepsilon f(X, \varepsilon, D = 0) dF_\varepsilon$$
$$= E(Y|X, T = 1, t = 0) + [E(Y|X, T = 0, t = 1) - E(Y|X, T = 0, t = 0)]$$

In general for this to hold it must be that the unobservables ε for each t and T are separable and additive in a group effect and a time effect. These are the usual common trends and time invariant group effect assumptions. While we do not investigate this issue here, note that we can also directly simulate the difference-in-differences parameter:

$$\alpha^{DD}_{SEM} = \int_X \int_\varepsilon f(X, \varepsilon, D = 1) dF_\varepsilon^{T=1,t=1} dF_X - \int_X \int_\varepsilon f(X, \varepsilon, D = 0) dF_\varepsilon^{T=1,t=0} dF_X$$
$$- \left[\int_X \int_\varepsilon f(X, \varepsilon, D = 0) dF_\varepsilon^{T=0,t=1} dF_X - \int_X \int_\varepsilon f(X, \varepsilon, D = 0) dF_\varepsilon^{T=0,t=0} dF_X \right]$$

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Table 1: The WFTC Reform

	April 1999 (FC)	October 1999 (WFTC)	June 2000 (WFTC)	June 2002 (WFTC)
Basic Credit	49.80	52.30	53.15	62.50
Child Credit				
under 11	15.15	19.85	25.60	26.45
11 to 16	20.90	20.90	25.60	26.45
over 16	25.95	25.95	26.35	27.20
30 hour premium	11.05	11.05	11.25	11.65
Threshold	80.65	90.00	91.45	94.50
Taper	70% of earnings after income tax and NI	55% of earnings after income tax and NI	55% of earnings after income tax and NI	55% of earnings after income tax and NI
Childcare	Childcare expenses up to £60 (£100) for 1 (more than 1) child under 12 disregarded when calculating income	Award increased by 70% of childcare expenses up to £100 (£150) for 1 (more than 1) child under 15	Award increased by 70% of childcare expenses up to £100 (£150) for 1 (more than 1) child under 15	Award increased by 70% of childcare expenses up to £135 (£200) for 1 (more than 1) child under 15

Notes: All monetary amounts are in pounds per week and expressed in nominal terms.

Table 2: Elasticities

(a) Youngest Child Aged 11-18

Earnings	Proportion	Extensive elasticity	Intensive elasticity
0	0.3933		
0-80	0.0618	0.2885	0.2885
80-140	0.1266	0.4232	0.0295
140-220	0.1738	0.5408	0.0442
220+	0.2446	0.4093	0.0142
Participation elasticity			1.1295

(b) Youngest Child Aged 5-10

Earnings	Proportion	Extensive elasticity	Intensive elasticity
0	0.4291		
0-80	0.0647	0.2321	0.2321
80-140	0.1782	0.2209	0.0191
140-220	0.1644	0.3483	0.0572
220+	0.1636	0.2982	0.0354
Participation elasticity			0.9348

(c) Youngest Child Aged 0-4

Earnings	Proportion	Extensive elasticity	Intensive elasticity
0	0.5804		
0-80	0.0921	0.1215	0.1215
80-140	0.1382	0.1449	0.0194
140-220	0.0943	0.2698	0.0409
220+	0.095	0.1649	0.0232
Participation elasticity			0.6352

Notes: Elasticities simulated under WFTC with complete take-up.

Table 3: Structural Simulations and Difference-in-Differences

	All reforms	WFTC only
Structural model	3.68 *(0.73)*	5.95 *(0.65)*
Difference-in-differences	3.57 *(0.81)*	

Notes: Standard errors in parentheses.

Table 4a: Marginal Rates for Optimal Schedule, Child Aged 5-10

	θ		
	-0.2	0.0	+0.1
0-80	0.17	0.24	0.17
80-140	0.37	0.20	0.33
140-220	0.38	0.05	-0.45
220+	0.91	0.90	0.90

Table 4b: Marginal Rates and Incomes by Age of Child, $\theta = -0.2$

	Age of youngest child					
	0-4		5-10		11-18	
	free	69%	free	69%	free	69%
0-80	0.41	0.47	0.17	0.15	0.26	0.26
80-140	0.72	0.62	0.37	0.43	0.38	0.37
140-220	0.19	0.42	0.38	0.57	0.60	0.65
220+	0.87	0.69	0.91	0.69	0.75	0.69
0	161.00	162.00	163.00	161.00	155.00	155.00
80	208.20	204.40	229.40	229.00	214.20	214.20
140	225.00	227.20	267.20	263.20	251.40	252.00
220	289.80	273.60	316.80	297.60	283.40	280.00
300	300.20	298.40	324.00	322.40	303.40	304.80

Notes: Upper panel presents marginal rates; lower panel presents net-incomes at different earnings levels.

Table 5: Transfer Required to Achieve Social Welfare Level without Partial Hours Observability (with and without Marginal Rate Restriction), $\theta = -0.2$

	Age of youngest child					
	0-4		5-10		11-18	
	free	69%	free	69%	free	69%
16 hours	0.02	0.00	0.22	0.16	0.42	0.34
30 hours	0.04	0.04	1.00	0.80	1.10	0.74
16 and 30 hours	-	0.04	-	0.92	-	1.10

Table A1: Summary Statistics

	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Youngest child 0-2[†]	0.2900	0.2819	0.2583	0.2625	0.2574	0.2464	0.2433	0.2169
Youngest child 3-4[†]	0.1669	0.1732	0.1543	0.1608	0.1440	0.1647	0.1593	0.1675
Youngest child 5-10[†]	0.3617	0.3452	0.3774	0.3707	0.3695	0.3749	0.3847	0.3707
Youngest child 11+[†]	0.1814	0.1998	0.2099	0.2060	0.2290	0.2140	0.2126	0.2449
Number of children	1.7907	1.8416	1.7933	1.8084	1.8501	1.8172	1.8059	1.7798
Non-white[†]	0.1025	0.0910	0.1027	0.1083	0.1004	0.0973	0.1246	0.0999
Age[§]	-0.0896	-0.0656	-0.0241	0.0122	0.0303	0.0454	0.0444	0.0661
Age-squared[§]	-0.6084	-0.4349	-0.1585	0.0629	0.2168	0.3043	0.2895	0.4454
Greater London[†]	0.1559	0.1436	0.1570	0.1581	0.1464	0.1366	0.1431	0.1236
Post-16 education[†]	0.2682	0.2506	0.2793	0.2966	0.3176	0.3013	0.3053	0.2987
Wage (non-workers)	3.8921	4.2084	4.1218	4.8126	4.9975	5.3903	5.4221	5.3084
Wage (workers)	4.5713	5.2281	5.0378	5.1738	5.4579	6.1412	6.2822	6.3379
Non-worker[†]	0.6529	0.6661	0.6076	0.5906	0.5773	0.5639	0.5527	0.5332
Receive FC/WFTC[†]	0.1608	0.1413	0.1661	0.1975	0.2054	0.2626	0.2833	0.3251

[§]Measured in terms of deviations from its mean value over entire sample period. [†]Denotes binary variable.

