Did Working Families' Tax Credit work? Analysing the impact of in-work support on labour supply and programme participation

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Abstract

With micro-data from before and after a major reform in 1999 to the structure and form of in-work transfers in the UK, this paper uses a structural model of labour supply and programme participation to show the impact of a reform to in-work support (Working Families' Tax Credit) on both labour supply and programme participation (or take-up). Estimates suggest that the changes in in-work incomes through the introduction of WFTC increased labour supply of lone mothers by around 4.6 percentage points, slightly reduced labour supply of mothers in couples by 0.2 percentage points, and increased the labour supply of fathers in couples by 0.8 percentage points, equivalent to a net increase in participation of 94,000 workers. Participating in Family Credit, the UK's in-work programme before October 1999, conferred a utility loss as well as a utility gain from the extra income, but we find this utility cost of participation to be lower under WFTC.

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1 Introduction

This paper provides an evaluation of the impact of Working Families' Tax Credit (WFTC) on the labour market behaviour of families with children. The results are preliminary, and further work will test the robustness of the findings and explore variations to this work. The key features of this paper are that it recognises and quantifies the role that programme participation (or "take-up") plays in determining the effective incentives arising from a given tax and benefit system. In addition, using micro-data from before and after a major reform to the structure and form of in-work benefits in the UK in 1999, we can analyse the impact such reforms have on both programme participation and labour supply. We do this using a structural model of labour supply and programme participation, which has two main benefits: it allows us to disentangle the impact of changes in in-work benefits from the changes in income tax, national insurance (the UK's payroll tax) and benefits to families with children who have no-one in work that also occurred between 1999 and 2000; it also allows to us to control for the fact that the individuals entitled to participate in income-related programmes form a self-selecting group.

In-work benefits - such as WFTC - have been used in the UK and the US for families with children for over two decades, and have recently gained popularity in other countries.[1] There has also been a small movement towards making such in-work transfers part of the tax system, although this can still lead to wide variations in design reflecting the variety of income tax systems. In the UK, WFTC was introduced in October 1999 to replace Family Credit (FC), although it in turn has since been replaced by the Child Tax Credit and the Working Tax Credit (see Brewer (2003)). Although it owed much to its predecessor in its eligibility conditions and structure, two key differences from FC were its increased generosity, and the fact that it was a payable tax credit administered by the Inland Revenue, rather than a traditional income-related cash benefit, administered by the Benefits Agency.

The stated goals at the time made clear that the rationale for WFTC was to reduce in-work poverty and stimulate labour supply amongst families with children; the change

[1] See Gradus (2001) for recent EU developments, Hotz and Scholz (2003) for EITC in the US, Blundell and Hoynes (2003) for WFTC and its predecessors.

in the payment mechanism and the administering agency was hoped to demonstrate more clearly the link between working and the in-work support, and to reduce stigma and increase programme participation. This reminds us that issues concerning programme participation can in principle affect tax credits just as much as income-related benefits and was perhaps an acknowledgement that the current Government was unsatisfied with the relatively low level of programme participation of Family Credit (for the UK), around 70 per cent.[2]

Non-participation in any sort of government programme is often rationalised through some utility costs of participating. This utility cost of participation is often referred to as "stigma", but we do not use this term in this report because our data and our model are not informative about the reasons why non-entitled participants do not participate.

Non-participation in income transfer programmes (whether work-contingent or not) is particularly important and interesting for a number of reasons. First, it indicates how well a transfer programme is reaching its intended population, assuming that the intended population is "everyone who is entitled to it".[3] This is often the way the debate is framed in the UK, because the main political justification for using income-related transfers is that allow greater increase in incomes for the less well-off for a given amount of government spending compared to non-income-related benefits like Child Benefit, which have almost full participation rates.

But programme non-participation also needs to be studied carefully by economists wanting to model labour supply behaviour. Tax credits, taxes and benefits together determine the effective (income) tax rate, and the way in which they do this will depend on both the eligibility conditions attached to tax credits, and programme participation behaviour. From Moffitt (1983), writing about the Aid for Families for Dependent Children (AFDC) program: "assuming that there is heterogeneity in the population in both tastes for work and distastes for welfare (for example, stigma), only those with relatively low distastes for welfare or low distastes for work will participate in the program". Focusing back on the UK and WFTC, a lone parent observed not working in a model that assumed full programme

[2]See Table 15.

[3]Although governments may deliberately allow for utility costs of participating as an additional targeting mechanism; see, for example, Yaniv (1997) and Besley and Coate (1992).

participation would be presumed to have relatively high distastes for work, relatively low tastes for income, or relatively high fixed costs of working, when the true cause could be that she has relatively high distastes for or relatively low knowledge of WFTC. Assuming full participation in any transfer programme that affects the shape of the budget constraint may lead to inconsistent estimates of preferences for income and work in a utility-maximising model of labour supply. It will also lead to misleading inferences about the extent of high effective marginal tax rates.

The introduction of WFTC in October 1999 provides an excellent example to investigate issues around programme participation in income-transfer schemes, and to build a more accurate picture of the labour supply preferences of families with children. WFTC is a national, entitlement-based, programme (all those who apply and satisfy the eligibility conditions receive it), and so there is no ideal "control" group. WFTC was also introduced at the same time as other changes to the tax and transfer system affecting families with children, making comparisons between similar populations over time uninformative. We therefore estimate a joint structural model of labour supply and programme participation, in a discrete choice framework, along the lines of Hoynes (1996), Keane and Moffitt (1998), Paull *et al.* (2000), Blundell *et al.* (1999, 2000), and Gong and van Soest (2002), and van Soest *et al.* (2002). Such a model can be used to predict the behaviour of the sample as WFTC replaced FC, and can also investigate whether the change in administration and payment methods in WFTC did increase programme participation.

The outline of our paper is as follows. Section 2 provides more background to and a fuller description of the reforms in the UK during 1999 that we intend to study. Section 3 sets out our model of programme non-participation and labour supply. Section 4 describes our data sources and the tax and benefit reforms that we simulate. Section 5 contains the results of the model and simulation results. Section 6 concludes. Readers primarily interested in our results could omit Section 3; the key point to note is that our methodology requires us to make inferences about parents' preferences for working by assuming that parents face a free choice about how many hours to work, given their wage.

To anticipate our conclusions, we find that the cost of participating in the UK's in-work support programme was lower under WFTC than under Family Credit, meaning that take-up of WFTC should be higher than that of FC, controlling for all other factors. Combining this effect with the impact of the changes in net incomes, we find that WFTC increased labour supply of lone mothers by around 4.6 percentage points. The effect on individuals in couples are more complicated: we find that WFTC reduced labour supply of mothers in couples by 0.2 percentage points, and increased the labour supply of fathers in couples by 0.8 percentage points. Overall, WFTC increased the proportion of single earner couples and reduced the proportion of no earner or two earner couples. Our estimates correspond to an aggregate effect of around 94,000 extra workers, two thirds of whom are mothers, and to a reduction in the number of workless households with children of 95,000. However, other changes to the tax and benefit system made around the time that WFTC was introduced acted, on balance, to reduce the labour supply of parents: the combined impact of all tax and benefit changes in October 1999 and April 2000 was to increase the labour supply of lone parents by 3.4 percentage points, and reduce that of men and women in couples by 0.4 percentage points. This corresponds to an increase in participation of 23,000 individuals, and a reduction in the number of workless households of 40,000.

When we consider all of the tax and benefit reforms enacted between April 1999 to April 2000, we find that these increased the participation of lone parents by 3.4 percentage points, but that the participation of men and women in couples declines by around 0.4 percentage points.

This paper reports preliminary conclusions. Further work will examine the robustness of the findings to changes in the estimation method and stochastic specification.[4] We also intend to report the results of evaluating WFTC using a reduced-form difference-in-difference approach.

[4]In particular, we would like to: explore the robustness of the estimated change in the utility cost of participating in in-work support by allowing for changes in preferences over time, experiment with a less restrictive sample selection rules, so that our sample is more closely representative of the population; test the robustness to changes in the hours choices allowed; restricting the choice-specific errors to be hours-specific; allowing for correlations in the random preference terms; testing the robustness to our assumptions on childcare use and price.

2 Background to and description of the reform

2.1 The WFTC reform

Working Families' Tax Credit (WFTC) was introduced in the UK in October 1999 as a replacement to Family Credit (FC), and was fully phased in by April 2000. Eligibility for the programme depended on hours of paid employment, the number of children, income, capital and formal childcare costs. Couples were assessed jointly. Unlike the Earned Income Tax Credit in the US, there was no "phase-in": families fulfilling the work condition - an adult in the family unit must work 16 or more hours a week - were immediately eligible for the maximum credit, but earnings above a threshold - £90 a week in October 1999 - reduced the credit at a rate of 55% of net income (so each pound of earnings after income tax and national insurance reduced awards of WFTC by 55p; the combined WFTC-income tax-national insurance effective marginal tax rate for someone paying basic-rate income tax was 69%: see Brewer (2001)). Financial assets over £3,000 reduced the award; savings over £8,000 removed eligibility completely. There was a small extra credit for families where someone worked more than 30 hours a week, and support for childcare was paid additionally to this. Spending on WFTC in 2000-1 was £2.1bn (83%) higher than on Family Credit in 1998-9 (2001/2 prices), and there was no attempt to present the reform as revenue neutral.

Although it owed much to its predecessor, two key differences between WFTC and FC were the generosity of WFTC and the payment mechanism.[5] WFTC was more generous than FC in three ways: it had higher credits, particularly those for young children, families could earn more before the credit was phased out, and it had a lower withdrawal rate. The change in the payment mechanism was that, while FC was paid direct as a cash benefit, WFTC was paid by employers through the wage packet (who are themselves reimbursed by the Inland Revenue) unless a couple collectively decided that the non-working adult should apply for and therefore be paid WFTC. WFTC also significantly changed the system of support for formal childcare costs. Under FC, childcare costs up to £60 (£100) a week for

[5]A detailed history of in-work benefits in the UK, and a comparison of WFTC and FC can be found in Blundell and Hoynes (2003), with shorter accounts in Blundell *et al.* (1999 and 2000) and Dilnot and McCrae (1999).

families with 1 (2) children could be disregarded before the credit was phased out, which only benefited families earning more than the earnings threshold. Under WFTC, there was a payable childcare tax credit. It was potentially much more generous than the FC childcare disregard, providing a 70% subsidy to the parent on costs up to £150 a week for families with two or more children of any age, and was paid in addition to WFTC, rather than an income disregard (for couples, the eligibility condition was that both must be working 16 or more hours). One final change is that Family Credit treated child support (or maintenance) above £15 a week as income, but WFTC disregarded all child maintenance when calculating awards.

The introduction of WFTC, though, is by no means the end of the story. At the time of the WFTC reform, there were three other main ways that the UK tax and transfer system provided support for children: Child Benefit, child allowances in Income Support, and a non-refundable income tax allowance.[6] Two points should be highlighted:[7] first, at the same time as WFTC was introduced and then increased further in generosity (October 1999 and April 2000 respectively), the value of out-of-work benefits for families with children under 11 also increased (see Section 4). Second, the way that different means-tested programmes interact with each other means that families receiving help with rental housing costs and local taxes (ie Housing Benefit (HB) and Council Tax Benefit (CTB) respectively) gained less from the WFTC reform that otherwise-equivalent families not receiving these benefits.

2.2 What was expected to happen?

The introduction of WFTC affected work incentives in complicated ways, but we can identify several different groups within which the impact was qualitatively similar.[8] At the margin of labour market participation (considering work of less than 16 hours a week as being "non-participation"), families with no earners before the reform would be expected to increase participation. The impact on hours worked conditional on working 16 or more

[6]See Adam *et al.* (2002).
[7]See Blundell and Hoynes (2003)).
[8]See also Blundell and Hoynes (2003), or Blundell *et al.* (2000).

hours is more complex. There are at least five cases:[9]

- people receiving the maximum FC award. These people will face an income effect away from work (but not below 16 hours a week). At the margin, there will be no substitution effect.

- people working more than 16 hours and not on maximum FC. These people will face an income effect away from work (but not below 16 hours a week), and a substitution effect towards work (i.e. the gains/losses from increasing/decreasing hours will weakly increase/decrease).

- 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 (i.e. the losses from decreasing hours will weakly decrease) if they claim WFTC.

- second earners in couples will face an income effect away from work, and this will not be bounded at 16 hours unless the couple claims help with childcare costs, implying that participation may decline amongst second earners in couples.

- over and above these effects on labour supply, existing and potential childcare users will face income effects (if childcare is a normal good) and substitution effects towards the sort of childcare expenditure subsidised by WFTC.

The introduction of WFTC did increase the financial reward to working for Housing Benefit (HB) recipients. But, as we indicated earlier, HB recipients face lower incentives to work 16 or more hours, and lower incentives to increase hours conditional on working 16 or more hours than those not receiving HB, and the overwhelming majority of non-working lone parents also claim HB.[10]

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[9] This is a more complex version of the general typology in Blank, Card and Robins (1999) that takes account of the particular structure of WFTC.

[10] See Giles, Johnson and McCrae (1997) for more details on HB; Brewer (2001) contains some recent quantification of how it interacts with WFTC to affect work incentives, Bingley and Walker (2001) models labour supply and programme participation in HB jointly.

An *ex-ante* evaluation of WFTC is presented in Blundell *et al.* (1999, 2000). This uses data from before the evaluation to estimate labour supply preferences, which are then used to simulate the impact of introducing WFTC. The methodology is explained more fully later, as we borrow and build on much of it in this study, and allowed for joint decision making in couples, programme non-participation under FC/WFTC, and changes in childcare use. It predicted an increase in labour market participation rates for lone parents of 2.2 percentage points, a small net decline (0.57 percentage points) in labour market participation amongst women in couples, and no net effect on the labour market participation rates of men in couples (a similar order of magnitude was predicted by a simpler, reduced-form study, which related moves into work with financial gains to work: see Gregg *et al.* (1999)).

But more things changed between April 1999 and April 2000 than just WFTC (full details are in Section 4). In particular, a rise in out-of-work benefits (ie income support and income-related jobseekers' allowance, with matching increases in HB and CTB) for families with children under 11 meant that replacement rates for those contemplating low-wage part-time work rose for families with children. This has led some people to view WFTC as part of attempts by UK governments since 1992 to increase the amount of money paid to low-income families for their children, whether in or out of work, whilst maintaining welfare benefits for adults in real terms.[11]

3 A model of labour supply and programme non-participation

This chapter sets out our theoretical model of labour supply and programme participation, and then describes how we estimate it,and how we use it to conduct simulations of policy reforms.

