Did Working Families' Tax Credit work? The final evaluation of the impact of in-work support on parents' labour supply and take-up behaviour in the UK

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Final version

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 evaluate the labour market impact of Working Families' Tax Credit (WFTC). Estimates suggest that by 2002, WFTC had increased labour supply of lone mothers by around 5.11 percentage points, slightly reduced labour supply of mothers in couples by 0.57 percentage points, and increased the labour supply of fathers in couples by 0.75 percentage points, compared with the benefit that preceded it, called Family Credit. In aggregate, these changes are equivalent to a fall of 99,000 in the number of workless families with children, and a net increase in labour market participation of 81,000 workers. However, contemporaneous tax and benefit reforms acted to reduce the labour supply of parents, and so the overall impact of tax and benefit changes introduced since 1999 is lower than stated above. Participating in Family

*©Crown Copyright 2005. Published by HM Revenue and Customs 2005. ISBN 1-904983-10-3. JEL classification: H24, H31, I38. Author affiliations: Mike Brewer and Andrew Shephard (Institute for Fiscal Studies), María José Suárez (University of Oviedo), Alan Duncan (University of Nottingham and Institute for Fiscal Studies). This paper is part of the project called "econometric Research: Impact of Working Families' Tax Credit" funded by the Inland Revenue. It is an updated version of one published in December 2003, with a similar title. The authors are grateful to Richard Blundell and Howard Reed, and to Mike Bielby and Medhi Hussain for comments on earlier drafts, and to participants at the 2002 TAPES conference, and seminar participants at ISER, University of Essex, and Policy Studies Institute. Data from the Family Resources Survey were made available by the Department for Work and Pensions, and are also available at the UK Data Archive. All errors and omissions remain those of the authors alone and not of the institutions mentioned here. Contact: Mike Brewer (m.brewer@ifs.org.uk).

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 in the final year of WFTC than it was in the last year of Family Credit for lone mothers, and no different for individuals in couples: this in itself induced more lone mothers to work.

Keywords: Labour supply, microsimulation, Working Families' Tax Credit, take-up, discrete choice

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. It makes use of data from all of WFTC's 42 month history (from October 1999 to March 2003), and therefore updates preliminary work first published in December 2003. Because entitlements to WFTC were increased in real terms at least every 12 months, this paper looks at both the immediate impact of replacing family credit with WFTC, and the cumulative impact of the changes to in-work support between April 1999 and March 2003. In April 2003, support for families was children was reformed again when Child Tax Credit and Working Tax Credit were introduced, and WFTC, amongst other things, abolished: this paper does not attempt, though, to examine the impact of these reforms.

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: first, it allows us to disentangle the impact of changes in in-work benefits from the other, substantial, changes to taxes and benefits affecting families with children taking place at the same time as WFTC was introduced; second, it also allows to us to control for the fact that the individuals entitled to participate in income-related programmes like WFTC 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

[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.

Credit (FC), although it in turn has since been replaced by the Child Tax Credit and the Working Tax Credit (see Brewer (2003)). Although WFTC 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 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 (see Brewer and Shephard (2004) and references therein). 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 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 entitled individuals do not participate. Regardless of its cause, 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 they 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 want-

[2] See Table 22.

[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).

ing to model labour supply behaviour. Tax credits, taxes and benefits together determine effective average or marginal tax rates, 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 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, meaning that comparisons of the labour market performance of, say, parents and non-parents will capture the impact of more than just WFTC. 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. Because WFTC was introduced at the same time as other changes to the tax and transfer system affecting families with children (see Section 2), comparisons of the labour market performance of, say, parents and non-parents will capture the impact of more than just WFTC. Indeed, because the extra spending on in-work support was accompanied by large real rises in entitlements to out-of-work benefits, some people have viewed 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;[4] the advantage of an evaluation based on a structural model is that it can separate out the contribution to changes in labour supply made by WFTC.

The outline of the rest of the paper is as follows. Section 2 provides more background to and a fuller description of the reforms in the UK that we intend to study. Since April 1999, in-work support in the UK has experienced almost continual change, if only in the real value of entitlements. Because of this - which makes it hard to isolate a stable post-reform period - this paper looks at both the immediate impact of replacing Family Credit with WFTC, and the cumulative impact of changes to taxes and benefits between April 1999 and March 2003. Section 3 sets out our model of programme non-participation and labour supply. Section 4 describes our data sources, presents the results of the model, and outlines the impact of the various packages of tax and benefit changes whose effect we simulate. Section 5 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 choice amongst a number of possible hours of work, given a fixed hourly wage.