Table A2: Wage Equation Estimates

		estimate	standard error
Wage equation‡:	age completed education	0.0244	0.0070
	age§	0.3272	0.0980
	age squared§	-8.9212	2.9494
	age cubed§	8.1055	2.9041
	non-white†	0.0276	0.0308
	home-owner†	0.3212	0.0198
	constant	-3.0181	1.0601
Selection equation‡:	net-income at zero hours	-0.0033	0.0003
	age completed education	-0.0027	0.0017
	age§	0.2421	0.1110
	age squared§	-5.2211	3.5061
	age cubed§	3.3176	3.6048
	non-white†	0.0015	0.0453
	home-owner†	0.9043	0.0287
	no. of children with health problems	-0.1627	0.0235
	constant	-3.9227	1.1388
	age of youngest child: 1†	0.1590	0.0668
	age of youngest child: 2†	0.2639	0.0653
	age of youngest child: 3†	0.4061	0.0655
	age of youngest child: 4†	0.5378	0.0662
	age of youngest child: 5†	0.6093	0.0676
	age of youngest child: 6†	0.7004	0.0690
	age of youngest child: 7†	0.7191	0.0704
	age of youngest child: 8†	0.7596	0.0727
	age of youngest child: 9†	0.6965	0.0742
	age of youngest child: 10†	0.7657	0.0756
	age of youngest child: 11†	0.8188	0.0797
	age of youngest child: 12†	0.8553	0.0809
	age of youngest child: 13†	0.9747	0.0833
	age of youngest child: 14†	1.0669	0.0887
	age of youngest child: 15†	0.9396	0.0924
	age of youngest child: 16†	0.9990	0.1045
	age of youngest child: 17†	1.2826	0.1452
	age of youngest child: 18†	1.2491	0.1796
Rho:		0.0964	0.0466
Sigma:		0.4797	0.0127
Lambda:		0.0463	0.0222

Notes: §Measured in terms of deviations from its mean value over entire sample period. †Denotes binary variable. ‡Dummy variables for year and region of residence were also included in the regressions.

Table A3: Structural Parameter Estimates

		estimate	standard error
$\alpha_{11}/10000$:	1	-0.3257	0.0451
	youngest child 0-2†	0.0948	0.0776
	youngest child 3-4†	0.0608	0.0563
	youngest child 5-10†	0.0656	0.0500
$\alpha_{22}/100$:	1	0.2848	0.0268
	youngest child 0-2†	0.0476	0.0454
	youngest child 3-4†	-0.0817	0.0483
	youngest child 5-10†	-0.0617	0.0348
$\alpha_{12}/10$:	1†	-0.2058	0.0252
	youngest child 0-2†	-0.1977	0.0438
	youngest child 3-4†	0.0030	0.0393
	youngest child 5-10†	0.0631	0.0311
$\beta_1/10$:	1	0.3113	0.0209
	age§	0.1570	0.0545
	age-squared§	-0.0183	0.0082
	post-16 education†	-0.0065	0.0077
	youngest child 0-2†	-0.0207	0.0308
	youngest child 3-4†	-0.0220	0.0259
	youngest child 5-10†	-0.0440	0.0218
	number of children$^{\sharp}$	0.0048	0.0043
	non-white†	-0.0610	0.0128
	σ_y	0.0058	0.0007
	ρ_{wy}	0.0176	0.0031
β_2:	1	-0.1185	0.0112
	age§	0.1411	0.0150
	age-squared§	-0.0174	0.0022
	post-16 education†	0.0333	0.0018
	youngest child 0-2†	-0.0153	0.0198
	youngest child 3-4†	0.0131	0.0208
	youngest child 5-10†	0.0028	0.0154
	number of children$^{\sharp}$	-0.0066	0.0019
	non-white†	-0.0072	0.0039
	σ_h	0.0000	0.0021
	ρ_{wh}	0.0276	0.0109

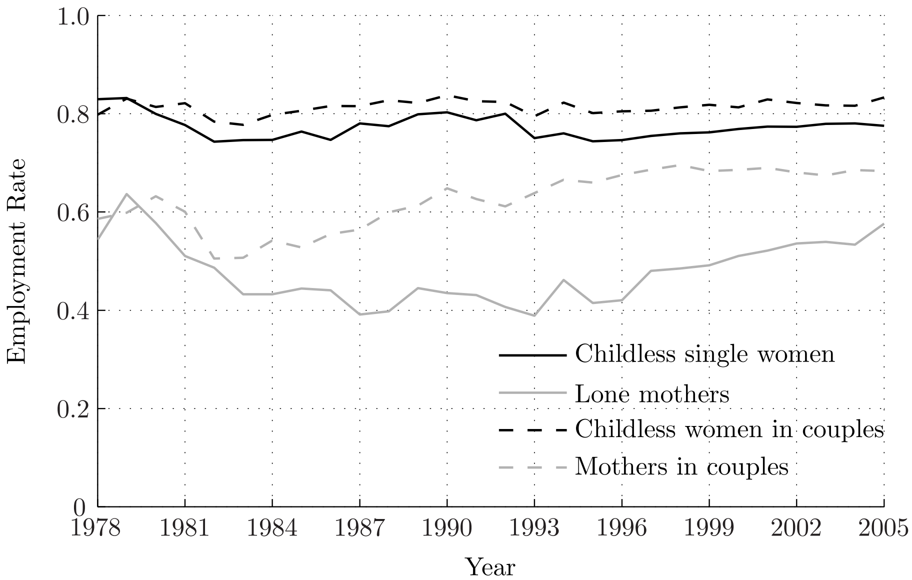
Notes: §Measured in terms of deviations from its mean value over entire sample period. †Denotes binary variable and $^{\sharp}$defined as one fewer than the actual number of children.

Table A3 continued: Structural Parameter Estimates

		estimate	standard error
WRC_1:	1	36.8019	5.3089
	youngest child 0-2†	19.5365	11.6169
	youngest child 3-4†	24.1712	11.8326
	youngest child 5-10†	11.7245	8.5467
	London†	54.6345	5.8798
	non-white†	40.4755	12.8670
	number of children$^\sharp$	2.4362	2.8193
	σ_f	2.8669	3.9606
WRC_2:	1	32.8536	5.3539
	youngest child 0-2†	19.2619	17.4462
	youngest child 3-4†	5.0688	13.4633
	youngest child 5-10†	12.9514	9.0849
	London†	-24.6658	8.1409
	non-white†	-63.6406	17.1177
	number of children$^\sharp$	4.2984	4.2525
η:	1	0.3599	0.0731
	post-April 1996†	0.1708	0.0887
	post-April 1997†	-0.1185	0.0896
	post-April 1998†	-0.2436	0.0874
	post-April 1999†	-0.0940	0.0999
	post-April 2000†	0.0760	0.0959
	post-April 2001†	-0.1080	0.0712
	post-April 2002†	-0.1994	0.0689
	age§	-0.4771	0.3655
	age-squared§	0.1205	0.0549
	post-16 education†	0.3602	0.0532
	non-white†	0.1316	0.0858
	σ_η	1.0134	0.0762

Notes: §Measured in terms of deviations from its mean value over entire sample period. †Denotes binary variable and $^\sharp$defined as one fewer than the actual number of children.

Figure 1a: Employment rate of women in Great Britain: 1978-2005



Notes: Figure uses FES data for the period 1978-1994, and FRS data thereafter.
Source: Hoynes (2008)

Figure 1b: Employment and Hours, Lone Mothers (aged 18-45): FRS, 1995-2002

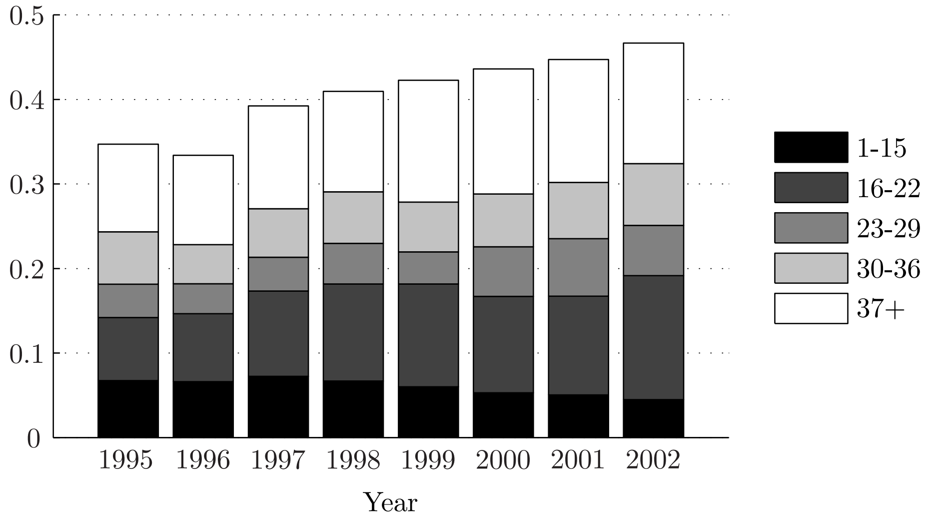


Figure 2: Hours Distribution for Low Education Single Childless Women and Lone Mothers (aged 18-45): FRS, 2002