[11] See Blundell and Hoynes (2003) and Brewer et al (2002).

3.1 A basic model of preferences for work and income

The starting point for our model builds directly on that presented in Blundell *et al.* (1999). [12] The basic approach is to assume that individuals maximize their utility subject to their own budget constraint. Individuals' preferences are written in terms of hours of work and net income, and a set of observable demographic factors and unknown preference parameters. [13] We let y_{hP} represent the net income available to a particular woman who is employed for h hours, computed as the product of hours of work h and the gross hourly wage w, plus investment income I, plus transfer payments $\Psi(w, h, I, P|Z_\Psi)$, minus all taxes $\Gamma(wh, I|Z_\Gamma)$. Here, the function $\Gamma(wh, I|Z_\Gamma)$ represents net tax payments, and depends on gross earned income, investment and other asset income I, and characteristics Z_Γ. The transfer payment function $\Psi(w, h, I, P|Z_\Psi)$ depends explicitly on hours (through the hours condition of entitlement for FC/WFTC) as well as earned and investment income, participation P in the FC/WFTC transfer programme, and household characteristics Z_Ψ. We assume that the wage does not depend on hours worked. This leads to an expression for y_{hP} of the form:

$$y_{hP} = wh + I - \Gamma(wh, I|Z_\Gamma) + \Psi(w, h, I, P|Z_\Psi)$$

Wages w are assumed to be generated by a log-linear relationship of the form:

$$\log w = X_w\beta_w + u_w$$

where X_w is a vector of observable characteristics, and u_w is an independent random component with distribution function $f(u_w)$.

If we approximate the direct utility function $U(\cdot, \cdot)$ by a second degree polynomial expansion in hours and net income then we obtain:

[12] Other examples include van Soest et al (2002), Hoynes (1996), Keane and Moffitt (1998), Bingley and Walker (1997). Other studies use discrete choice methods to model labour supply but without modelling program participation issues; Moffitt (1983) also models labour supply and programme participation jointly, but that study simplifies the budget constraint so that hours of work can be modelled as a Tobit.

[13] Our approach assumes that the number of children is exogenous to the decision to work. It is appealing, although extremely theoretically and empirically complicated, to model fertility and labour supply jointly in an inter-temporal utility maximizing model. Powell (1997) was able to reject the null that the the number of children aged 2 was exogenous. We continue to assume that fertility is exogenous, and this means that our estimated preferences for labour supply may partially reflect preferences for fertility.

$$u(h, y_{hP}) = \alpha_{11} {y_{hP}}^2 + \alpha_{22} h^2 + \alpha_{12} y_{hP} h + \beta_1 y_{hP} + \beta_2 h$$

where α and β are preference parameters. We allow both observable and unobservable factors to enter preferences, according to:

$$\begin{aligned}
\beta_1 &= X_1 \beta_{1x} + u_y \\
\beta_2 &= X_2 \beta_{2x} + u_h \\
\alpha_{11} &= X_{11} \alpha_{11x} \\
\alpha_{22} &= X_{22} \alpha_{22x} \\
\alpha_{12} &= X_{12} \alpha_{12x}
\end{aligned}$$

where $X = [X_1, X_2, X_{11}, X_{22}, X_{12}]$ represents observable demographic and other household characteristics, and where u_y and u_h are included to capture unobserved preference heterogeneity. These random preference terms play an important part in relaxing the IIA assumption implied by the choice of extreme value state-specific errors. Unfortunately (and as found by van Soest *et al.* (2002), the eventual estimates of their standard deviation prove to be small and imprecise.

3.2 Modelling Discrete Choices over Hours

Given the considerable non-convexities in the budget constraint generated by the tax and transfer system, assuming a linear budget set would be grossly inadequate. Instead, we work directly with preferences defined over net income and hours for a discrete subset of hours choices. [14] To make this estimation feasible, we assume that there is an additive stochastic component ε_{hP} which varies in hours and programme participation. They can be interpreted as unobserved alternative specific utility components, or errors in perception of the alternatives' utilities, but they do not reflect random preferences derived from unobserved family characteristics.

[14] Blundell and MaCurdy (2000) reviews labour supply modelling and conclude that discrete choice modelling represents best practice. Assuming a limited discrete choice reduces the complexity of modelling, but allows for the non-convex budget constraints that we almost always observe in practice. The risk is that the parameter estimates may not be robust to changes in the thresholds and the hours values chosen.

$$U(h, y_{hP}) \approx \alpha_{11} {y_{hP}}^2 + \alpha_{22} h^2 + \alpha_{12} y_{hP} h + \beta_1 y_{hP} + \beta_2 h + \varepsilon_{hP}$$

Assuming that individuals optimise their choice of hours over the discrete set of alternatives, and (for now) that there is full participation in FC/WFTC (so that the programme participation indicator P is set to 1) then the probability of any hours choice h_j can be written as:

$$\Pr(h = h_j | X, w, u_y, u_h) = \Pr[U(h_j, y_{h_j}; X, w, u_y, u_h) > U(h_k, y_{h_k}; X, w, u_y, u_h) \; \forall \; h_k \neq h_j]$$

If we further assumed that that all state-specific errors ε_h follow a standard (Type-I) extreme-value distribution [15], then we can derive this probability $\Pr(h = h_j | X, w, u_y, u_h)$, conditional on the random components u_y and u_h, the observable explanatory variables X, and the wage w, as:

$$\Pr(h = h_j | X, w, u_y, u_h) = \frac{\exp\{U(h_j, y_{h_j}; X, w, u_y, u_h)\}}{\sum_{k=1}^{J} \exp\{U(h_k, y_{h_k}; X, w, u_y, u_h)\}}$$

3.2.1 The basic Log Likelihood

If there were no random terms u_y and u_h, and w in this expression, then the likelihood function would be a product of the probabilities $\Pr(h = h_j | X, w, u_y, u_h)$, and would closely resemble a conditional logit model. However, estimation needs to take account of the additional stochastic terms by integrating over the distributions of u_y, u_h and $u_w = w - E(w|X_w)$ in the probabilities $\Pr(h = h_j | X, X_w, u_y, u_h, u_w)$.

The basic log-likelihood expressed over J hours alternatives $h \in \{h_1, \ldots, h_J\}$ may be written as:[16]

$$\log \mathcal{L} = \sum_i \log \int_{u_w} \int_{u_y} \int_{u_h} \prod_{j=1}^{J} \Pr(h = h_j | X, X_w, u_y, u_h, u_w)^{1(h=h_j)} f(u_h) f(u_y) f(u_w) du_h du_y du_w$$

[15]This assumption is common, and follows Blundell *et al.* (1999) and Keane and Moffitt (1998). van Soest *et al.* (2002) discuss some possible interpretations of the errors, but the main advantage is in providing positive probabilities for all choices for all parameter values. Its implications are a subject for further work.

[16]This has been written with the stochastic terms independent.

Unfortunately, this model is not sufficient to describe adequately the observed outcomes in the data. For that we need three extensions to the basic model: first, we need to control for additional fixed costs of employment; second, we need to account explicitly for childcare costs and childcare usage; and third, we need to extend the model to account for FC/WFTC programme non-participation.

3.3 Controlling for costs of employment

3.3.1 Fixed costs of employment

Fixed work-related costs are the costs that an individual has to pay to get to work. In addition to childcare costs, there are costs such as transport which will vary by household type and by region. 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) are defined by:

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

and are modelled to depend on observed characteristics X_{f1}, X_{f2} and a random component u_f, and the parameters β_{f1} and β_{f2} are to be estimated. An individual working full-time will therefore face a work-related cost equal to $X_{f1}\beta_{f1} + X_{f2}\beta_{f2} + u_f$.

3.3.2 Childcare costs

Inferring parents' labour supply preferences from observed behaviour without considering childcare is likely to lead to biased conclusions. And, as both FC and WFTC provide financial support for formal childcare costs for families where all adults are working, evaluating the impact of WFTC on labour supply requires us to specify the childcare costs of working parents.

A full consideration of childcare would require that the decision to use childcare and how much to spend is modelled jointly with employment choices. This is theoretically and empirically challenging.[17] Given that the focus of this paper is on labour supply and programme participation, we follow Blundell *et al.* (1999, 2000) by allowing for childcare costs explicitly, but by 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.[18] We have therefore implicity 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 $C = C(h; X_f, X_{cc}, p_c, u_f)$ of

[17] Andren (2003) is an example of a joint model of labour supply, childcare use and programme participation. Other papers that have modelled childcare demand have simplified either the labour supply behaviour or assumed full programme participation: see Brewer and Paull (2003).

[18] We approximate the distribution by 6 fixed discrete points.

working is given by the following expression:

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

where $I_{h1} = 1(h > 0)$ is an employment indicator, $I_{h2} = 1(h > 30)$ is a *full-time* employment indicator, and $I(\cdot)$ is the indicator function. An extended preference function in the presence of childcare and other unobserved fixed costs is given by:

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

where y_h contains the value of the childcare disregard (under FC) or the childcare tax credit (under WFTC).

3.4 Modelling programme non-participation

In-work benefits in the UK have experienced less than full participation since their inception. As has been discussed, part of the motivation for the administrative changes between WFTC and FC was to reduce the costs of receiving transfer payments, and so our goal is to model jointly labour supply and programme participation decisions. In this section, we describe how allowing for programme non-participation affects our theoretical model and its estimation.

3.4.1 An economic model of programme participation

Programme non-participation is usually rationalised by assuming that there are some costs to participating.[19] We implement this by first expanding individuals' choice sets to include the choice of whether to participate in the FC/WFTC programme, in addition to the choice of the number of hours of work h.

As above, let P be an indicator of programme participation. The decision to participate in FC/WFTC affects total net income y_{hP} in two ways. First, y_{hP} includes any direct

[19] As we said in the introduction, this utility cost of participation is often referred to as "stigma", but we do not use this term in this report because our data and our model are not informative about the reasons why non-entitled participants do not participate.

entitlement to FC/WFTC if the worker chooses to make a claim. And second, the level of (and eligibility to) other transfer payments may depend on the level of entitlement to FC/WFTC. To isolate the income effect of claiming FC/WFTC, we disaggregate total transfer payments in the following way: Let $\Psi_0 = \Psi_0(w, h, I|Z_\Psi)$ be the level of entitlement to all transfer payments other than FC/WFTC, and define $\Psi_1 = \Psi_1(w, h, I|Z_\Psi)$ to be the net value of FC/WFTC if it is claimed.[20] Then, total transfer income with endogenous FC/WFTC programme participation is:

$$\Psi(w, h, I, P|Z_\Psi) = \Psi_0(w, h, I|Z_\Psi) + P \cdot \Psi_1(w, h, I|Z_\Psi)$$

so that total net income with FC/WFTC programme participation may be written as:

$$\begin{aligned} y_{hP} &= wh + I - \Gamma(wh, I|Z_\Gamma) + \Psi_0(w, h, I|Z_\Psi) + P \cdot \Psi_1(w, h, I|Z_\Psi) \\ &= \widetilde{y}_h + P \cdot \Psi_1(w, h, I|Z_\Psi), \end{aligned}$$

where $\widetilde{y}_h$ represents total net income from all sources other than FC/WFTC, and $\Psi_1(\cdot)$ is the net income gain from claiming FC/WFTC. Of course, eligibility to FC/WFTC might be zero at certain hours choices, either through the explicit hours conditions to entitlement, or because the level of earned income is sufficient to reduce entitlement to zero: let the $E_h = 1(\Psi_1 > 0)$ be an indicator of positive entitlement to FC/WFTC at hours h.

We then introduce additional terms into the preference function to capture the *utility cost* (denoted η) of receiving in-work support. These costs may therefore include information costs, the hassle or transaction costs of applying , or genuine welfare stigma. Our model is a static one, and so we do not distinguish between the costs of applying and the

[20] We choose not to model the decision to participate in transfer programmes other than FC/WFTC. However, the methods used here may be extended to account for participation in multiple transfer programmes, as in Keane and Moffitt (1998).

costs of receiving FC/WFTC. The extended preference function now takes the form:

$$\begin{aligned} U_P(h, y_{hP}, P; C) &= \alpha_{11}(\widetilde{y}_h + P \cdot \Psi_1 - C)^2 + \alpha_{22}h^2 + \alpha_{12}(\widetilde{y}_h + P \cdot \Psi_1 - C) \cdot h \\ &+ \beta_1(\widetilde{y}_h + P \cdot \Psi_1 - C) + \beta_2 h + \varepsilon_{hP} - (P \cdot E_h) \cdot \eta \\ \\ &= U(h, \widetilde{y}_h + P \cdot \Psi_1 - C) - (P \cdot E_h) \cdot \eta, \end{aligned}$$

where $U(\cdot, \cdot)$ is analogous to the earlier preference function, and $(P \cdot E_h) \cdot \eta$ represents the costs associated with choosing to claim a (positive) transfer payment entitlement. These utility costs of participation, whilst not observed, are assumed to depend linearly on a set of observed characteristics X_η and a stochastic component u_η, so that:

$$\eta = X_\eta \beta_\eta + u_\eta$$

Conditional on working h_j hours and being eligible for a positive transfer payment, people choose to participate in a transfer programme *at that hours level* if the utility gain from receipt of the extra transfer income Ψ_1 outweighs the disutility of claiming and participating. Families will therefore claim Ψ_1 in FC/WFTC at hours h_j if:

$$U_P(h_j, \widetilde{y}_{h_j} + \Psi_1 - C, P = 1) > U(h_j, \widetilde{y}_{h_j} - C).$$

This has the interpretation that the utility cost among those who choose to claim FC/WFTC must not exceed the utility gain from receipt of FC/WFTC transfer income relative to non-receipt:

$$\eta < U(h_j, \widetilde{y}_{h_j} + \Psi_1 - C) - U(h_j, \widetilde{y}_{h_j} - C)$$

As we discuss later, this condition places an equivalent restriction on the value of the stochastic utility cost term u_η in our linear specification. For given h_j and X_η, an individual will choose to claim FC/WFTC only if $u_\eta < \Omega_U$, where

$$\Omega_U = U(h_j, \widetilde{y}_{h_j} + \Psi_1 - C) - U(h_j, \widetilde{y}_{h_j} - C) - X_\eta \beta_\eta$$

As we mentioned in Section 2, one of stated motivations behind moving from FC to WFTC was that tax credits might have lower participation costs (through being less stigmatizing, for example). To allow for this, we include among the characteristics X_η two indicators for WFTC receipt - one capturing the phase-in period between October 1999 and March 2000, and one for observations after April 2000. Formally, this measures the change in the utility cost of participating over time, and we attribute all of the changes between October 1999 and April 2000 to WFTC.