To anticipate our conclusions, we find that WFTC increased labour supply of lone mothers by 5.11 percentage points. The effect on individuals in couples are more complicated: we find that WFTC reduced labour supply of mothers in couples by 0.57 percentage points, and increased the labour supply of fathers in couples by 0.75 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

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

81,000 extra workers, two thirds of whom are female, and to a reduction in the number of workless families with children of almost 100,000. However, other contemporaneous changes to the tax and benefit system affecting families with children acted, on balance, to reduce the labour supply of parents: we estimate that the combined impact of all tax and benefit changes between April 1999 and March 2003 was to increase the labour supply of lone mothers by 3.72 percentage points, and reduce that of men and women in couples by 0.40 and 0.49 percentage points respectively; overall, these correspond to an increase in participation of 22,000 individuals, and a reduction in the number of workless families with children of 43,000.

These estimates come from simulating the impact of policies. It is possible to estimate the standard errors around such estimates through boot-strapping techniques, although this assumes that our underlying model is correctly specified; although we do not report the standard error of every simulation result, all of the results highlighted here are statistically different from zero.

We find that the utility cost of participating in the UK's in-work support programme initially rose when WFTC was introduced, but then fell in successive years. By 2002, the cost of participating in WFTC was lower for lone mothers than it was under Family Credit; for couples, it was the same. This means that, other things being equal, take-up of WFTC by 2002 should have been higher than that of FC amongst lone mothers even if entitlements had not risen (explored in detail in Adam *et al.* (2005)). The most likely interpretation of this trend in the cost of participating in FC/WFTC is that it reflects a lack of information amongst those families who became newly entitled to in-work support when WFTC was introduced. Our data is not directly informative about this issue, however.

A paper very similar to this one but presenting interim findings was published as Brewer et al (2003). The work presented in this paper reflects three main changes:

- the inclusion of data from 2002/3.
- a change in the stochastic specification so that the choice-specific errors are now hours-specific (see Section 3.4.2)

- programme participation costs are now allowed to vary in each year.

In general, the results presented in this paper imply that WFTC had smaller (less positive) impacts on labour supply amongst lone parents than did the results in Brewer et al (2003). This is partly because the second change mentioned above has led an estimated utility function under which lone parents are less responsive to a given change in the budget constraint, but it is also because the pattern of programme participation costs over time (discussed in Section 4.2.3) had not been estimated in Brewer et al (2003).

Since this project began, other studies have been published which evaluate the labour market impact of WFTC using a difference-in-differences approach: see, for example, Blundell et al (2005), Francesconi and van der Klauw (2004), Leigh (2004), Gregg and Harkness (2003); we do not discuss them here. In a companion paper to this one, Adam et al (2005) analyses how take-up of FC/WFTC changed amongst those families who were entitled to it: this ignores the simultaneity of labour supply and programme participation decisions, but allows a more detailed investigation of the determinants of programme participation.

2 Background to and description of the reform

2.1 Working Families' Tax Credit and other changes to support for families with children since 1999

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 in addition to this. Spending on Family Credit in 1998/9 was £2.4 billion (bn), and this rose in cash terms to £4.6bn by 2000/1 and £6.3bn by 2002/3 (real rises of 85 % and 140 % using GDP deflators), 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 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 whole story. First, we must not forget the other important taxes and transfers available to families with children. During the period under consideration, there were three other main ways that the UK tax and

[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).

transfer system provided support for children: Child Benefit (paid to all families regardless of income), child allowances in Income Support (the means-tested safety-net benefit), and a non-refundable income tax allowance for parents known as the Children's Tax Credit (between April 2001 and March 2003).[6] Some families with children also received other means-tested benefits, and some of those (such as those that gave assistance with rental housing costs and local taxes, known as Housing Benefit and Council Tax Benefit respectively) interacted with WFTC in a way that meant that families receiving these other benefits gained less from the WFTC reform that otherwise-equivalent families not receiving these benefits.

Second, although the most obvious single change was the replacement of FC with WFTC in October 1999, the tax and transfer system affecting low-income families with children has experienced almost continual change since 1999. The most important of the other changes to taxes and benefits between April 1999 and March 2003 are as follows:[7]

- 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 (payroll tax) are payable by employees.
- abolition of the mortgage interest subsidy programme (MIRAS).
- abolition (in April 2000) 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, replaced (in April 2001) by a more generous tax credit for parents of children aged under 16 (known as the Children's Tax Credit).
- increase in entitlements to WFTC, through real increases in the basic credit, the extra amounts paid for children, and in the maximum value of the childcare tax credit.
- increases in Income Support/Jobseekers Allowance (income-related) and associated benefits for families with children, particularly for those with children under 11.