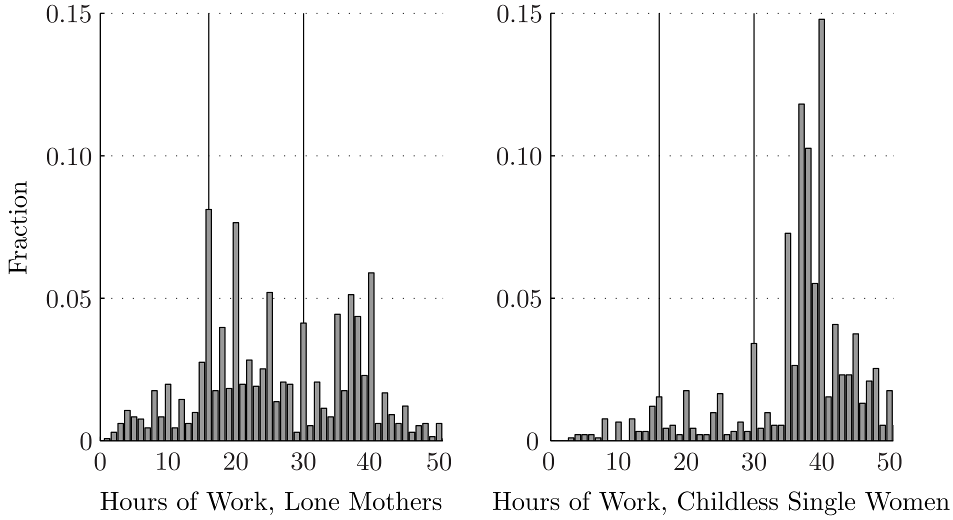


Figure 3: WFTC Interactions with Other Taxes and Benefits (April 2002): Lone Mother with Child Aged 5, £6 hourly wage, £50 Housing Costs and Average London Band C Council Tax