3.4.2 Individual choice sets and joint probabilities

We can now derive the probabilities $\Pr(h = h_j, P = p \,|\mathbf{X}, \mathbf{u})$ for each discrete hours alternative $h_j \in \{h_1, \ldots, h_J\}$ and each programme participation choice $P \in \{0, 1\}$, conditional on observed characteristics $\mathbf{X} = [X, X_w, X_{f1}, X_{f2}, X_\eta]$, and for given random components $\mathbf{u} = (u_y, u_h, u_f, u_\eta, u_w)$. If we continue to assume that the state-specific stochastic utility terms ε_{hP} are extreme value, then these probabilities will be similar to the probabilities for the model of hours of work described earlier. However, care is required to ensure that the choice sets from which individuals select their preferred option include only the following:

$$\begin{array}{lll} \{h = h_j, P = 0\} & \text{for all} & j = 1, \ldots J \\ \{h = h_j, P = 1\} & \text{for } \textit{any} & j = 1, \ldots J \text{ for which } E_{h_j} = 1 \end{array}$$

Since eligibility E_h depends on individual characteristics, so too does the choice set on which observed probabilities are to be based. A woman with high wages, for example, may earn too much income to qualify for FC/WFTC at any hours level, so her choice set is restricted to the J hours choices with no programme participation. On the other hand, a married women on a low hourly wage may be entitled to positive FC/WFTC payments at all hours alternatives, in which case her choice set extends to the $2J$ combinations. Taking these individual variations into account, we can derive the joint probabilities $\Pr(h = h_j, P = p \,|\mathbf{X}, \mathbf{u})$ of hours and transfer programme participation, under the assumption that all choice-specific errors ε_{hP} are extreme value[21].

For given random components $\mathbf{u}$, these are:

$$\Pr(h = h_j, P = p \,|\mathbf{X}, \mathbf{u}) =$$

$$\frac{\exp\{U(h_j, \widetilde{y}_{h_j} + p \cdot \Psi_1 - C, P = p) - (p \cdot E_{h_j}) \cdot \eta\}}{\sum_{k=1}^{J} [\exp\{U(h_k, \widetilde{y}_{h_k} - C, P = 0)\} + E_{h_k}. \exp\{U(h_k, \widetilde{y}_{h_k} + \Psi_1 - C, P = 1) - E_{h_k} \cdot \eta\}]}$$

3.5 Estimation

For the general model, the extended log-likelihood is given by :

$$\begin{aligned}
\log \mathcal{L} = \sum_i \log \int_{u_w}\int_{u_{cc}}\int_{u_y}\int_{u_h} \Bigg[& \int_{u_\eta < \Omega_U} \prod_{j=1}^{J} \Pr(h = h_j, P = 1 |\mathbf{X}, \mathbf{u})^{1(h=h_j, E_{h_j}=1, P=1)} f(u_\eta) du_\eta \\
& + \int_{u_\eta > \Omega_U} \prod_{j=1}^{J} \Pr(h = h_j, P = 0 |\mathbf{X}, \mathbf{u})^{1(h=h_j, E_{h_j}=1, P=0)} f(u_\eta) du_\eta \\
& + \int_{u_\eta} \prod_{j=1}^{J} \Pr(h = h_j, P = 0 |\mathbf{X}, \mathbf{u})^{1(h=h_j, E_{h_j}=0)} f(u_\eta) du_\eta \\
& \Bigg] f(u_w) f(u_{cc}) f(u_y) f(u_h) du_w du_{cc} du_y du_h
\end{aligned}$$

The log-likelihood depends on

- the preference parameters α_{11}, α_{22}, α_{12}, β_1 and β_2;
- the unobserved work-related cost parameters β_{f1} and β_{f2};

[21]In future work, we hope to relax this assumption, and constrain the choice-specific errors to be hours-specific. This will produce a slightly different expression for the choice probabilities, because, having conditioned on $\mathbf{u}$, the difference in utilities between participating and not participating at each hours choice will be deterministic, and so the model will collapse to one with only J choices.

- the parameters β_η in the utility cost of participating
- the distributions of the stochastic terms
- The childcare hours parameters β_{cc}, the distribution of childcare prices p_c, and the wage parameters β_w, which are all estimated in an initial stage.[22]

In estimation, the integrals are approximated using simulation methods (see Train (2003)). This means that the random preferences for income u_y and hours u_h, wages u_w, fixed costs u_f, programme participation u_η, and childcare prices p_c are integrated out by drawing a number of times from the distribution, and computing the average likelihood across these realisations. We assume that the unobserved components $\mathbf{u} = (u_y, u_h, u_f, u_w, u_\eta)$ are independent normal with standard deviations σ_y, σ_h, σ_f, σ_w and σ_η respectively, and approximate the distribution of p_c with 6 discrete mass points, and we use 10 pseudo-random draws. [23] 10 draws is low compared to other studies that have used SML, but the low number of draws is partially offset by our relatively large sample (numbered in the tens of thousands, rather than the hundreds or thousands). Having conditioned on a first-stage estimation of wage rates, the standard deviation of the wage disturbance is fixed at the ML estimate σ_w, but the standard deviations of the random heterogeneity terms are estimated. Because our choice-specific errors vary by choice, and not by hours point, the bounds on u_η derived earlier are not used in estimation. [24] As stated earlier, the choice-specific errors ε_{hP} are assumed to be distributed as extreme value, and do not require simulating.

[22] Wages are only observed for those in work, and we account for the sample selection bias using standard techniques, using the age of youngest child and net income that would be obtained if the adult did not work as instruments (see Heckman (1979)). Joint estimation of the wage equation with labour supply preferences would be ideal, but is prohibitively time-consuming given the need to calculate disposable income after taxes and benefits for every wage and hours combination.

[23] Blundell *et al.* (1999) discuss the possibility of allowing for correlation among the unobservable components in their discrete model of labour supply. They nevertheless indicate the difficulties associated with identification of correlation terms in the likelihood.

[24] In future work, we hope to relax the assumption that the extreme value errors are choice-specific, and constrain them to be hours-specific. Having done this, it will be important to take into account the bounds on stigma. This will require that the random FC/WFTC participation cost u_η is integrated over a bounded range which 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 should instead be integrated over the unrestricted range of u_η.

Heterogeneity in observables is allowed to affect the coefficients on the both the linear (X_1 and X_2) and quadratic (X_{11},X_{12} and X_{22}) terms in the utility function, the level of the fixed costs (through X_{f1} and X_{f2}), and the utility cost of participating in FC/WFTC (through X_η). We assume a choice set of weekly working hours {0, 10, 19, 26, 33, 40}, largely dictated by the empirical distribution of hours that we observe in our data, corresponding to the hours ranges 0, 1-15, 16-22, 23-29, 30-36 and 37- respectively[25]

The scale of utility is fixed by the standard deviation of the choice-specific errors[26]. Identification is achieved through the functional form assumptions. In practice, identification relies on the different tax and benefit regimes over time, and different types of individual with varying eligibility status. Unobserved costs of working are identified because lone parents choose between 5 states with positive hours of work; FC/WFTC participation costs are identified separately from fixed work-related costs because some lone parents are not entitled to FC/WFTC at certain levels of hours. Data from before and after the WFTC reform is needed to identify the change in the utility costs of participation.

3.6 Extending the model to couples

The model presented above is for single decision-makers. We could use this sort of model to describe couples' behaviour if we assume that women make their labour market decisions taking that of their partner as given. Another approach is to specify a full unitary model in which both individuals in a couple make simultaneous labour market decisions to maximise joint utility. We denote $\mathbf{w} = (w_M, w_F)$ as the vector of female and male wages, with the same log-linear relationship as earlier assumed.

$$\begin{aligned}\log w_M &= X_{w_M}\beta_{w_M} + u_{w_M}\\ \log w_F &= X_{w_F}\beta_{w_F} + u_{w_F}\end{aligned}$$

[25]We hope to test the robustness of our findings to changes in the assumed choice set of hours.

[26]Some studies fix one of the preference parameters and additionally constrain the standard deviation of the choice-specific errors. We hope to test whether this affects our results in future work.

Let $\mathbf{h} = (h_M, h_F)'$ be the vector of male and female hours, and let $\mathbf{h_j}$ now correspond to an hours choice by each individual. Net income is given by:

$$y_{\mathbf{h}P} = \widetilde{y}_{\mathbf{h}P} + P \cdot \Psi_1(\mathbf{w}, \mathbf{h}, I|Z_\Psi)$$

where $\widetilde{y}_{\mathbf{h}} = \mathbf{wh} + I - \Gamma(w_M h_M, w_F h_F, I|Z_\Gamma) + \Psi_0(\mathbf{w}, \mathbf{h}, I|Z_\Psi)$ is total income from all sources except FC/WFTC.

¿From this net income, we subtract predicted childcare costs and fixed work-related costs (WRC_1 and WRC_2) in the same way as for lone parents (for simplicity, we assume that fathers do not face work-related costs; the function relating childcare use to hours of work is extended to allow it to depend on the hours worked by the mother and father). The total cost of work is therefore given by:

$$C(h; X_f, X_{cc}, p_c, u_f) = WRC_1 \cdot I_{h_F 1} + WRC_2 \cdot I_{h_F 2} + p_c \cdot h_{cc}$$

with WRC_1 and WRC_2 defined as before, and $I_{h_F 1} = 1(h_F > 0)$ and $I_{h_F 2} = 1(h_F > 30)$ denoting the female employment indicators.

Utility is defined over net household income and both male and female hours. Again this is approximated by a second-order polynomial expansion:

$$\begin{aligned}
U_P(\mathbf{h}, \widetilde{y}_{\mathbf{h}}, P; C) &= \alpha_{11}(\widetilde{y}_{\mathbf{h}} + P \cdot \Psi_1(\mathbf{w}, \mathbf{h}, I|Z_\Psi) - C)^2 + \alpha_{12}^f(\widetilde{y}_{\mathbf{h}} + P \cdot \Psi_1(\mathbf{w}, \mathbf{h}, I|Z_\Psi) - C)h_F \\
&+ \alpha_{12}^m(\widetilde{y}_{\mathbf{h}} + P \cdot \Psi_1(\mathbf{w}, \mathbf{h}, I|Z_\Psi) - C)h_M + \alpha_{22}^f {h_f}^2 + \alpha_{22}^m {h_M}^2 + \alpha_{22}^{fm} h_F h_M \\
&+ \beta_1(\widetilde{y}_{\mathbf{h}} + P \cdot \Psi_1(\mathbf{w}, \mathbf{h}, I|Z_\Psi) - C) + \beta_2^f h_F + \beta_2^m h_M + \varepsilon_{h_M h_F P} - (P \cdot E_{\mathbf{h}}) \cdot \eta \\
&= U(\mathbf{h}, \widetilde{y}_{\mathbf{h}}, P; C) - (P \cdot E_{\mathbf{h}}) \cdot \eta
\end{aligned}$$

when $\eta = X_\eta \beta_\eta + u_\eta$ is the utility cost of claiming FC/WFTC, and $E_{\mathbf{h}}$ is an indicator for eligibility at the male-female hours combination $\mathbf{h}$. It then follows that individuals will claim FC/WFTC if and only if the following condition holds:

$$u_\eta < \Omega_U = U(\mathbf{h_j}, \widetilde{y}_{\mathbf{h_j}} + \Psi_1 - C) - U(\mathbf{h_j}, \widetilde{y}_{\mathbf{h_j}} - C) - X_\eta \beta_\eta$$

The extended log-likelihood takes the same form for our model of lone mothers, except that we now integrate over the distribution of both male and female wages:

$$\log \mathcal{L} = \sum_i \log \int_{u_{w_M}} \int_{u_{w_F}} \int_{u_{cc}} \int_{u_y} \int_{u_h} \Bigg[\int_{u_\eta < \Omega_U} \prod_{j=1}^{J} \Pr(h = h_j, P = 1 | \mathbf{X}, \mathbf{u})^{1(h=h_j, E_{h_j}=1, P=1)} f(u_\eta) du_\eta$$
$$+ \int_{u_\eta > \Omega_U} \prod_{j=1}^{J} \Pr(h = h_j, P = 0 | \mathbf{X}, \mathbf{u})^{1(h=h_j, E_{h_j}=1, P=0)} f(u_\eta) du_\eta$$
$$+ \int_{u_\eta} \prod_{j=1}^{J} \Pr(h = h_j, P = 0 | \mathbf{X}, \mathbf{u})^{1(h=h_j, E_{h_j}=0)} f(u_\eta) du_\eta$$
$$\Bigg] f(u_{w_M}) f(u_{w_F}) f(u_{cc}) f(u_y) f(u_h) du_{w_M} du_{w_F} du_{cc} du_y du_h$$

where $\mathbf{u} = (u_y, u_h, u_f, u_\eta, u_{w_M}, u_{w_F})$ and $\mathbf{X} = [X, X_{w_M}, X_{w_F}, X_{f1}, X_{f2}, X_\eta]$. We assume a choice set for mothers of weekly working hours {0, 10, 19, 26, 33, 40}, corresponding to the hours ranges 0, 1-15, 16-22, 23-29, 30-36 and 37- respectively. For fathers, we assume a choice between {0, 37, 45} corresponding to the hours ranges 0, 1-39, 40 or more. Allowing men to have three hours choices is an advance on the work of Blundell *et al.* (1999), where fathers merely chose whether or not to work. Experimentation with an model where fathers chose whether or not to work led to very different parameter estimates, with less than a third of couples having a positive valuation on fathers' leisure time, compared with over 90% in the specification presented[27]. It would be desirable, though, to allow for symmetry in the hours choices between fathers and mothers, despite the fact that very few fathers work part-time, and we hope to return to this in future work. The wage equations, childcare use function, and childcare price distribution are all estimated in a first stage, as for lone parents, with the unobserved component of a mother's wages assumed independent from that of their partner's.

[27]Furthermore, with a quadratic utility function, common covariates to the coefficient on the hours and hours squared (including the constant term) will have undefined asymptotic standard errors (proof by differentiation).

3.7 Simulating policy reforms

Having estimated the parameters of the model, we can use it to simulate the impact of policy reforms. To compute the probability that an individual would choose each hours and programme participation choice under a given tax and transfer system, we numerically average over the unobserved components in the model ($\mathbf{u}$, ε_{hP} and p_c) in a way similar to that used when constructing the SML estimator.