[6] See Adam *et al.* (2002).

[7] We do not consider the changes that look place in or before April 1999, such as the 10% starting rate of income tax, reforms to national insurance (payroll tax), and a new minimum wage.

- increases in support available to parents of children under 12 months through a lump-sum grant paid to families on low-incomes, and (from April 2002) an additional non-refundable tax credit for income-tax-paying parents.

These near-continuous changes make it very difficult to point to a stable post-reform period, and this paper therefore looks both at the effect of replacing FC with WFTC, and at the cumulative impact of all of the changes to taxes and benefits between April 1999 and March 2003. It also distinguishes between the impact of the immediate change to WFTC, and the impact in the final year of its existence. In April 2003, support for families was children was reformed again when Child Tax Credit and Working Tax Credit were introduced, and WFTC, amongst other things, abolished: this paper does not attempt to examine the impact of these reforms.

2.2 What was expected to happen when WFTC was introduced?

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 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).

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

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

- 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 labour market 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 (*i.e.* formal childcare, rather than care by relatives or friends).

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]

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. The model estimated 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 mothers 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

[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.

work: see Gregg *et al.* (1999)); unpublished work suggests that the two main reasons why the ex ante evaluation estimated smaller increases in labour supply amongst lone parents than this study are that it only estimated the impact of the increases in entitlement that happened in October 1999, and it assumed that programme participation cost of WFTC was no different from that of Family Credit.

2.3 What did happen when WFTC was introduced?

Changes in employment rates for parents, which underlie estimates of the impact of WFTC based on a difference-in-difference approach, are presented in Brewer and Shephard (2004). The proportion of parents who work has been on a rising trend for at least a decade: 71.5 per cent of parents were working in 1994, rising to 73.1 per cent in 1997 and 76.7 per cent in 2004. Over the same period, there has been an increase of a quarter in the proportion of lone parents working, from 43 to 54 per cent, and a smaller rise in the proportion of mothers in couples who work, concentrated among mothers whose partner is not working. The employment rate for fathers in couples has also risen, albeit very slightly, over this period.

The number of recipients of in-work support increased markedly after the introduction of WFTC 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.[11]

Official estimates of the programme participation rates for the main means-tested benefits in the UK are published every year: see Table 22 (these are calculated by estimating the recipient population from administrative data, and estimating the eligible non-participants population from survey data). The Table shows that programme participation rates for WFTC have risen since 2000/1, so that, by 2001/2, take-up of WFTC was higher than it had been for FC in 1998/9. But aggregate take-up rates, whether by caseload or expenditure, conflate changes in behaviour with changes in the underlying distribution of entitlements: see Adam et al (2005) for more detail.

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.

3.1 A basic model of preferences for work and income

Our model builds directly on that presented in Blundell *et al.* (1999). Other examples of structural labour supply models that use discrete choice techniques and incorporate non-participation in transfer programmes include Hoynes (1996), Keane and Moffitt (1998) and Bingley and Walker (1997). Other studies use discrete choice methods to model labour supply but without modelling program participation issues: van Soest *et al.* (2002) is a recent example; 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.

The basic approach is to assume that individuals maximize their utility subject to their

[11] 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).

own budget constraint, which is determined by a fixed hourly wage and the tax and benefit system. Individuals' preferences are written in terms of hours of work and net income, and a set of observable demographic factors and unknown preference parameters.[12] The model is a static one, in that it ignores intertemporal decisions.

Let $y_{h,P}$ 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 hourly wage does not depend on hours worked. This leads to an expression for $y_{h,P}$ of the form:

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

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:

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

[12] 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.

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 are important theoretically because they relax 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 in our model 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 inadequate. Instead, we work directly with preferences defined over net income and hours for a discrete subset of hours choices.[13] To make this estimation feasible, we assume that there is an additive stochastic component $\varepsilon_{h,P}$ which potentially varies with both the choice of hours and programme participation (this is discussed more in Section 3.4.2). 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.

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

[13]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.