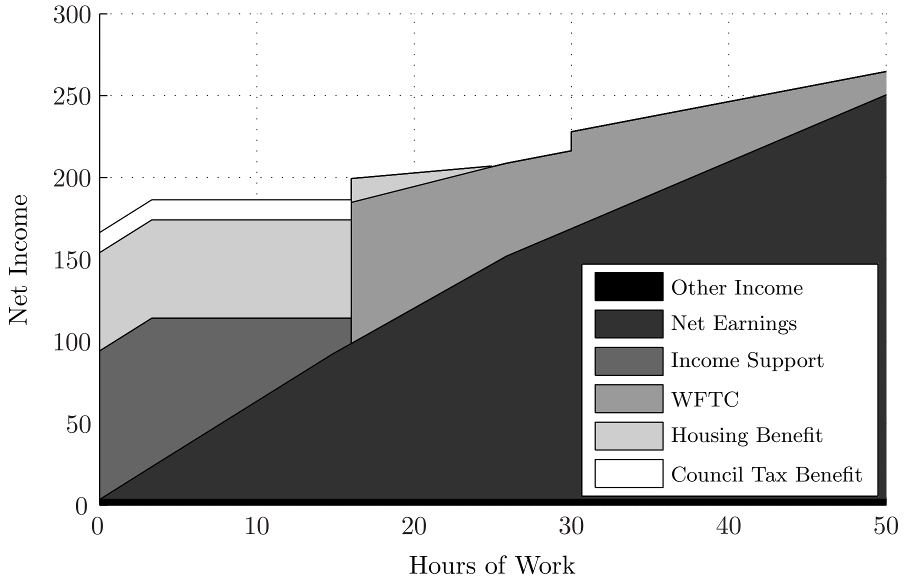


Figure 4a: Social Welfare Weights, Youngest Child Aged 0-4

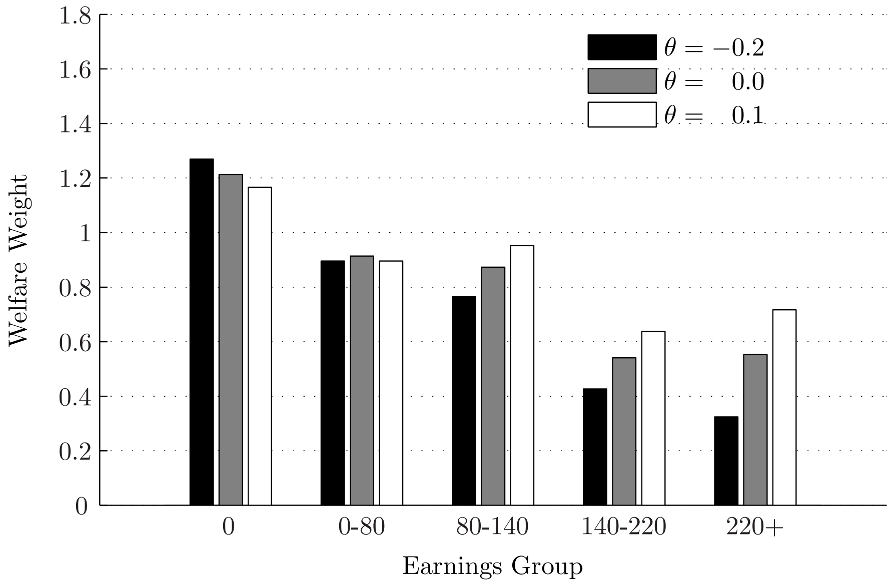


Figure 4b: Social Welfare Weights, Youngest Child Aged 5-10

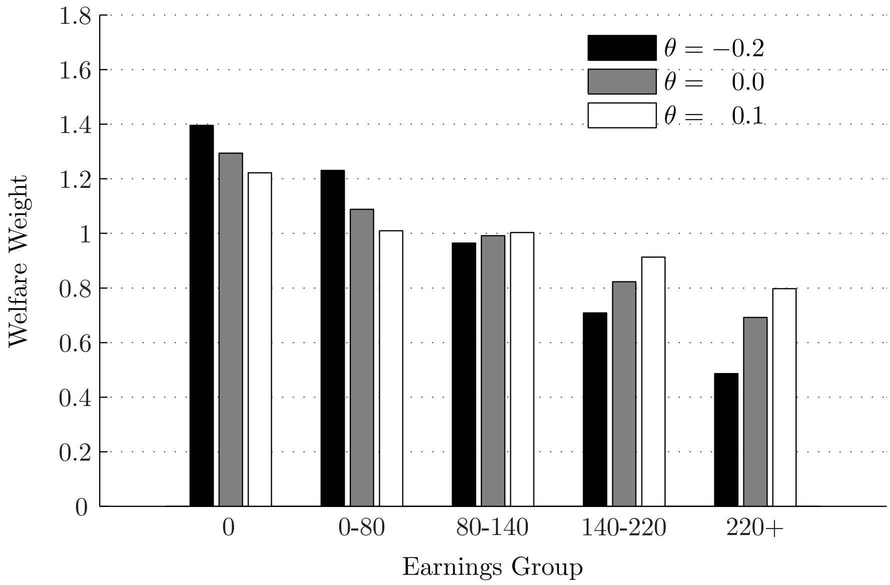


Figure 4c: Social Welfare Weights, Youngest Child Aged 11-18

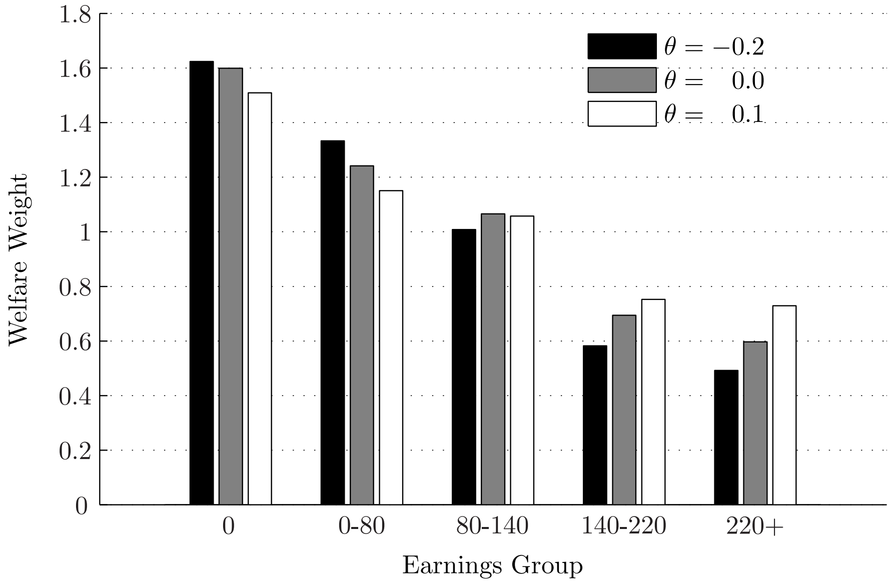


Figure 5(a): The Structure of the Constraint, Youngest Child Aged 5-10

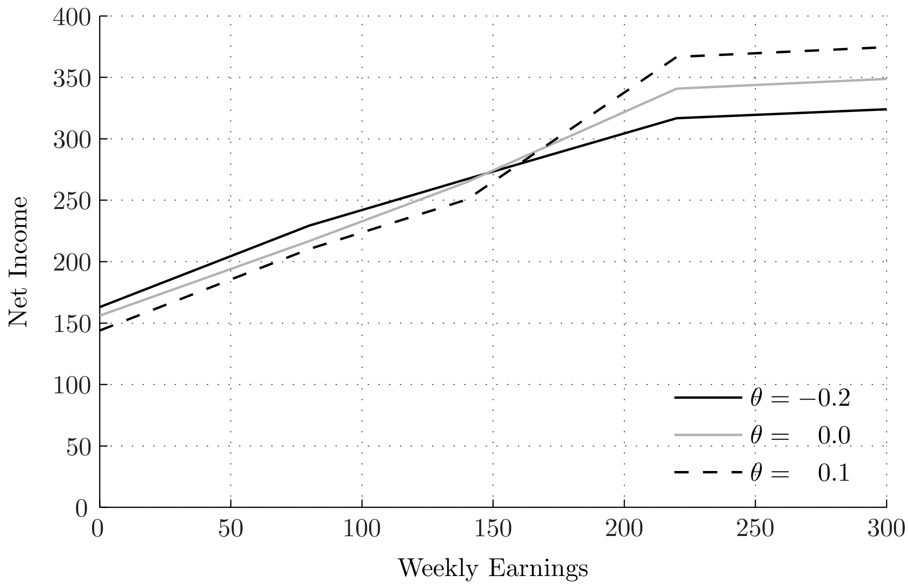


Figure 5(b): The Structure of the Constraint, Youngest Child Aged 11-18

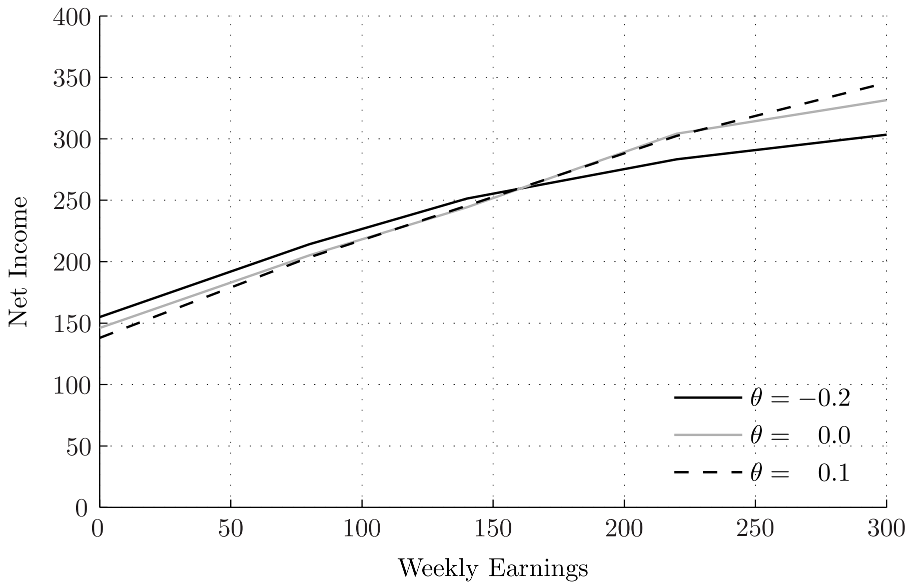


Figure 5(c): The Structure of the Constraint, Youngest Child Aged 0-4

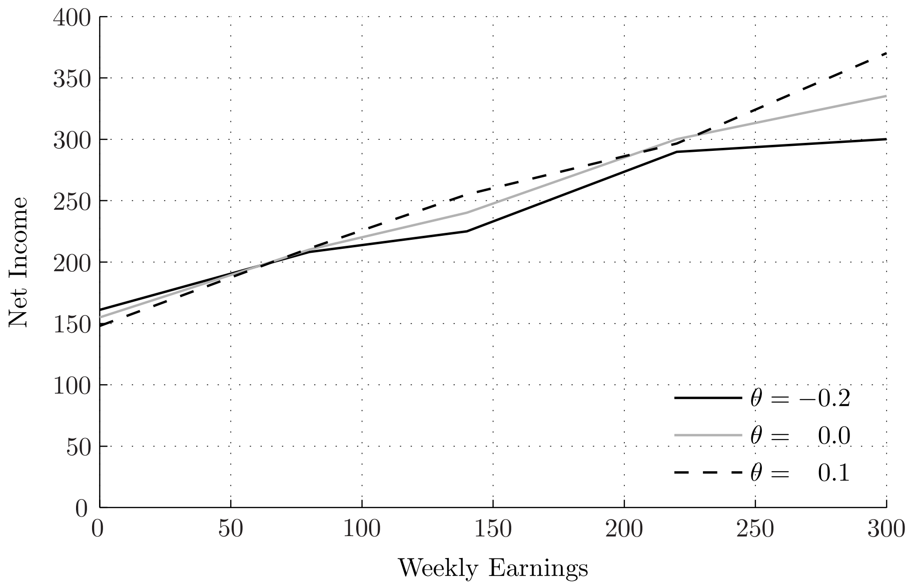


Figure 5(d): Constrained Top Rate at 69%, Youngest Child Aged 5-10, $\theta = -0.2$

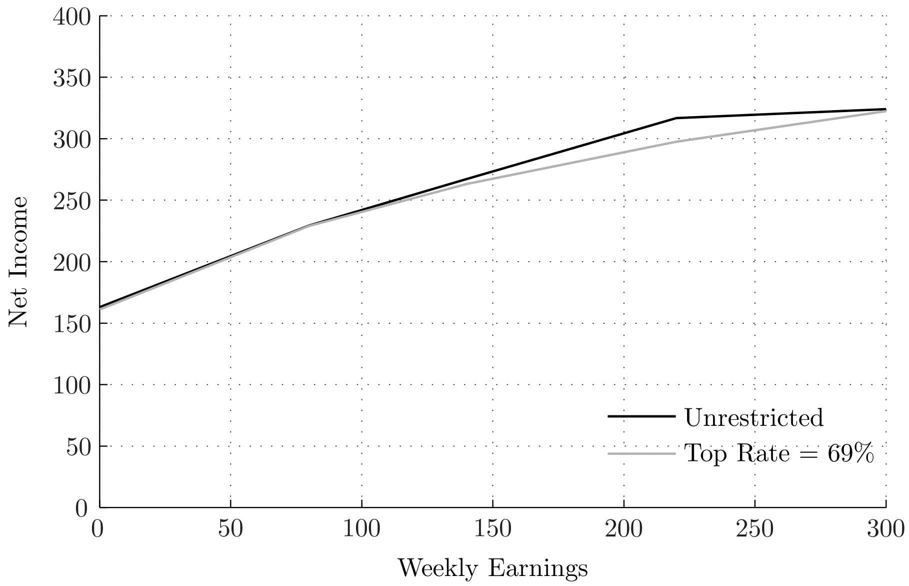


Figure 5(e): The Specification of the Utility Function, Youngest Child Aged 5-10, $\theta = -0.2$