To simulate the impact of a change in the tax and benefit system, we use the same numerical draws to compute the of probabilities for each hours and programme participation choice under both tax and benefit systems, and these probabilities can be combined to produce a transition matrix defined over the hours and participation choices. These numbers can be thought of as the estimated expected (or average) values of the transition matrix given the parameter estimates, where the expectation is over $\mathbf{u}$, ε_{hP} and p_c. We can estimate confidence intervals around the average probabilities that reflect that the parameters in our model are not known. These standard errors are calculated by repeatedly drawing from the estimated asymptotic distribution of the parameters (which in turn assumes that our model is correct) and re-calculating the expected value of the transition matrix given the new parameters.

Looking ahead, the standard errors for some elements of the transition matrix are presented in Table 1 in the following section: they are typically very small relative to the point estimates, and this reflects that our relatively large sample enables us to estimate the 40 or so parameters in our model relatively accurately.

4 Data and description of reforms

4.1 Data

We have used a well-known UK data-set, the Family Resources Survey (FRS). The FRS is a cross-section household-based survey drawn from postcode records across Great Britain: around 30,000 families are asked detailed questions about earnings and other forms of income. It is the data set most often used to micro-simulate tax and benefit reforms in the

UK, and was used to model labour supply in Blundell *et al.* (1999, 2000) and Paull *et al.* (2000).[28]

What actually happened when WFTC was introduced? The number of recipients increased markedly after its introduction in October 1999, and continued to rise at a much faster growth rate than seen under Family Credit (see Inland Revenue, 2002). A year after its introduction, caseload had risen by 39%, and the majority of this increased caseload seems to have come directly from the increased generosity making more families entitled, rather than from families moving into work. The caseload of lone parents on out-of-work benefits (income support) has declined steadily and slowly since late 1996, with no discernable change around 1999-2000 (Department of Work and Pensions, 2002). Analysis of administrative data that tracks individuals across income-related programmes shows that the net inflow of lone parents from out-of-work benefits to WFTC in the 12 months from November 1999 to November 2000 was 50,000, 17,000 higher than the last 12 months of FC. Overall, the number of children in families on either out-of-work welfare benefits or FC/WFTC has increased since early 1999.[29]

Official estimates of the programme participation rates for the main means-tested benefits in the UK are published every year: see Table 15.[30] Take-up rates for FC or WFTC were not estimated in 1999-00, and, by 2000-01, take-up of WFTC was roughly the same as it had been for FC for lone parents, but had fallen for couples. But aggregate take-up rates, whether by caseload or expenditure, cannot account for changes in the underlying distribution of entitlements.

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[28] It is important that the FRS records receipt of FC accurately: Clark and McCrae (2001) finds that when the official grossing factors are used to weight the FRS, it under-records receipt of FC by around 25%, but around half of this discrepancy is explained by families receiving FC having smaller weights than families with children not receiving FC. The sample weights are not used in our estimation.

[29] This compares net movements from “lone parents” to “working family” in Table 10.5 of the November 2000 and Table 3.5 in the August 1999 Client Group Analysis of people of Working Age (DSS/DWP, various b). It excludes lone parents who claim unemployment (as opposed to “inactive”), sickness or disability benefits, and it will not capture lone parents who experience a change in family status. It is even more problematic to track couples using this data set. Number of children on means-tested benefits cited in Table 3 in Brewer, Clark and Wakefield (2002).

[30] Our estimates operate by calculating entitlement to all income-related programmes and simulate tax payments using a micro-simulation model. The aggregate take-up rate is calculated differently in official statistics, which estimate the recipient population from administrative data, and eligible non-participants from survey data.

4.2 Description of reforms

The task of this paper is to evaluate the impact of WFTC on labour supply. One of the attractions of doing this with a structural model is that WFTC was introduced at the same time as other changes to the tax and transfer system affecting families with children, making changes over time uninformative: a structural model allows us to estimate the impact of WFTC alone.

It is necessary, however, to consider the impact on labour supply of all of the tax and benefit changes that took effect around the time that WFTC was introduced to gain a fuller understanding of what happened to the labour supply behaviour of families over this period. We have therefore simulated the impact of moving from the tax and benefit system in operation in April 1999 to the one in existence in April 2000. [31] The main changes are:

- replacing Family Credit with WFTC.
- a cut in the basic rate of income tax from 23% to 22%.
- an increase in the Primary Threshold, which is the point at which national insurance contributions are payable by employees.
- abolition of the mortgage interest subsidy programme (MIRAS).
- abolition of the Married Couple's Allowance and Additional Personal Allowance for the under-65s, which together provided a non-refundable tax credit to married couples and parents.
- increases in Income Support/Jobseekers Allowance (income-related) and associated benefits for families with children aged under 11 (see Table 18).

The most important of these reforms for families with children in terms of the amount of money that it raised or cost the government is the introduction of WFTC, but the next most important is the increase in Income Support and associated benefits for families with children.

[31] We do not evaluate the labour supply impact of the changes in April 1999, such as the new 10% starting rate of income tax and the new national minimum wage.

Some of these reforms would have been expected to increase labour supply, some to reduce labour supply, and some have theoretically ambiguous effects. We therefore look at the net overall impact in Section 5.2 and 5.3.

5 Joint labour supply and programme participation estimates

This section first discusses the estimates of the preference coefficients, and then uses these to estimate the impact of WFTC.

5.1 Results

As explained in section 3, 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; identification comes from including age of the youngest child, the net income that the benefit unit would obtain if no member of the couple were working and a dummy for cohabiting couples in the employment equation (the results are shown in Table 11, 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).

For our childcare equations, we defined 12 groups according to the number of children (1, 2, more than 2), whether any of their children were aged under 3, and whether a lone parent or couple. 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 18 different groups (how many children, whether any aged under 3, and whether a lone parent, single earner couple or two-earner couple): results are also available on request.

The main parameter estimates are given in Table 12 and Table 13. The (unobserved) fixed costs of working are assumed to vary by the number of children, age of youngest child, region and ethnicity. These 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 the London, and to a lesser extent, the ethnic effect. 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 (£47 for the initial fixed cost compared to £30 for a working lone parent). A similar picture emerges for couples, but these fixed costs are now lower on average (an initial fixed cost of £21 for a married non-working mother compared to £12 for married working mothers on average).

The vector of variables (X_1 and X_2) 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 17). Additionally, the age of youngest child dummies enter through the quadratic terms (X_{11}, X_{12} and X_{22}. 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 difficult because it enters both the linear and quadratic terms of the utility function. For lone mothers, the effect of age on the preference for income is not well determined, but we do find that individuals who are aged above average have a greater preference for hours of work. Higher levels of education are associated with a lower valuation of income and a higher valuation of work (meaning that an hour of work leads to less disutility for lone parents with high levels of education compared to those with low levels of education). The same pattern is true comparing non-white individuals with white individuals.

A similar picture exists for couples, but preferences for income decrease with age of both the male and female. We find that non-white mothers in couples appear to have a greater preference for hours of work, but non-white fathers in couples have a lower preference for hours worked, and both of these effects are highly significant. As with lone parents, there is greater preference for income, and less for hours of work, the greater the number of children, and interpreting the impact of the age of the youngest child is difficult because it enters both the linear and quadratic terms of the utility function.

Recall that incomplete programme participation is rationalised by assuming that there is an associated fixed utility cost, although we cannot say whether this is due to hassle, information, difficulties with the claim form or psychological stigma. These FC/WFTC participation costs are assumed to vary with age of parent, ethnicity, education. We also include a dummy capturing those families observed after October 1999, and those observed after April 2000, reflecting the phase-in and full-implementation periods of WFTC respectively.[32]

The utility cost of participating in FC/WFTC is found to be significantly different from zero, and higher for older and better-educated parents. It is higher for non-white lone parents than white lone parents, but the reverse is true for couples (which might reflect that "non-white" is too broad a classification, because non-white lone parents are from different ethnic backgrounds to non-white couples). Crucially, though, for both lone parents and couples, the programme participation cost is lower in April 2000 than it is in April 1999, a change which we attribute to WFTC. We tested for a trend in the utility cost of participation, and found no evidence of one, which supports our decision to attribute the decline in the costs of participation during 1999-00 to WFTC.

We find that the estimated parameter values for this model are broadly consistent with economic theory. In particular, for lone parents 99.0% of lone parents have positive marginal utility of net income at their observed state, and 81.0% have negative marginal utility of work. At their observed state, 99.9% of couples have positive marginal utility of income, with 98.9% and 90.8% having negative marginal utility of female and male hours respectively.[33]

[32] We cannot model entitlement perfectly for families observed between October 1999 and April 2000, as we cannot tell whether families are receiving FC or WFTC. Our approach is to model WFTC entitlement for those not participating, and for those participating, we estimate the weighted average of entitlement under FC and WFTC, weighted by the number of months since October 1999.

[33] In Appendix A empirical indifference curves are presented for selected individuals in our sample. Table 19 and Table 20 compare the predicted and observed states for lone mothers and couples respectively, averaged over the period of our data.

5.2 Simulating the labour supply impact of WFTC

These parameters, particularly those of the change in the utility cost of participating in FC/WFTC, are informative in their own right, but the great advantage of structural models comes when they are used to simulate the impact of tax and benefit changes.

We have simulated the impact of two reforms to the tax and benefit system. First, we consider the effect on labour supply of moving from Family Credit to Working Families' Tax Credit, holding all other things equal. Second, we simulate a move from the April 1999 system to an April 2000 system, adjusted for inflation.[34] This section will focus on the first reform; results from the latter reform will be summarised, and the full results are available upon request.

Lone Parents

We have used our model to simulate a transition matrix defined over each potential labour market state. For ease of interpretation, the full transition matrix has been collapsed into a 3×3 matrix.[35] Non-participation corresponds to the zero hours point, part-time work encapsulates the hours points 10, 19, and 26, and full-time work is given by 33 and 40 hours. Simulation results are presented in Table 1.

The diagonal elements of the 3×3 transition matrix correspond to the proportion (probability) of individuals' labour market status remaining unchanged as we move between the two systems. The elements above the diagonal correspond to increases in labour supply; those below it correspond to decreases. Table 1 implies an increase in participation of 56.56-51.90=4.66ppt. Of this increase, there was a net movement of 23.72-22.31=1.41ppt in to part-time work and a net movement of 24.37-21.13=3.24ppt into full-time work. In the base system, 22.31% of individuals were working part time, but of these 1.47ppt moved into full time work following the introduction of WFTC. However, of the 21.13% of individuals who

[34]In fact, we actually perform both simulations in reverse, simulating the impact of moving from the actual April 2000 system to either of the reform systems, using the sample of families observed in 2000-01: in what follows, we present the simulations the correct way round (ie starting with an April 1999 tax and benefit system).

[35]The full transition matrix is a 12×12 matrix (six hours points under FC/WFTC take-up and non-take-up, for both base and reform systems, although 2 of the choices are degenerate).

Table 1: Simulation Results, Lone Parents

		Post WFTC			
		Non Participation	Part Time	Full Time	Total
Pre WFTC	Non Participation	**51.90**	1.95	2.71	56.56
	Part Time	0.00	**20.84**	1.47	22.31
	Full Time	0.00	0.93	**20.20**	21.13
	Total	51.90	23.72	24.37	100.00

Change in participation rate	4.66	(0.15)
Average change in hours (unconditional)	1.63	(0.05)
Average change in hours (workers only)	0.69	(0.03)
Average hours under base system (unconditional)	13.69	(0.14)
Average hours under base system (workers only)	28.47	(0.15)

Applying grossing weights to our selected sample gives a total of 1,471,497 lone parents. This represents 83% of the total population of lone parents (see Appendix B for more details).

were initially working full time, 0.93ppt reduced their labour supply by moving into part-time work in the reform system. Conditioning upon workers only, our results imply a small average *increase* in weekly hours of approximately 0.69 hours per worker.

The estimated preference parameters reveal that both the number of dependent children, and the age of the youngest child, are extremely important determinants of lone parents' decision to work. It is therefore of interest to disaggregate our simulation results on this basis. These results (Table 2) suggest that WFTC has a larger impact on lone parents whose youngest child is aged 3 to 4 or 5 to 10, where participation increases by 5.15ppt and 5.65ppt respectively, than it does on those whose youngest child is aged 11 or more (a little under 4ppt) or aged between 0 and 2 (3.60ppt). Similarly, the estimated effect is smaller for lone parents with one child (an average increase in participation of 4.13ppt) than those with more children (5.31ppt and 4.93ppt respectively for those with two, or three or more children).

Table 2 also summarises results for the second reform, which replaces the April 1999 system with the April 2000 system.[36] The increases in participation are systematically lower compared to when WFTC was considered alone, and this is likely to reflect that the contemporaneous increases in Income Support dulled the positive labour supply impact of WFTC.

Married Women

There are a number of ways in which our results for couples can be presented. The full transition matrix is potentially 36 x 36. First, though, we look at the transition matrices for married women and men separately. Second, we display some simplified intra-household dynamics which show how the distribution of employment within households might have changed in response to WFTC. Simulation results for married women are presented in Table 3.

Table 3 implies that WFTC changed participation of mothers in couples by 31.50-31.66=-0.16ppt, or a very small negative effect upon participation. The transition matrix shows that this small net effect comprises two offsetting impacts: a small proportion of women reduce their labour supply (the elements below the diagonal), and some move into part-time and full-time work (above the diagonal). Because the theoretical incentives vary by the employment status of their partners, it is useful to disaggregate our results in this way.[37]

For married women whose partners are working, we find that there are small reductions in the proportions engaged in full time and part time work, with participation changing by -0.31ppt for this group. However, WFTC is predicted to increase participation of married women whose partners are not working by 1.11ppt. Given that the latter group is much smaller than the former, a small negative effect of -0.16ppt is found on average.

[36] The changes in participation and both conditional and unconditional hours are again statistically significant at the 0.1% level.

[37] We condition upon their partner's predicted employment status under Family Credit.