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 equal 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 $\varepsilon_{h,P}$ follow a standard (Type-I) extreme-value distribution,[14] 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:

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

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:

$$\log \mathcal{L} = \sum_i \log \int_{\mathbf{u}} \prod_{j=1}^{J} \Pr(h = h_j|X, X_w, \mathbf{u})^{1(h=h_j)} f(\mathbf{u}) d\mathbf{u}$$

where $\mathbf{u} = (u_w, u_h, u_y)$.

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

[14] 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.

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 actual and psychological 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: Heim and Meier (2004) argue that these costs are likely to be large, and important determinants of individuals' working patterns. Empirically, a number of studies have shown that estimating labour supply models without unobserved work-related costs is more likely to lead to estimates of preferences that are non-convex; conversely, allowing for work-related costs tends to lead to estimates of preferences which are convex (see references in Heim and Meier (2004)). We model work-related costs as an unobserved, fixed weekly cost (WRC_1) subtracted from net income at positive values of working time, with an additional cost (WRC_2) if people work thirty or more hours, defined as:

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

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 $X_{f1}\beta_{f1} + X_{f2}\beta_{f2} + u_f$.

The decision to let the unobserved costs vary with full-time work is arbitrary, but does give the model more flexibility when attempting to reflect why so many parents work part-time; it may also serve to relax the assumption that hourly wages do not vary with hours worked per week, given studies that have estimated a part-time pay penalty (see Manning and Petrongolo (2004)).

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.[15] 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 assuming that non-working women do not use childcare.

To estimate the childcare price per child p_c, we compute the empirical distribution of hourly child-care costs (approximated with six fixed points) for various groups of working mothers defined by their family status and number and age of children, without accounting for any sample selection bias. This is implicity assuming 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 that they would face the same prices (results are discussed in Section 4.2.1).

[15] 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 (2004) for a review.

We have also estimated the relationship between hours of childcare and hours of maternal employment using data from before and after the WFTC reform; this is effectively assuming that the childcare tax credit had no impact on the market-clearing price of childcare, and no impact on families' use of childcare except in that in induces families to change their hours of work (evidence on the price of childcare in the UK is limited, but Brewer and Shaw (2004) find little evidence that the rate of increase in the real price changed around 2000).

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 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 $1(\cdot)$ 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 increase programme participation rates, 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.[16] 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 $y_{h,P}$ in two ways. First, $y_{h,P}$ includes any direct 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.[17] 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:

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

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 $E_h = 1(\Psi_1 > 0)$ be an indicator of positive entitlement to FC/WFTC at hours h.

[16] 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.

[17] We choose to assume full participation 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).

We then introduce additional terms into the preference function to capture the *utility cost* (denoted η) of receiving in-work support. These costs may 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 one-off costs of applying and the ongoing costs of receiving FC/WFTC. The extended preference function now takes the form:

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

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 the 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 time dummies in the characteristics X_η, allowing the utility cost of participating to change over time.

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 $\varepsilon_{h,P}$ 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:

$$\{h = h_j, P = 0\} \quad \text{for all} \quad j = 1, ...J$$

$$\{h = h_j, P = 1\} \quad \text{for } \textit{any} \quad j = 1, ...J \text{ for which } E_{h_j} = 1$$

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. 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 various assumptions about the choice-specific errors $\varepsilon_{h,P}$.

In preliminary work, we assumed that $\varepsilon_{h,P}$ are distributed as iid extreme value errors. In this paper, we present estimates that have assumed that $\varepsilon_h = \varepsilon_{h,P=0} = \varepsilon_{h,P=1}$ for all $h_j \in \mathbf{h}$, or, in other words, that the choice-specific errors are only hours-specific. The significance of having having hours-specific errors is that, conditional on $\mathbf{u}$, the difference in utilities between participating and not participating in FC/WFTC at each hours choice will be deterministic, and so the model will collapse to one with only J choices.

If $\varepsilon_{h,P}$ are distributed as iid extreme value errors, then, given random components $\mathbf{u}$, the choice probabilities are:

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

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

For our preferred specification, where $\varepsilon_h = \varepsilon_{h,P=0} = \varepsilon_{h,P=1}$ for all $h_j \in \mathbf{h}$, and ε_h are distributed as iid extreme value errors, the choice probabilities are, given random components $\mathbf{u}$:

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

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

3.5 Estimation

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

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

where $\mathbf{u}_{-u_\eta} = (u_w, u_{cc}, u_y, u_h)$.

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};
- 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.[18]

In estimation, the integrals in the log-likelihood 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

[18] 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.

$\mathbf{u} = (u_y, u_h, u_f, u_w, u_\eta)$ 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.[19] The use of 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). 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.