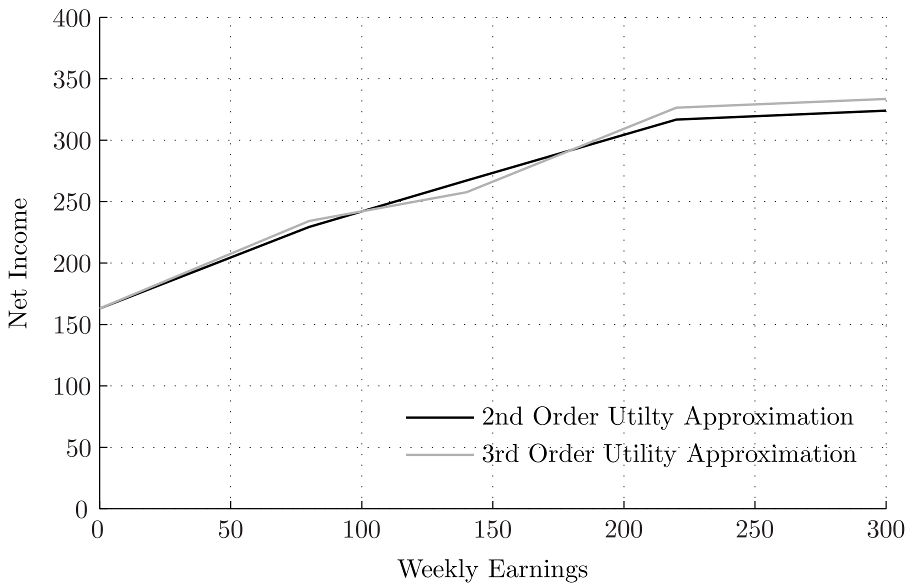


Figure 6(a): An Hours Bonus at 16 Hours per-Week, Youngest Child Aged 0-4, $\theta = -0.2$

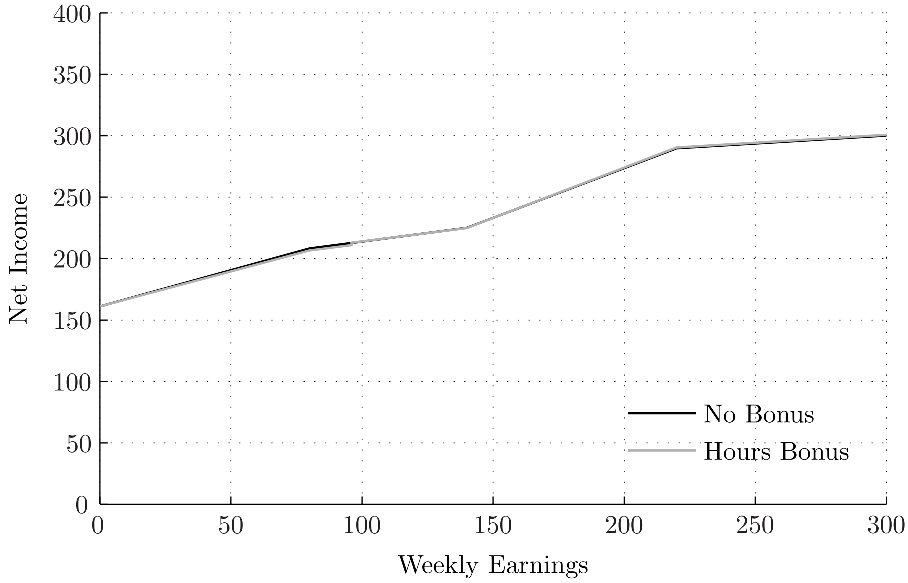


Figure 6(b): An Hours Bonus at 16 Hours per-Week, Youngest Child Aged 5-10, $\theta = -0.2$

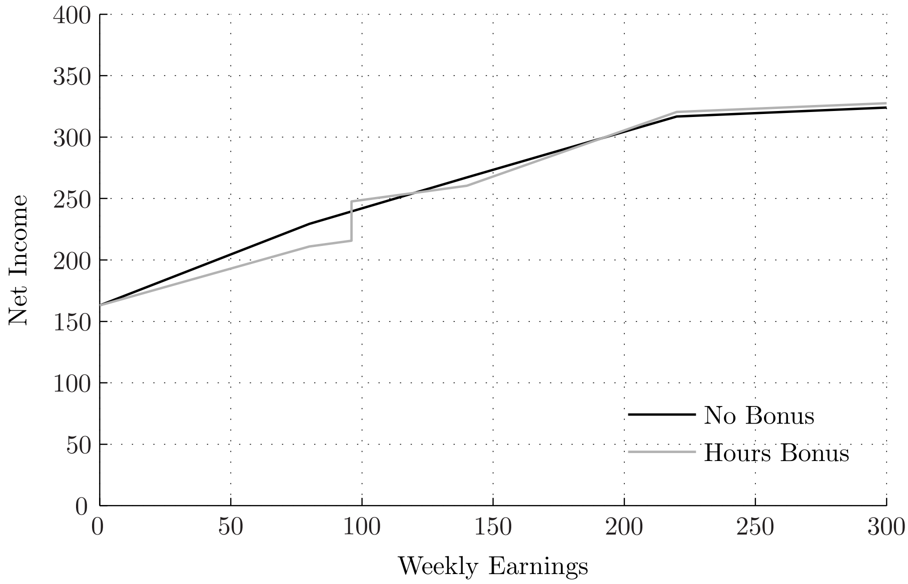


Figure 6(c): An Hours Bonus at 16 Hours per-Week, Youngest Child Aged 11-18, $\theta = -0.2$

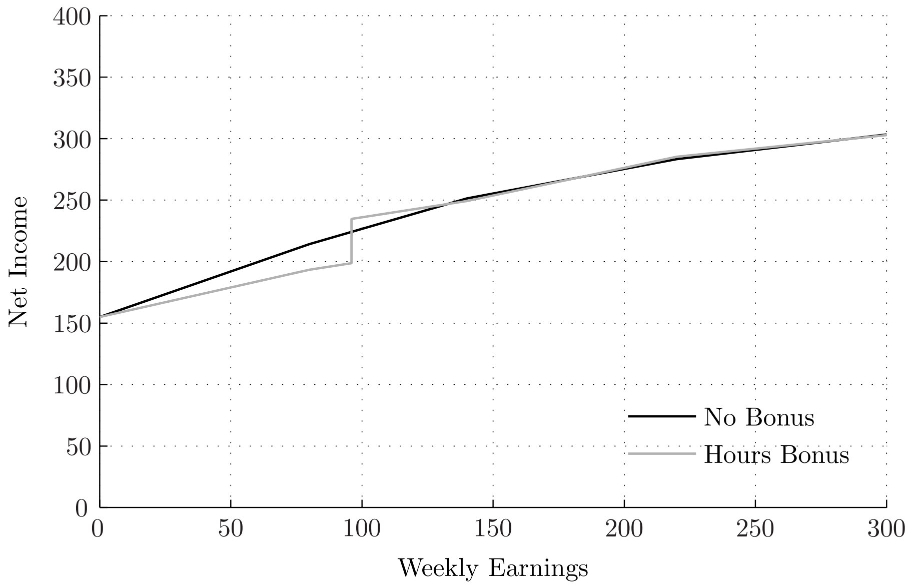


Figure 6(d): Marginal Rates with an Hours Bonus at 16 Hours per-Week, Youngest Child Aged 11-18, $\theta = -0.2$