Table 2: Simulation Results: Lone Parents, WFTC Results Summary

		All	Age of youngest child				Number of children		
			0-2	3-4	5-10	11+	1	2	3+
WFTC alone	Change in participation rate (ppt)	4.66	3.60	5.15	5.64	3.98	4.13	5.31	4.93
	Average change in hours per worker								
	Unconditional	1.63	1.10	1.56	1.97	1.65	1.52	1.82	1.57
	Workers only	0.69	0.75	0.70	0.91	0.65	0.62	0.76	1.11
All reforms	Change in participation rate (ppt)	3.37	2.12	2.99	4.08	3.70	3.14	3.82	3.22
	Average change in hours per worker								
	Unconditional	1.22	0.66	0.91	1.45	1.56	1.19	1.36	1.05
	Workers only	0.57	0.47	0.40	0.68	0.63	0.53	0.63	0.77

Table 3: Simulation Results, Married Women

		Post WFTC			
		Non Participation	Part Time	Full Time	Total
Pre WFTC	Non Participation	**30.94**	0.49	0.07	31.50
	Part Time	0.56	**36.89**	0.06	37.52
	Full Time	0.16	0.15	**30.68**	30.99
	Total	31.66	37.53	30.82	100.00

Change in participation rate		
Overall	-0.16	(0.00)
Partner Working	-0.31	(0.01)
Partner Not Working	1.11	(0.03)
Average change in hours (unconditional)	-0.06	(0.00)
Average change in hours (workers only)	-0.03	(0.00)
Average hours under base system (unconditional)	18.39	(0.07)
Average hours under base system (workers only)	26.85	(0.08)

Applying grossing weights to our selected sample gives a total of 3,729,848 couples. This represents 72% of the total population of couples (see Appendix B).

Married Men

We find that WFTC has a net positive effect of 0.84ppt on the participation of married men (see Table 4). WFTC induced 0.91ppt of men to move from a non-participating to participating state. A very small proportion of individuals (0.07ppt) reduce their labour supply to produce the net movement of 0.84ppt. When we disaggregate this change by the employment status of their partner, we find that most of the movement is from individuals whose partner was predicted to not work under FC.

Intra-household Dynamics

In our model for couples, labour supply decisions are made simultaneously to maximise household utility. This raises the possibility of some interesting intra-household dynamics. To keep the exposition as simple as possible, we consider only whether each individual is working or not, and so there are four possible states. The 4×4 matrix of transition

Table 4: Simulation Results: Married Men

		Post WFTC		
		Non Participation	Participation	Total
Pre WFTC	Non Participation	**10.23**	0.91	11.14
	Participation	0.07	**88.80**	88.87
	Total	10.30	89.70	100.00

Change in participation rate		
Overall	0.84	(0.04)
Partner Working	0.26	(0.02)
Partner Not Working	2.11	(0.10)
Average change in hours (unconditional)	0.32	(0.02)
Average change in hours (workers only)	-0.04	(0.00)
Average hours under base system (unconditional)	37.13	(0.08)
Average hours under base system (workers only)	41.79	(0.02)

Applying grossing weights to our selected sample gives a total of 3,729,848 couples. This represents 72% of the total population of couples (see Appendix B).

probabilities is displayed in Table 5, with the first element corresponding to the participation status of the male in the couple, and the second element to that of the female. For example, if just the man who is working then this is denoted $(1, 0)$, while if both are working this is denoted $(1, 1)$.

Table 5 shows that, under FC, our model predicts that 7.15% of couples with children had no earners. Following its introduction, however, $0.47 + 0.03 = 0.50$ppt of these couples moved to having one earner, while 0.22ppt moved to becoming a two-earner household. Given that no other household types entirely withdraw their labour supply, the proportion of households with no earners clearly declines.

For households where only the father worked under Family Credit (24.35%), 0.30ppt moved to a two-earner household and 0.02ppt displayed the more unusual transition to a female earner household. Similarly, of the 3.99% of households that are initially female-earner households, 0.10ppt move to two-earner households while there is a switch of earner for 0.12ppt. Finally, of the 64.52% of households where both adults in the couple are

Table 5: Simulation Results: Intra-household Dynamics

		Post WFTC				
		(0,0)	(1,0)	(0,1)	(1,1)	Total
Pre WFTC	(0,0)	**6.44**	0.47	0.03	0.22	7.15
	(1,0)	0.00	**24.03**	0.02	0.30	24.35
	(0,1)	0.00	0.12	**3.76**	0.10	3.99
	(1,1)	0.00	0.60	0.05	**63.87**	64.52
	Total	6.44	25.21	3.86	64.49	100.00

Change in proportion of		
Workless households	-0.71	(0.04)
One-earner households	0.74	(0.04)
Two-earner households	-0.03	(0.01)

Applying grossing weights to our selected sample gives a total of 3,729,848 couples. This represents 72% of the total population of couples (see Appendix B).

initially working, 0.60ppt have the transition to a male-earner household and 0.05ppt move to a female-earner only household.

Adding up these estimated transitions for individuals in couples, our simulated responses suggest that WFTC reduced the proportion of workless households by 0.71ppt, increased the proportion of single-earner households by 0.74ppt and reduced the proportion of two-earner households by 0.03ppt. A summary of results for couples, including some further disaggregation by the number of dependent children, and the age of the youngest child, are presented in Table 6.This shows that fathers are more likely to start work, the more children they have and the younger are the children. Women are more likely to change their behaviour the more children they have, and if their youngest child is aged between 3 and 4.

Married Couples: all reforms between April 1999 and April 2000

Analogous to the lower panel of Table 2, the impact of all of the reforms between April 1999 and April 2000 is presented in Table 7. Recall that for lone parents, our simulations showed that reforms other than WFTC between April 1999 and April 2000 acted to reduce labour supply. For couples, we also find that reforms other than WFTC led to reductions in labour supply. Our simulations suggested that WFTC increased participation for married men by 0.84ppt, but reduced that of married women by -0.16ppt, both significantly different from zero at the 0.1% level. However, all reforms between April 1999 and April 2000 reduced participation of both men and women in couples (by -0.37ppt and -0.35ppt respectively). Similarly, WFTC alone encouraged single-earner households at the expense of both workless- and two-earner households, but all reforms between April 1999 and April 2000 had precisely the opposite impact. Again, the differences in these simulation results remind us of how sensitive our conclusions can be to the precise counter-factual that is considered.

Table 6: Simulation Results: Married Couples, WFTC Results Summary

	All	Age of youngest child				Number of children		
		0-2	3-4	5-10	11+	1	2	3+
Change in participation rate (ppt)								
Men, overall	0.84	1.60	1.04	0.63	0.20	0.44	0.73	1.89
Men, partner working	0.26	0.49	0.35	0.26	0.06	0.13	0.26	0.60
Men, partner not working	2.11	2.78	2.15	1.68	0.86	1.38	1.80	3.33
Women, overall	−0.16	−0.19	−0.25	−0.18	−0.05	−0.11	−0.16	−0.26
Women, partner working	−0.31	−0.40	−0.46	−0.34	−0.14	−0.19	−0.31	−0.60
Women, partner not working	1.11	1.00	1.51	1.18	0.91	0.67	1.27	1.36
Change in proportion of								
Workless households	−0.71	−1.40	−0.88	−0.49	−0.17	−0.37	−0.59	−1.65
Single-earner households	0.74	1.39	0.96	0.53	0.19	0.42	0.61	1.67
Two-earner households	−0.03	0.01	−0.09	−0.04	−0.02	−0.04	−0.02	−0.02
Average predicted change in hours								
Men, overall (unconditional)	0.32	0.62	0.40	0.24	0.07	0.16	0.28	0.73
Men, overall (conditional)	−0.04	−0.06	−0.04	−0.03	−0.01	−0.02	−0.03	−0.07
Women, overall (unconditional)	−0.06	−0.06	−0.09	−0.08	−0.04	−0.05	−0.06	−0.09
Women, overall (conditional)	−0.03	−0.02	−0.05	−0.04	−0.02	−0.02	−0.03	−0.06

Table 7: Simulation Results: Married Couples, All Reforms 1999-2000 Results Summary

	All	Age of youngest child				Number of children		
		0-2	3-4	5-10	11+	1	2	3+
Change in participation rate (ppt)								
Men, overall	−0.37	−0.66	−0.63	−0.39	0.09	−0.17	−0.40	−0.69
Men, partner working	−0.43	−0.78	−0.74	−0.48	−0.02	−0.25	−0.45	−0.87
Men, partner not working	−0.25	−0.53	−0.45	−0.13	0.60	0.05	−0.28	−0.50
Women, overall	−0.35	−0.50	−0.60	−0.41	0.02	−0.17	−0.33	−0.72
Women, partner working	−0.44	−0.63	−0.69	−0.49	−0.05	−0.21	−0.42	−0.95
Women, partner not working	0.44	0.39	0.23	0.34	0.81	0.21	0.57	0.55
Change in proportion of								
Workless households	0.28	0.55	0.47	0.23	−0.06	0.12	0.29	0.53
Single-earner households	0.17	0.06	0.29	0.34	0.01	0.10	0.15	0.35
Two-earner households	−0.44	−0.61	−0.76	−0.57	0.05	−0.22	−0.44	−0.88
Average predicted change in hours								
Men, overall (unconditional)	−0.17	−0.30	−0.28	−0.18	0.03	−0.08	−0.18	−0.32
Men, overall (conditional)	−0.02	−0.03	−0.02	−0.01	−0.00	−0.01	−0.02	−0.04
Women, overall (unconditional)	−0.07	−0.12	−0.15	−0.11	0.05	−0.01	−0.07	−0.21
Women, overall (conditional)	0.03	0.02	−0.00	−0.00	0.05	0.06	0.02	−0.06

Table 8: Aggregate Participation Responses of the Reforms

	Lone Parents	Married Women (with children)	Married Men (with children)	Total
WFTC	69,000	−6,000	31,000	94,000
All Reforms, 1999 - 2000	50,000	−13,000	−14,000	23,000

5.3 Aggregation and Selection

In our estimation and simulation it was necessary to exclude some individuals from our sample. For example, individuals aged 55 and above were omitted since their labour market behaviour is unlikely to be motivated by the simple leisure/income trade-off as they approach retirement age. The sample selection criteria we used is discussed in more detail in Appendix B.

An implication of such sample selection is that it is unclear whether our simulated responses can be applied to the aggregate population. Furthermore, our simulated responses do not provide bounds, because the excluded individuals could have either negative or positive responses to the reforms. If, however, those excluded are relatively unresponsive to the changes in financial incentives that these reforms represent, then the grossed-up sample size may still provide a good estimate of the aggregate impact of these reforms.

In Table 8 we present the grossed-up participation responses for the reforms considered, using the sample weights contained in the FRS (the earlier tables reported the relevant grossed-up population totals). We calculate that WFTC induced 69,000 lone parents to participate in the labour market. However, married women with children experienced a net negative effect of -6,000, while their partners' participation increased by a net 31,000. The overall impact is that WFTC increased participation by 94,000 workers, two thirds of whom were women, and reduced the number of workless households with children by 95,000.

Similarly, we estimate that all of the reforms over the period April 1999 to April 2000 increased participation by just 23,000 individuals, and reduced the number of workless households by 40,000. The main reason why this is lower than that obtained from the WFTC reform is because of the very different behaviour of fathers in couples (a decline of 13,000 compared to the previous increase of 31,000), together with smaller increases in participation for lone parents and mothers in couples.

6 Conclusion

Using micro-data from before and after a major reform to the structure and form of in-work benefits in the UK in 1999, we have analysed the impact of WFTC on labour supply and programme participation using a structural model of individuals' preferences. Our preliminary results suggest that there is a utility cost to participating in FC/WFTC, that this varies with family and individual characteristics, and that this cost is lower under WFTC than it was under FC.

We estimate that WFTC increased lone parents' employment by 4.7 percentage points, reduced the participation of women in couples by around 0.2 percentage points, and raised participation of men in couples by 0.8 percentage points. These estimates correspond to an extra 69,000 lone parents working, 6,000 fewer mothers in couples working, and 31,000 more fathers in couples working, a net increase in participation of 94,000 workers. The number of workless households with children is estimated to have fallen by 95,000. Our results are the same in sign, although larger in magnitude, to those predicted from an *ex ante* study whose methodology we have drawn upon (Blundell *et al.*, 1999). Future work will compare our results to those estimated using a difference-in-difference methodology.

When we consider all of the tax and benefit reforms enacted between April 1999 to April 2000, we find that these increased the participation of lone parents by 3.4 percentage points, but that the participation of men and women in couples declines by around 0.4 percentage points. This corresponds to an increase in participation of 23,000 individuals, and a reduction in the number of workless households of 40,000. Reforms between April 1999 and April 2000 other than WFTC, then, particularly the increases in out-of-work benefits for families with children under 11, reduced the positive impact of WFTC on work incentives.

Our main concern has been to recognise and quantify the role that programme participation plays in determining the effective incentives arising from a given tax and benefit system by modelling the decision to claim FC/WFTC simultaneously with the decision to work. We intend that future work will test how robust our findings are to some of our assumptions.

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Appendices

A Estimated Indifference Curves

Using the simulated maximum likelihood estimates, we are able to draw the empirical indifference curves of actual individuals and couples in our sample. These show the trade off between income and hours of work. The precise shape that these indifference curves take will depend upon both the observable characteristics of individuals, and the random preference heterogeneity. For a selection of individuals we present their estimated indifference curve, at their actual observed utility level, for a given random draw under both take-up and non-take-up of family credit (where applicable). For our models with children, take-up effects the level of utility through the estimated utility cost of programme participation.

The indifference map is drawn in hours-income space, with hours varying between -10 and 50 hours per week. Clearly, negative hours have no meaningful interpretation here, but rather they are shown to illustrate the discontinuity that fixed work costs introduce.

A.1 Lone Parents

We first present the results for lone parents, with the second discontinuity at 30 hours reflecting the additional full time cost of work incorporated in our model. In Table 9 the observable characteristics of each individual shown are presented. In the corresponding figures (Figures 1 to 6) the indifference curve under programme participation is shown by the dashed line, whereas the solid line corresponds to the indifference curve under programme non-participation.