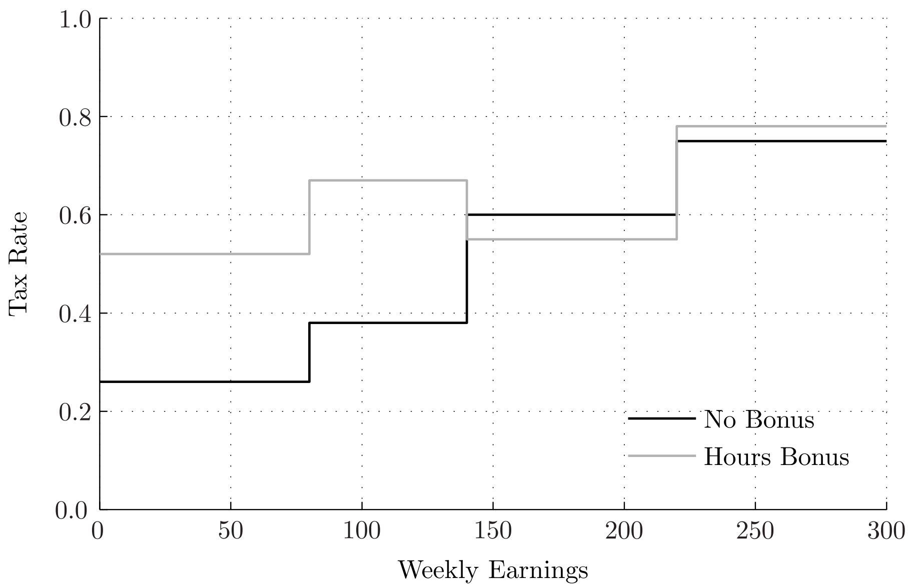


Figure 6(e): An Hours Bonus at 16 Hours per-Week with Marginal Rate Restriction, Youngest Child Aged 0-4, $\theta = -0.2$

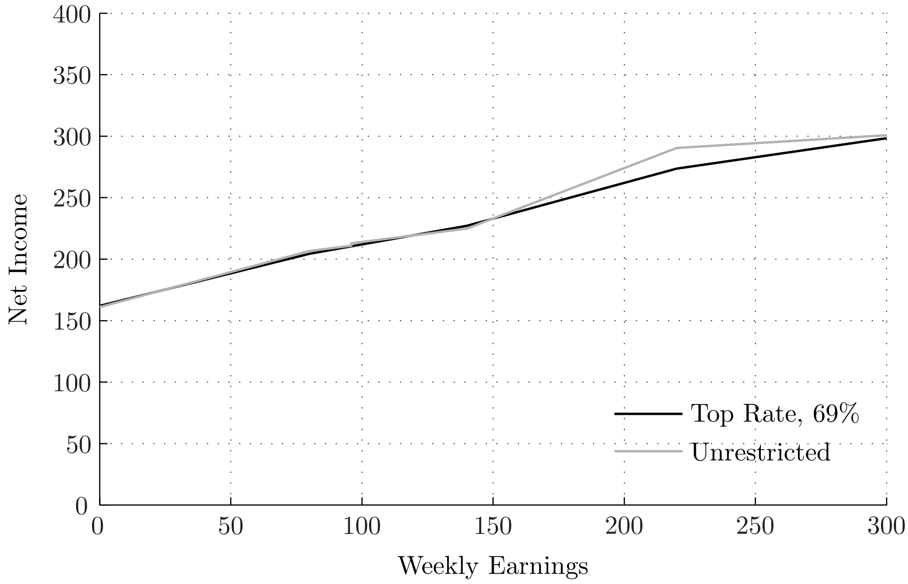


Figure 6(f): An Hours Bonus at 16 Hours per-Week with Marginal Rate Restriction, Youngest Child Aged 5-10, $\theta = -0.2$

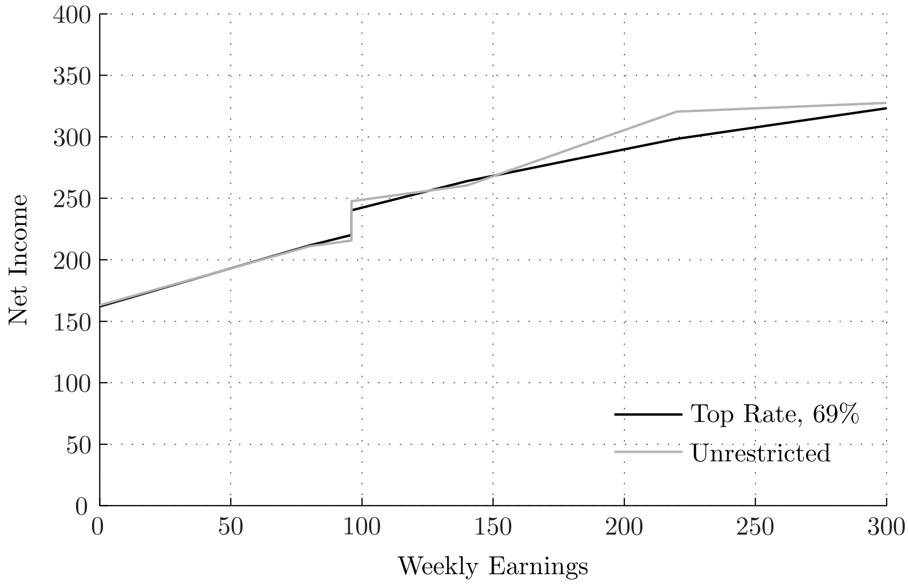


Figure 6(g): An Hours Bonus at 16 Hours per-Week with Marginal Rate Restriction, Youngest Child Aged 11-18, $\theta = -0.2$

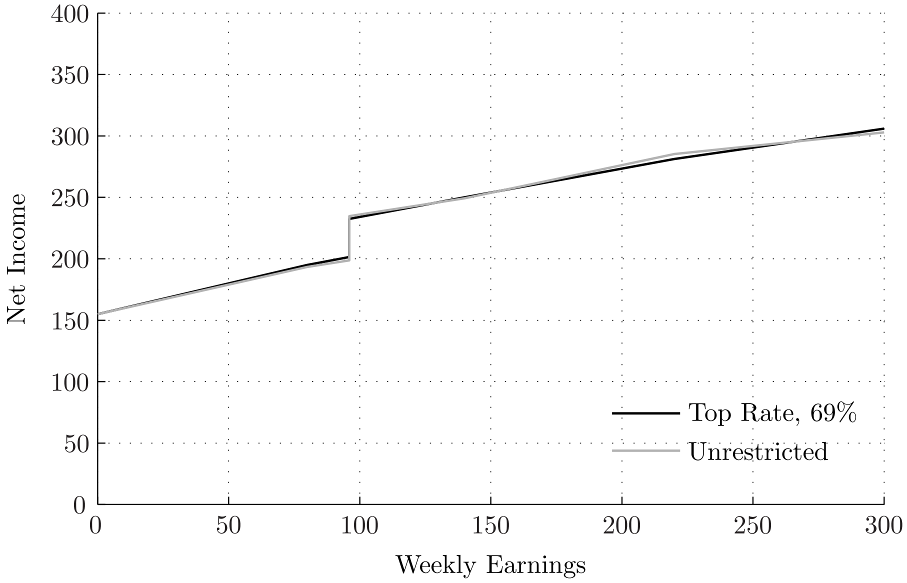


Figure 6(h): An Hours Bonus at 16 Hours per-Week, Youngest Child Aged 11-18, $\theta \in \{-0.2, 0.0, 0.1\}$

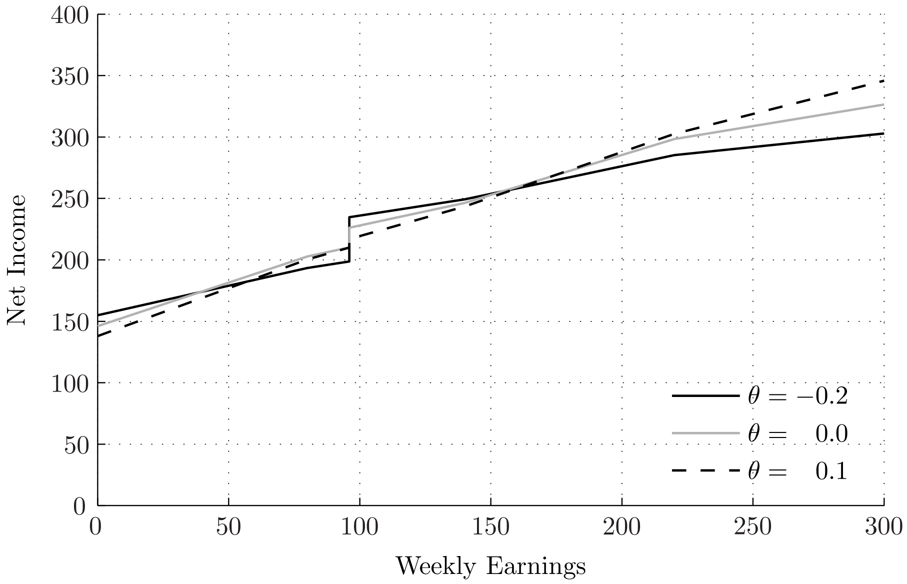


Figure 7(a): An Optimal Hours Bonus, Youngest Child Aged 0-4, $\theta = -0.2$

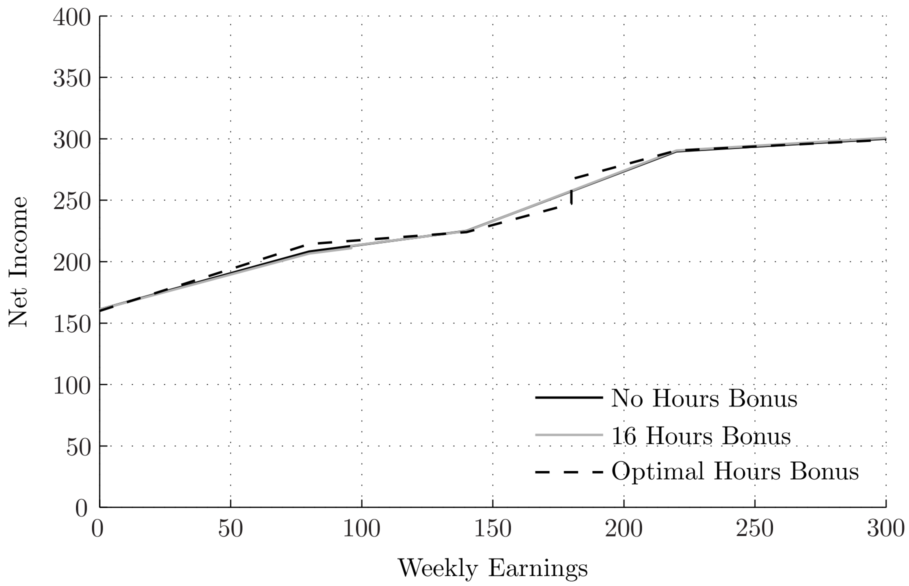


Figure 7(b): An Optimal Hours Bonus, Youngest Child Aged 5-10, $\theta = -0.2$

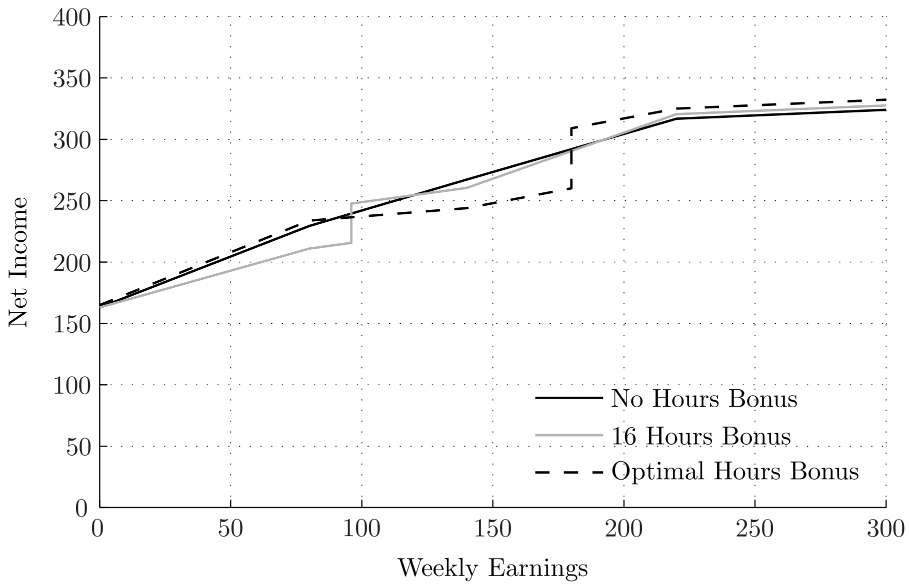


Figure 7(c): An Optimal Hours Bonus, Youngest Child Aged 11-18, $\theta = -0.2$

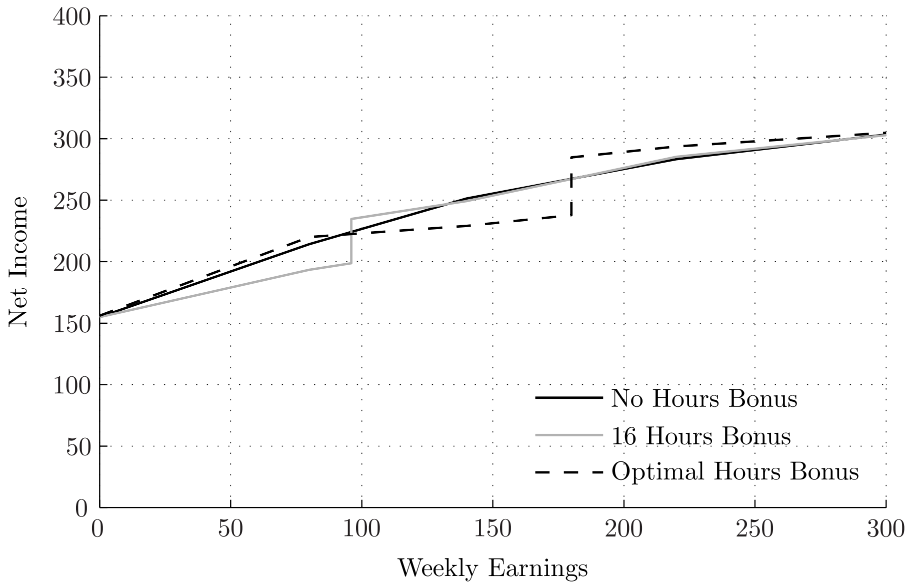


Figure 7(d): The Hours Distribution with Hours Bonus', Youngest Child Aged 0-4, $\theta = -0.2$

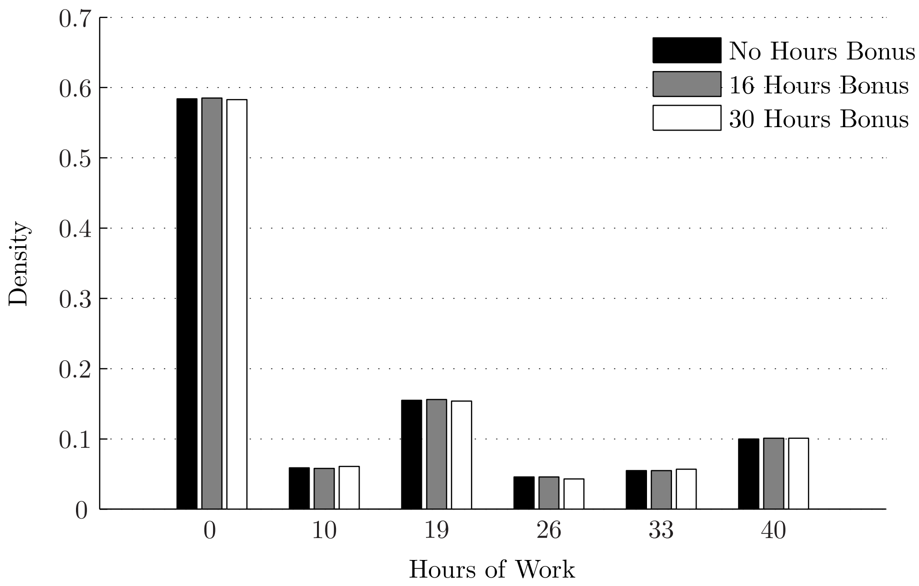


Figure 7(e): The Hours Distribution with Hours Bonus', Youngest Child Aged 5-10, $\theta = -0.2$