Table 9: Observable Characteristics: Lone Parents

	Age	Post 16 Education	Non-white	London	Number of children	Age group of youngest child
Person 1	21	Yes	No	No	1	3 - 4
Person 2	35	Yes	No	No	2	5 - 10
Person 3	25	Yes	No	Yes	1	3 - 4
Person 4	58	Yes	No	No	1	11 - 18
Person 5	38	No	No	No	3	5 - 10
Person 6	33	No	No	No	4	0 - 2

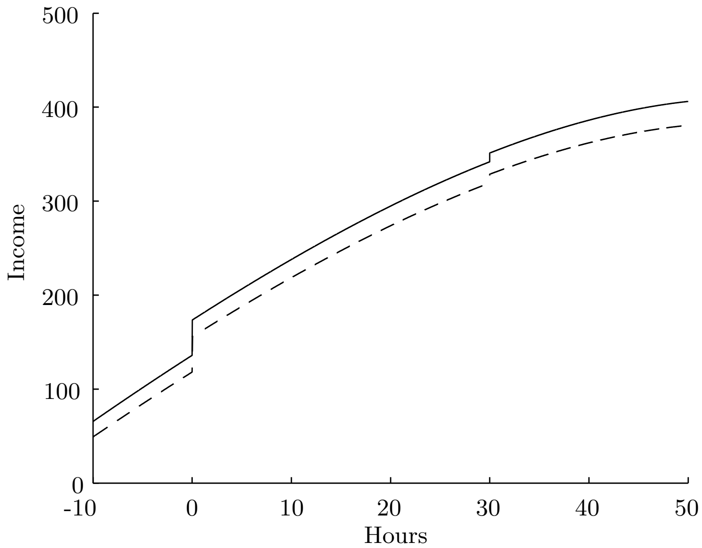

Figure 1: Indifference Curves, Person 1

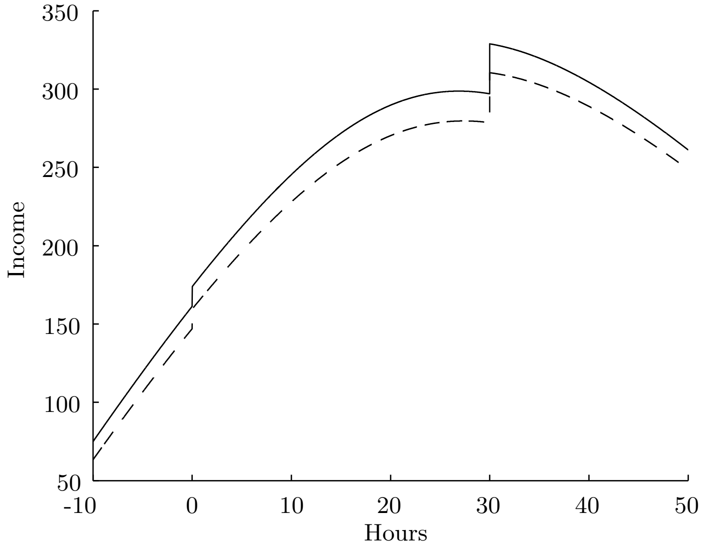

Figure 2: Indifference Curves, Person 2

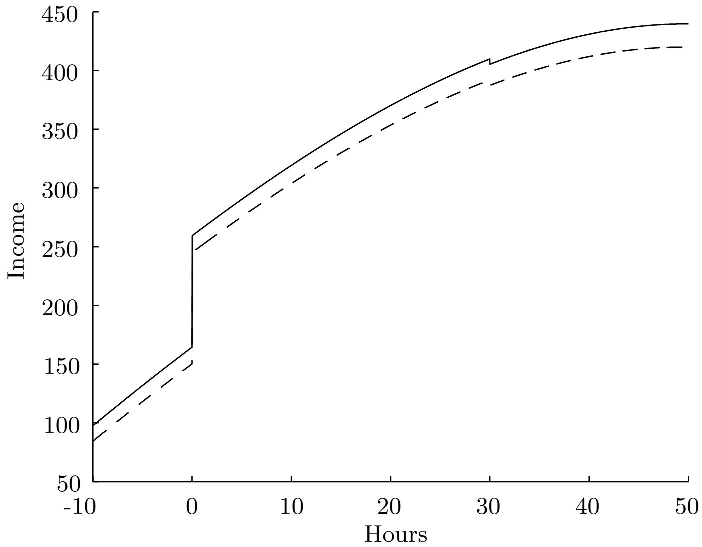

Figure 3: Indifference Curves, Person 3

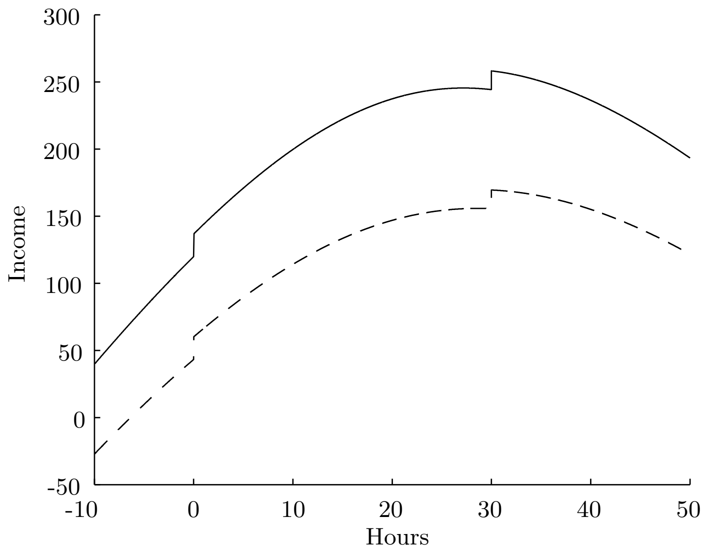

Figure 4: Indifference Curves, Person 4

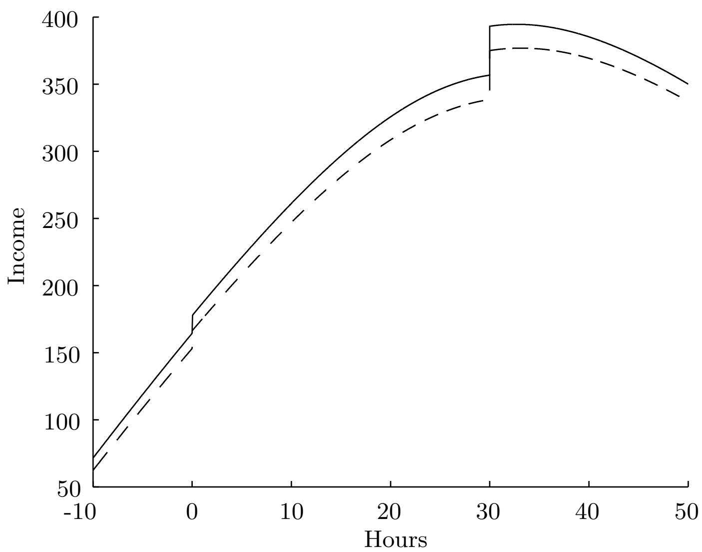

Figure 5: Indifference Curves, Person 5

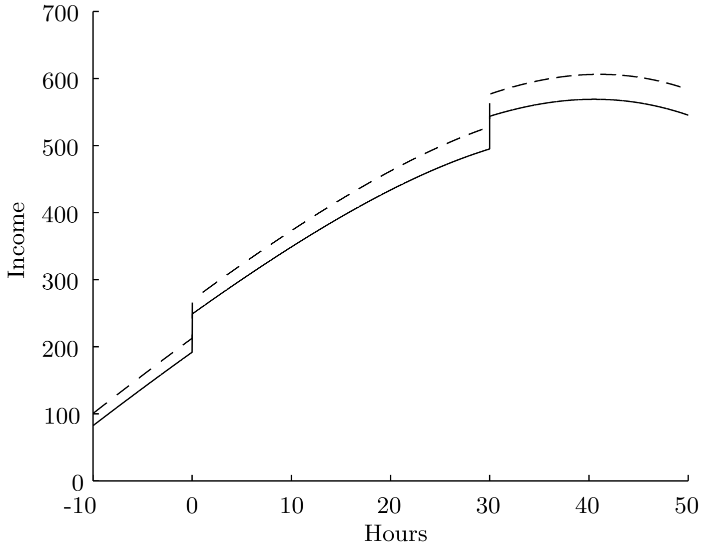

Figure 6: Indifference Curves, Person 6

A.2 Couples with Children

In our couples model utility is defined over net income and both male and female hours. The first fixed cost of work occurs when the *female* partner works a strictly positive number of hours, with the second fixed cost being introduced at the 30 hours point. In Figures 7 to 11 the lower hyperplane corresponds to the indifference map in the presence of programme participation costs. Meanwhile, the observable characteristics of these couples are presented in Table 10.

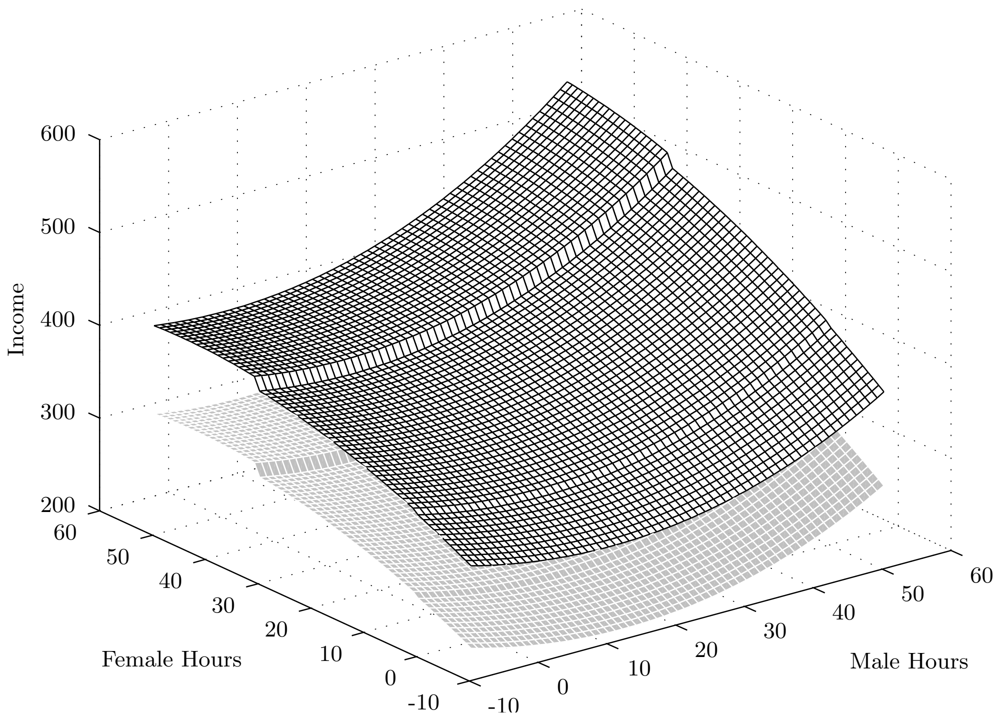

Figure 7: Indifference Map, Couple 1

Table 10: Observable Characteristics: Couples with Children

	Female Age	Male Age	Female Post 16 Education	Male Post 16 Education	Non-white (Either)	London	Number of children	Age group of youngest child
Couple 1	46	48	No	No	No	No	1	11 - 18
Couple 2	40	48	No	No	No	Yes	3	5 - 10
Couple 3	26	35	No	Yes	Yes	Yes	2	5 - 10
Couple 4	38	44	No	Yes	Yes	Yes	1	11 - 18
Couple 5	28	37	No	Yes	No	Yes	2	0 - 2

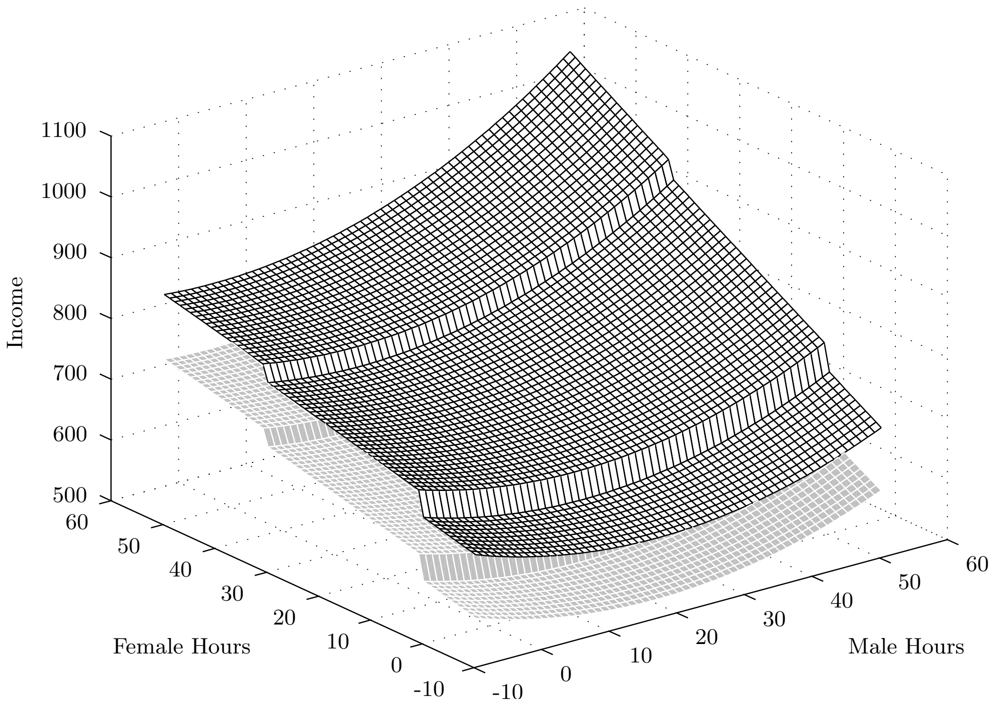

Figure 8: Indifference Map, Couple 2

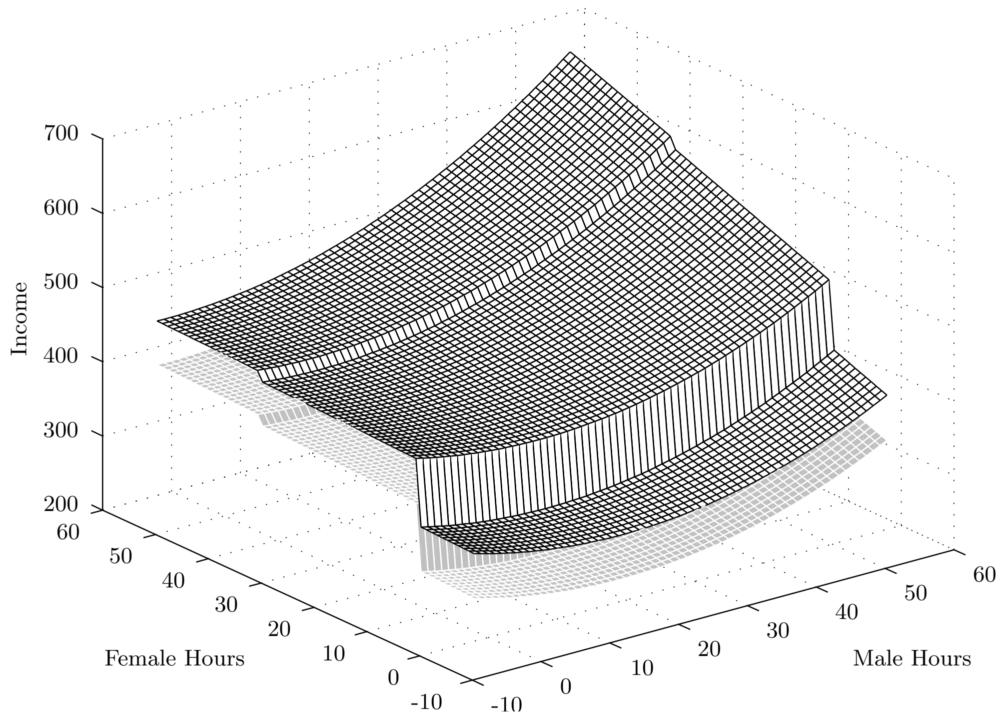

Figure 9: Indifference Map, Couple 3

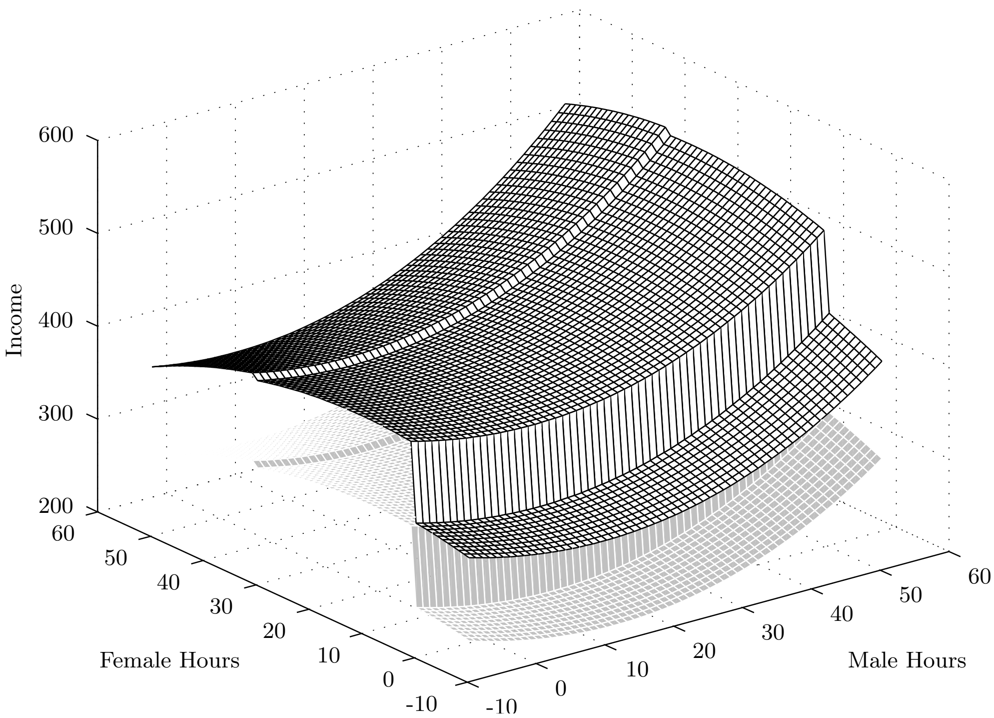

Figure 10: Indifference Map, Couple 4

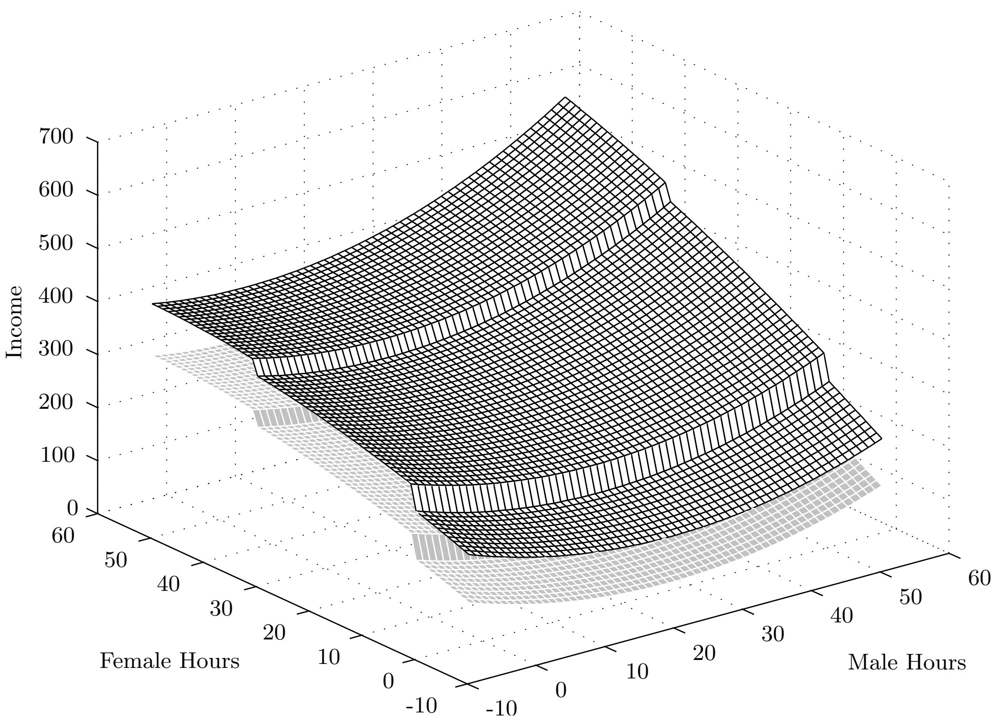

Figure 11: Indifference Map, Couple 5

B Sample Selection and Aggregation

The data-set used in the estimation of our structural labour supply model is the Family Resources Survey, from 1995/6 to 2001/2. This provides a sample of 95,616 working age individuals in families with children. We can also make use of sample weights which allow each year of the FRS to be grossed up to the true population of Great Britain. However, we have to exclude some observations when estimating the labour supply model. In common with many studies of labour supply, we exclude the following observations:

- Adults in full-time education
- Pensioners
- Adults receiving a disability benefit
- The self-employed
- Adults receiving statutory maternity or sickness pay.

Some of these individuals are omitted because it is difficult to estimate the budget constraint correctly (such as the self-employed). Others are omitted because their labour market behaviour is unlikely to be motivated by the simple leisure/money trade-off that lies behind our model (such as adults in full-time education, and those approaching retirement age). We exclude the disabled mostly because the FRS does not give us an objective measure of health status. We also exclude lone fathers, but future work will vary this.

These exclusions have a large impact on the sample of couples with children, and a smaller impact on the sample of lone parents (see Table B). The table also shows that our exclusion restrictions are more likely to drop adults who are not working than those who are working.

The fact that our sample is no longer representative of the population, even with the supplied FRS grossing factors, means that it is not immediately clear what our simulation results imply about changes in the aggregate participation or employment rate. The approach that we have adopted so far is to multiply the predicted changes in participation by

	Lone Parents	Couples with Children
Total	1,781,933	10,402,700
Pensioner	13,577	52,532
Total Working Age	1,768,356	10,350,168
of whom are not working	947,930	2,202,404
of whom are working	820,426	8,147,764
Self-employed	40,977	1,835,944
F-T education	14,551	36,192
Disability benefit	115,510	793,656
SMP/SSP	23,635	224,680
Lone fathers	102,186	-
Remaining Individuals	1,471,497	7,459,696
of whom are not working	787,645	1,406,704
of whom are working	683,852	6,052,992
Remaining individuals		
Proportion of all	83%	72%
Proportion of non-pensioners	83%	72%
Proportion of non-workers	83%	64%
Proportion of workers	83%	74%

the total sample weight of our sample, but without using sample weights during estimation. This would give the correct answer if the individuals who we omitted from our sample were totally unresponsive to financial incentives. An alternative assumption would be to pretend that the individuals that we omitted were omitted at random: aggregate estimates based on this assumption could be achieved by multiplying the aggregate estimates presented in this report by the numbers in Table B (for example, estimates of the aggregate changes for lone parents would be multiplied by 1/0.83, and couples by 1/.72).

C Tables

Table 11: Wage Equations (Heckman selection model)

	Lone Mothers		Women in Couples		Men in Couples	
	Estimate	z	Estimate	z	Estimate	z
Wage equation‡						
Age Completed Education	0.071	13.100	0.069	47.690	0.089	38.540
Age§	0.086	2.120	0.053	2.550	0.111	3.810
Age Squared§	−0.187	−1.590	−0.021	−0.390	−0.189	−2.360
Age Cubed§	0.129	1.190	−0.062	−1.350	0.087	1.240
Non-white†	−0.038	−1.030	−0.423	−25.110	−0.215	−9.580
Home owner†	0.304	14.290	0.438	44.300	0.343	25.190
(Age - Year) Cubed§	−0.013	−2.160	−0.010	−2.960	−0.029	−6.350
Selection equation‡						
Net income at 0 hours	−0.003	−9.700	−0.001	−7.740	−0.001	−11.020
Age Completed Education	0.114	14.020	0.051	9.910	0.059	15.310
Age§	0.162	2.690	0.130	2.590	0.146	3.180
Age Squared§	−0.321	−1.830	−0.180	−1.380	−0.281	−2.170
Age Cubed§	0.151	0.930	−0.018	−0.170	0.092	0.790
Non-white†	−0.083	−1.670	−0.570	−13.720	−0.614	−19.030
Home owner†	0.804	26.080	1.128	44.100	0.774	37.040
(Age - Year) Cubed§	−0.064	−7.300	−0.052	−6.400	−0.055	−7.990
Age of Youngest Child: 1†	0.346	4.600	0.044	0.900	0.351	9.110
Age of Youngest Child: 2†	0.416	5.580	0.117	2.140	0.436	10.900
Age of Youngest Child: 3†	0.557	7.380	0.160	2.660	0.482	11.600
Age of Youngest Child: 4†	0.648	8.500	0.062	1.070	0.620	14.180
Age of Youngest Child: 5†	0.759	9.730	0.071	1.150	0.813	17.640
Age of Youngest Child: 6†	0.858	10.830	0.077	1.150	0.801	16.850
Age of Youngest Child: 7†	0.868	10.630	0.142	2.140	0.944	19.170
Age of Youngest Child: 8†	0.936	11.280	0.127	1.940	1.035	16.150
Age of Youngest Child: 9†	0.884	10.400	0.035	0.520	1.104	20.830
Age of Youngest Child: 10†	0.948	11.130	0.123	1.750	1.159	20.850
Age of Youngest Child: 11†	1.061	11.900	0.207	2.810	1.315	21.450
Age of Youngest Child: 12†	1.110	12.260	0.192	2.540	1.261	21.150
Age of Youngest Child: 13†	1.202	12.980	0.310	4.100	1.339	22.080
Age of Youngest Child: 14†	1.407	14.470	0.193	2.600	1.369	21.180
Age of Youngest Child: 15†	1.383	13.800	0.408	4.780	1.537	21.920
Age of Youngest Child: 16†	1.447	13.590	0.404	4.400	1.477	21.240
Age of Youngest Child: 17†	1.577	11.910	0.254	2.560	1.553	18.410
Age of Youngest Child: 18†	1.706	10.970	0.153	1.300	1.491	15.910
Children Health Problems: 1†	−0.124	−3.670	−0.104	−3.200	−0.063	−2.650
Children Health Problems: 2†	−0.266	−3.510	−0.184	−2.520	−0.181	−3.050
Children Health Problems: 3†	−0.218	−0.970	−0.717	−4.540	−0.737	−3.060
Children Health Problems: 4†	−0.066	−0.140	−0.780	−2.090	−6.867	−42.730
Children Health Problems: 5†	-	-	−6.633	−37.750	−5.773	−33.620
Rho	0.007	0.120	0.588	24.266	0.595	18.588
Sigma	0.514	34.633	0.524	122.263	0.636	64.379
Lambda	0.004	0.120	0.308	24.802	0.378	23.072
Sample size		11549		28709		28620
Censored sample		6573		2831		9025
Uncensored sample		4976		25878		19595
Log likelihood		-10037		-26622		-32901

Notes: ‡Dummy variables for year and region were also included. § denotes that the variable is measured in terms of deviation from its mean value, while discrete variables are denoted by †.

Table 12: Parameter Estimates: Lone Parents

	Parameter	Estimate	Standard Error	z	$P > \|z\|$
α_{11}:	Constant	−0.321	0.044	−7.290	0.000
	Youngest Child 0-2	0.210	0.074	2.844	0.004
	Youngest Child 3-4	0.212	0.065	3.244	0.001
	Youngest Child 5-10	−0.059	0.061	−0.969	0.332
α_{22}:	Constant	0.308	0.027	11.317	0.000
	Youngest Child 0-2	0.024	0.062	0.385	0.700
	Youngest Child 3-4	−0.152	−0.031	−2.401	0.016
	Youngest Child 5-10	−0.031	0.037	−0.833	0.405
α_{12}:	Constant	0.010	0.004	2.693	0.007
	Youngest Child 0-2	−0.019	0.005	−3.541	0.000
	Youngest Child 3-4	−0.015	0.006	−2.427	0.015
	Youngest Child 5-10	0.005	0.005	1.099	0.272
β_1:	Constant	0.327	0.023	14.538	0.000
	Age (DM)	−0.027	0.047	−0.579	0.563
	Age Squared (DM)	0.003	0.006	0.546	0.585
	Education 16	−0.015	0.009	−1.677	0.093
	Youngest Child 0-2	−0.085	0.037	−2.270	0.023
	Youngest Child 3-4	−0.046	0.035	−1.320	0.187
	Youngest Child 5-10	0.012	0.030	0.399	0.690
	Number of Children	0.012	0.007	1.889	0.059
	Non-white	−0.068	0.017	−3.966	0.000
	Random Term (SD)	0.004	0.009	0.400	0.689
β_2:	Constant	−0.213	0.015	−13.993	0.000
	Age (DM)	0.106	0.012	8.708	0.000
	Age Squared (DM)	−0.012	0.002	−7.334	0.000
	Education 16	0.034	0.003	13.188	0.000
	Youngest Child 0-2	0.017	0.027	0.614	0.539
	Youngest Child 3-4	0.062	0.028	2.197	0.028
	Youngest Child 5-10	−0.011	0.020	−0.553	0.581
	Number of Children	−0.012	0.003	−3.565	0.000
	Non-white	0.016	0.009	1.878	0.060
	Random Term (SD)	0.000	0.002	0.000	1.000
η:	Constant	−0.252	0.061	−4.120	0.000
	October 1999	0.024	0.113	0.213	0.832
	April 2000	−0.210	0.116	−1.809	0.071
	Age (DM)	−0.349	0.386	−0.905	0.365
	Age Squared (DM)	0.119	0.054	2.214	0.027
	Education 16	0.767	0.085	9.060	0.000
	Non-white	0.399	0.148	2.699	0.007
	Random Term (SD)	0.215	0.103	2.085	0.037
FC_1:	Constant	8.955	6.978	1.283	0.199
	Youngest Child 0-2	42.298	14.532	2.911	0.004
	Youngest Child 3-4	32.760	12.810	2.557	0.011
	Youngest Child 5-10	5.542	8.984	0.617	0.537
	Number of Children	3.015	2.836	1.063	0.288
	Non-white	38.256	13.018	2.939	0.003
	London	48.089	4.593	10.469	0.000
	Random Term (SD)	5.304	3.140	1.689	0.091
FC_2:	Constant	13.963	5.576	2.504	0.012
	Youngest Child 0-2	21.091	14.245	1.481	0.139
	Youngest Child 3-4	−4.638	11.045	−0.420	0.675
	Youngest Child 5-10	13.364	7.747	1.725	0.085
	Number of Children	4.558	3.476	1.311	0.190
	Non-white	−33.931	12.492	−2.716	0.007
	London	−13.858	5.952	−2.328	0.020
	Maximised Log Likelihood				-15564.720
	Observations				11594

Note: Standard errors are calculated analytically from the Simulated Maximum Likelihood estimates. Parameters are scaled as follows: α_{11} (divided by 10,000), α_{12} and α_{22} (divided by 100), β_1 (divided by 10). Additionally, 'Age' is divided by 10, and 'Age Squared' by 100. DM denotes that the respective variable is measured in terms of deviation from its mean value. SD denotes standard deviation. Number of children is defined to be one less than the actual number of children.