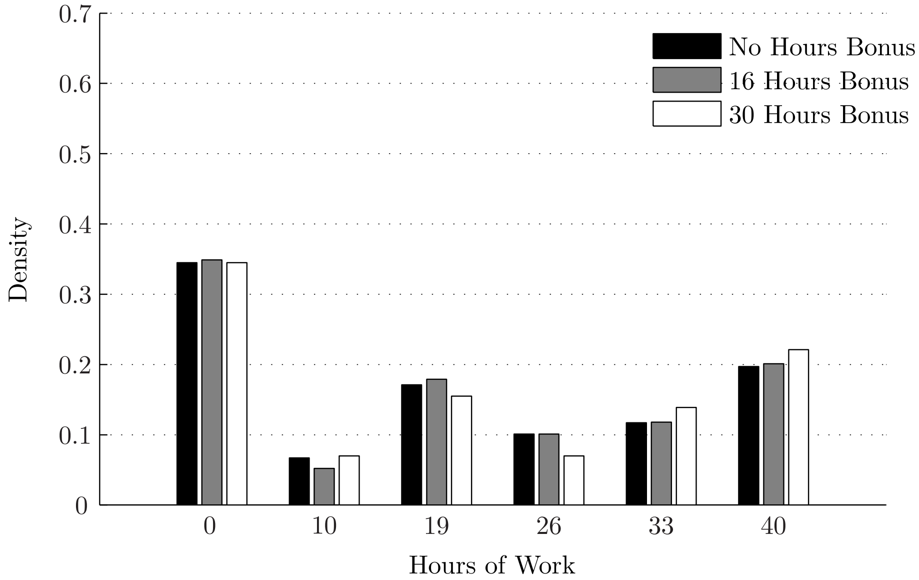


Figure 7(f): The Hours Distribution with Hours Bonus', Youngest Child Aged 11-18, $\theta = -0.2$

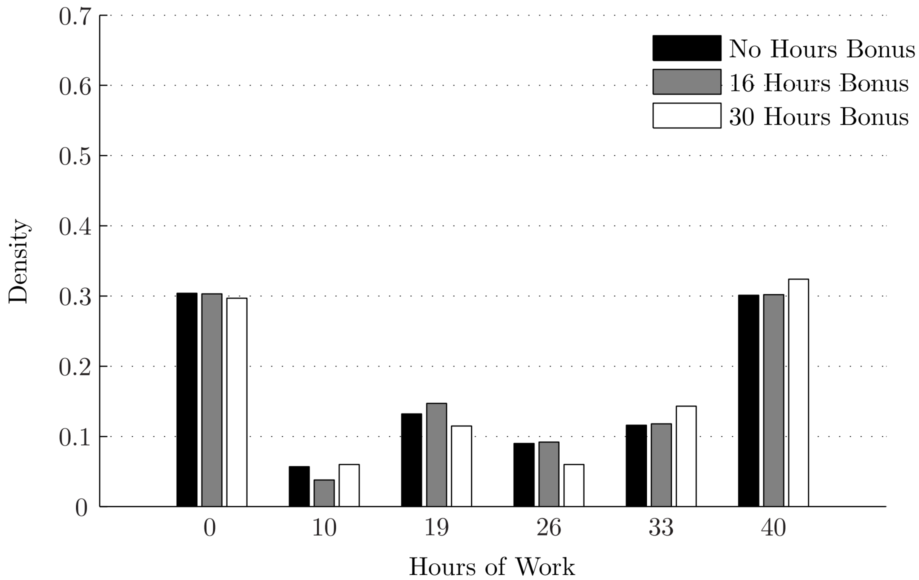


Figure 8(a): The Optimal Structure with Two Hours Conditions and Marginal Rate Restriction, Youngest Child Aged 0-4, $\theta = -0.2$

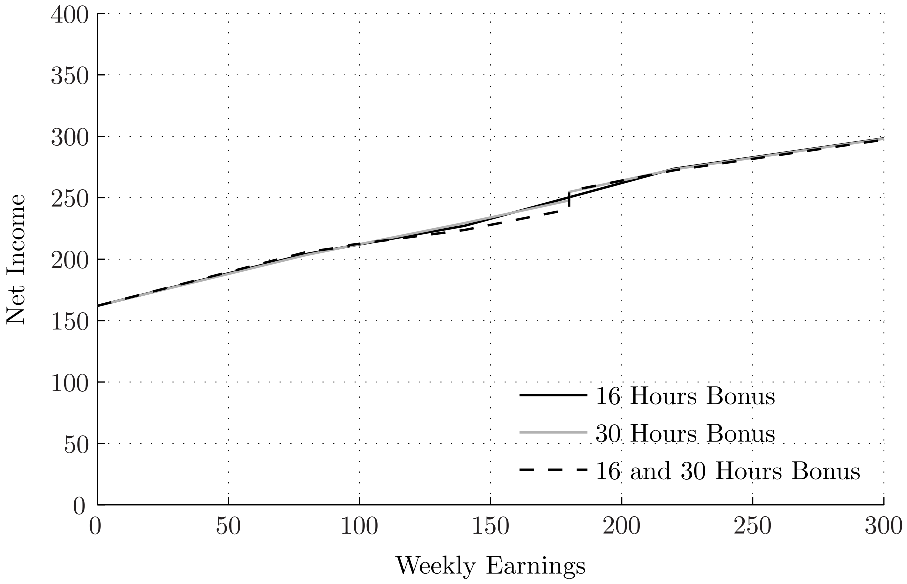


Figure 8(b): The Optimal Structure with Two Hours Conditions and Marginal Rate Restriction, Youngest Child Aged 5-10, $\theta = -0.2$

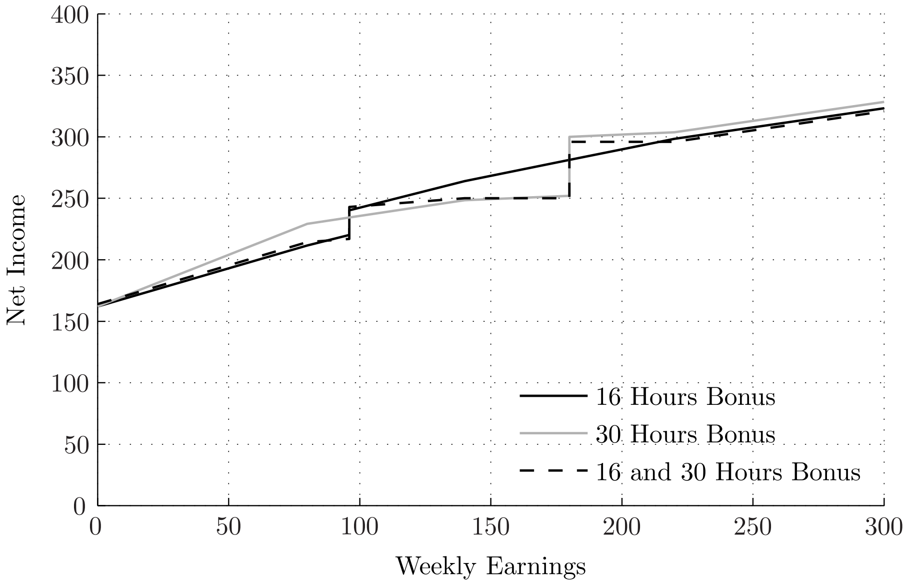


Figure 8(c): The Optimal Structure with Two Hours Conditions and Marginal Rate Restriction, Youngest Child Aged 11-18, $\theta = -0.2$