Table 13: Parameter Estimates: Couples

	Parameter	Estimate	Standard Error	z	$P > \|z\|$
α_{11}:	Constant	−0.321	0.044	−7.290	0.000
	Youngest Child 0-2	0.210	0.074	2.844	0.004
	Youngest Child 3-4	0.212	0.065	3.244	0.001
	Youngest Child 5-10	−0.059	0.061	−0.969	0.332
α_{22}^{f}:	Constant	0.308	0.027	11.317	0.000
	Youngest Child 0-2	0.024	0.062	0.385	0.700
	Youngest Child 3-4	−0.152	−0.031	−2.401	0.016
	Youngest Child 5-10	−0.031	0.037	−0.833	0.405
α_{22}^{m}:	Constant	0.308	0.027	11.317	0.000
	Youngest Child 0-2	0.024	0.062	0.385	0.700
	Youngest Child 3-4	−0.152	−0.031	−2.401	0.016
	Youngest Child 5-10	−0.031	0.037	−0.833	0.405
α_{22}^{fm}:	Constant	0.308	0.027	11.317	0.000
	Youngest Child 0-2	0.024	0.062	0.385	0.700
	Youngest Child 3-4	−0.152	−0.031	−2.401	0.016
	Youngest Child 5-10	−0.031	0.037	−0.833	0.405
α_{12}^{f}:	Constant	0.010	0.004	2.693	0.007
	Youngest Child 0-2	−0.019	0.005	−3.541	0.000
	Youngest Child 3-4	−0.015	0.006	−2.427	0.015
	Youngest Child 5-10	0.005	0.005	1.099	0.272
α_{12}^{m}:	Constant	0.010	0.004	2.693	0.007
	Youngest Child 0-2	−0.019	0.005	−3.541	0.000
	Youngest Child 3-4	−0.015	0.006	−2.427	0.015
	Youngest Child 5-10	0.005	0.005	1.099	0.272
β_1:	Constant	0.327	0.023	14.538	0.000
	Age (DM)	−0.027	0.047	−0.579	0.563
	Age Squared (DM)	0.003	0.006	0.546	0.585
	Education 16	−0.015	0.009	−1.677	0.093
	Youngest Child 0-2	−0.085	0.037	−2.270	0.023
	Youngest Child 3-4	−0.046	0.035	−1.320	0.187
	Youngest Child 5-10	0.012	0.030	0.399	0.690
	Number of Children	0.012	0.007	1.889	0.059
	Non-white	−0.068	0.017	−3.966	0.000
	Random Term (SD)	0.004	0.009	0.400	0.689
β_2^{f}:	Constant	−0.213	0.015	−13.993	0.000
	Age (DM)	0.106	0.012	8.708	0.000
	Age Squared (DM)	−0.012	0.002	−7.334	0.000
	Education 16	0.034	0.003	13.188	0.000
	Youngest Child 0-2	0.017	0.027	0.614	0.539
	Youngest Child 3-4	0.062	0.028	2.197	0.028
	Youngest Child 5-10	−0.011	0.020	−0.553	0.581
	Number of Children	−0.012	0.003	−3.565	0.000
	Non-white	0.016	0.009	1.878	0.060
	Random Term (SD)	0.000	0.002	0.000	1.000

Table 13: Parameter Estimates: Couples (continued)

	Parameter	Estimate	Standard Error	z	$P > \|z\|$
β_2^m:	Constant	−0.213	0.015	−13.993	0.000
	Age (DM)	0.106	0.012	8.708	0.000
	Age Squared (DM)	−0.012	0.002	−7.334	0.000
	Education 16	0.034	0.003	13.188	0.000
	Youngest Child 0-2	0.017	0.027	0.614	0.539
	Youngest Child 3-4	0.062	0.028	2.197	0.028
	Youngest Child 5-10	−0.011	0.020	−0.553	0.581
	Number of Children	−0.012	0.003	−3.565	0.000
	Non-white	0.016	0.009	1.878	0.060
	Random Term (SD)	0.000	0.002	0.000	1.000
η:	Constant	−0.252	0.061	−4.120	0.000
	October 1999	0.024	0.113	0.213	0.832
	April 2000	−0.210	0.116	−1.809	0.071
	Age (DM)	−0.349	0.386	−0.905	0.365
	Age Squared (DM)	0.119	0.054	2.214	0.027
	Education 16	0.767	0.085	9.060	0.000
	Non-white	0.399	0.148	2.699	0.007
	Random Term (SD)	0.215	0.103	2.085	0.037
FC_1^f:	Constant	8.955	6.978	1.283	0.199
	Youngest Child 0-2	42.298	14.532	2.911	0.004
	Youngest Child 3-4	32.760	12.810	2.557	0.011
	Youngest Child 5-10	5.542	8.984	0.617	0.537
	Number of Children	3.015	2.836	1.063	0.288
	Non-white	38.256	13.018	2.939	0.003
	London	48.089	4.593	10.469	0.000
	Random Term (SD)	5.304	3.140	1.689	0.091
FC_2^f:	Constant	13.963	5.576	2.504	0.012
	Youngest Child 0-2	21.091	14.245	1.481	0.139
	Youngest Child 3-4	−4.638	11.045	−0.420	0.675
	Youngest Child 5-10	13.364	7.747	1.725	0.085
	Number of Children	4.558	3.476	1.311	0.190
	Non-white	−33.931	12.492	−2.716	0.007
	London	−13.858	5.952	−2.328	0.020
	Maximised Log Likelihood				-15564.720
	Observations				11594

Note: Standard errors are calculated analytically from the Simulated Maximum Likelihood estimates. Parameters are scaled as follows: α_{11} (divided by 10,000), α_{12}^f, α_{12}^m, α_{22}^f, α_{22}^m and α_{22}^{fm} (divided by 100), β_1 (divided by 10). Additionally, 'Age' is divided by 10, and 'Age Squared' by 100. DM denotes that the respective variable is measured in terms of deviation from its mean value. SD denotes standard deviation. Number of children is defined to be one less than the actual number of children.

Table 14: Parameters of FC/WFTC

	April 1999 (FC)	October 1999 (WFTC)	June 2000 (WFTC)
Basic Credit	49.80	52.30	53.15
Child Credit			
under 11	15.15	19.85	25.60
11 to 16	20.90	20.90	25.60
over 16	25.95	25.95	26.35
30 hour premium	11.05	11.05	11.25
Threshold	80.65	90.00	91.45
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
Help with 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

Table 15: WFTC and Family Credit take-up rates

	Lone parents		Couples	
	As % caseload	As % expenditure	As % caseload	As % expenditure
2000/1	80	85	51	65
1998/9	81	88	58	66
1997/8	77	84	62	74
1996/7	81	88	68	82
1995/6	80	91	62	76
1994/5	80	90	61	75
1993/4	77	86	66	76
1992	73	66		
1990-1991	68	62		

Notes: Estimates were not broken down by family type before 1992: figures are averaged across lone parents and couples; half of FC claims were by lone parents throughout the period under consideration. Figures shown are mid-points of stated range in some years; 95% error bands to around ±4 percentage points. Excludes full-time self-employed. No statistics available for 1999/2000.
Source: Inland Revenue (2002) and Department of Work and Pensions, (2001) and previous editions.

Table 16: Changing profiles of FC/WFTC awards, 1999-2001

	Lone parents		Couples	
	August 1999	August 2000	August 1999	August 2000
Receiving WFTC	405,000 (52%)	527,000 (48%)	379,000 (48%)	562,000 (52%)
Mean award	£62.60	£76.71	£63.27	£73.32
% with childcare tax credit/disregard	11%	21%	0.40%	2%
Actual childcare costs	£43.88	£51.26[c]	£33.93[a]	£60.15[c]
Extra award through childcare tax credit/disregard	£22.08[b]	£33.38[b]	-	-
Mean age main earner	35	36	35	36
Mean number of children	1.7	1.6[c]	2.4	2.3[c]
Mean gross weekly earnings (employees only)	£112	£142	£144	£176
Mean hours worked (employees only; maximum for couple)	24.2	26.7	31.7	35.1
Number claiming 30 hour premium	125,000 (31%)	239,000[c] (41%)	255,000 (67%)	414,000[c] (76%)
% main earner self-employed	8%	4%[d]	23%	15%[d]

Notes: [a]Excludes those receiving because of a disabled partner. [b]Averaged over couples as well. All figures for GB only except [c]UK. [d]November 2000.
Source: Various DSS (1999) and IR (2002)

Table 17: Summary Statistics of variables used in estimation

Variable	Lone mothers		Couples	
	Mean	s.d.	Mean	s.d.
Greater London†	0.149	-	0.101	-
Youngest Child 0-2†	0.245	-	0.294	-
Youngest Child 3-4†	0.151	-	0.139	-
Youngest Child 5-10†	0.348	-	0.294	-
October 1999†	0.361	-	0.347	-
April 2000†	0.293	-	0.278	-
Non-white†	0.103	-	0.090	-
Number of Children	1.768	0.930	1.876	0.874
Female Education†	0.290	-	0.395	-
Female Age§	0.000	0.825	0.000	0.733
Female Age Squared§	0.000	5.807	0.000	5.442
Female Predicted Wage	5.546	2.090	6.560	3.208
Female Weekly Hours	11.945	15.522	18.272	15.479
Male Education†	-	-	0.455	-
Male Age§	-	-	0.000	0.783
Male Age Squared§	-	-	0.000	6.275
Male Weekly Hours	-	-	37.655	13.102
Male Predicted Wage	-	-	10.789	4.412

Derived from FRS 1994-2001 using selection criteria as detailed in Appendix B. All monetary amounts are expressed in March 2002 prices. § denotes that the variable is measured in terms of deviation from its mean value. For couples, 'Non-white' refers to *either* the male or female being non-white. Discrete variables are denoted by †.

Table 18: Child Rates of Income Support and income-based JSA, 1999 - 2000

	Child Element, Age		
	0 to 10	11 to 15	16 to 18
April 1999	£21.90	£28.00	£33.50
October 1999	£27.00	£28.00	£33.50
April 2000	£28.40	£28.40	£33.80

Note: All monetary amounts are expressed in April 2003 prices.

Table 19: Predicted and Observed States: Lone Parents

Hours Point	Observed (%)	Predicted (%)
0	57.1	57.8
10	6.2	7.4
19	10.2	7.8
26	5.3	6.8
33	6.6	6.9
40	14.5	13.3
Take-up Rate	63.29	69.3

Table 20: Predicted and Observed States: Couples, with children

Female Hours Point	Male Hours Point	Observed (%)	Predicted (%)
0	0	6.8	7.6
10	0	0.5	2.6
19	0	0.8	0.3
26	0	0.4	0.3
33	0	0.4	0.3
40	0	1.2	0.8
0	37	10.3	9.8
10	37	4.6	4.3
19	37	5.6	4.2
26	37	3.4	4.8
33	37	4.3	4.4
40	37	7.2	8.1
0	45	14.8	15.7
10	45	7.1	7.3
19	45	8.7	6.7
26	45	6.0	7.1
33	45	5.8	6.0
40	45	12.0	9.7
Take-up Rate		28.8	26.1

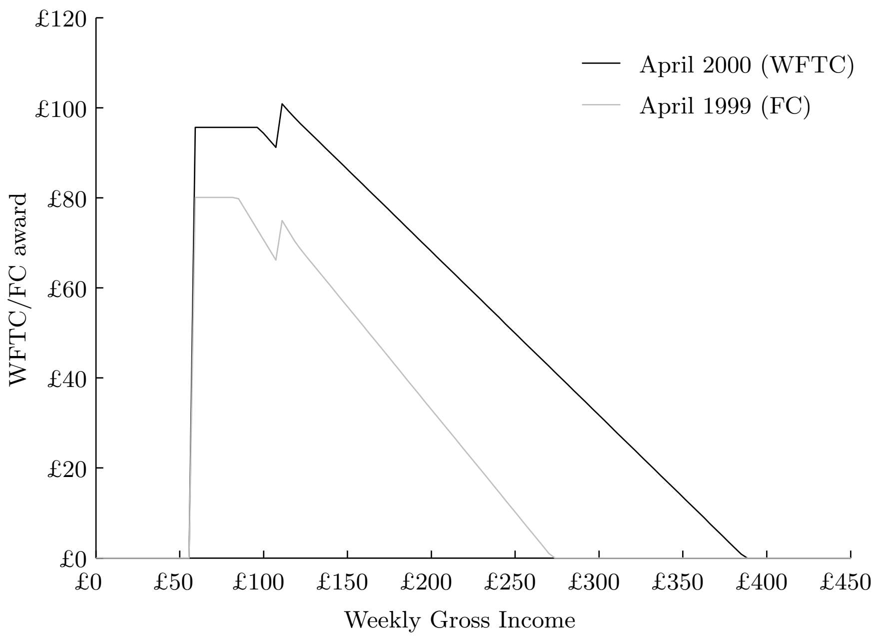

Figure 12: Example WFTC Schedule