We also make use of the bounds on u_η, derived earlier: this requires that the random participation cost u_η is integrated over a range that guarantees that the observed programme participation choice remains the most preferred outcome. With no entitlement to FC/WFTC at the observed hours h_j, then we have no information on the value of FC/WFTC participation cost, and the likelihood contributions are instead be integrated over the unrestricted range of u_η. The extreme value errors ε_h do not require simulating, and the scale of utility is fixed by the standard deviation of these errors.[20]

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 $\mathbf{h} = \{0, 10, 19, 26, 33, 40\}$, 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.

There is no non-parametric identification: instead, we rely on the functional form assumptions. In practice, variation comes from the changes to the tax and benefit regimes over time, and the fact that different types of individual have varying eligibility status to FC/WFTC. Unobserved costs of working are identified because lone mothers choose between 5 states with positive hours of work; FC/WFTC participation costs are identi-

[19] 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.

[20] In Keane and Moffitt (1998) and other discrete choice models, both the standard deviation of the extreme value errors and one other parameter are fixed, usually to make the extreme value error "small" in some sense. We do not adopt this approach.

fied separately from fixed work-related costs because some lone mothers are not entitled to FC/WFTC at certain levels of hours. Finally, 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.

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

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 mothers (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 $I_{h_F1} = 1(h_F > 0)$ and $I_{h_F2} = 1(h_F > 30)$ 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 at hours $\mathbf{h_j}$ 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 (in other words, if we define

$\mathbf{u} = (u_y, u_h, u_f, u_\eta, u_{w_M}, u_{w_F})$, $\mathbf{u}_{-\eta} = (u_y, u_h, u_f, u_{w_M}, u_{w_F})$ and $\mathbf{X} = [X, X_{w_M}, X_{w_F}, X_{f1}, X_{f2}, X_\eta]$, then the likelihood is as given above.

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. It would be attractive to test whether the parameter estimates and key conclusions from the simulations are robust to allowing for symmetry in the hours choices available to men and women, but this study follows the literature by restricting the choices facing fathers to ease the computational burdens of estimating the model.

The wage equations, childcare use function, and childcare price distribution are all estimated in a first stage, as for lone mothers, with the unobserved component of a mother's wages assumed independent from that of their partner.

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_h 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 probabilities for each hours and programme participation choice under both tax and benefit systems, and we can combine these probabilities into a transition matrix defined over the hours and participation choices. The numbers in the transition matrix should be thought of as the expected (or average) values of the transition matrix given the parameter estimates, where the expectation is over $\mathbf{u}$, ε_h and p_c. We can estimate confidence intervals around these expectations that reflect that the parameters in our model are not known with certainty, and these standard errors are calculated by repeatedly drawing from the estimated asymptotic distribution of the parameters, and re-calculating the expected value of the transition matrix.

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; this reflects that our relatively large sample enables us to estimate the 40 or so parameters in our model relatively accurately. However, these standard errors are only correct under the assumption that our model is correctly specified.

4 Labour supply estimates, and results of policy simulations

This section first discusses the data we used, then the estimates of the preference coefficients, and finally uses these to estimate the impact of WFTC and contemporaneous tax and benefit changes.

4.1 Data

We have used 8 repeated cross-sections from the Family Resources Survey (FRS), from financial 1995/6 to 2002/3. The FRS is a cross-section household-based survey drawn from postcode records across Great Britain: around 30,000 families with and without children each year are asked detailed questions about earnings, other forms of income and receipt of state benefits. It is now 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).

It is obviously very important that the FRS records receipt of FC/WFTC 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 grossing weights than families with children not receiving FC, and grossing weights (which are designed to correct for non-random non-response) are not used in our estimation.

The starting point for our sample is 110,700 parents across 8 years. We drop 626 adults in families with a pensioner, 17,559 adults with a self-employed worker in the family, 411 adults where a parent in the family is involved in full-time education, 8,055 adults in families who are receiving a benefit because of a disability, 2,381 adults in families who are receiving either statutory sick or maternity pay and 1,138 lone fathers, leaving a sample of 13,558 lone mothers and 33,486 couples with children. Dropping families with missing observations of crucial variables, and those observed during the phase-in period of October 1999 to March 2000 restricts this further to 12,729 lone parents and 31,403 couples with children.

Section 2 described how WFTC was abolished in April 2003 as the child and working tax credits were introduced. To ease the transition, there was a short "phase-out" period between December 2002 and March 2003 during which all WFTC awards due for renewal were automatically extended to the end of March 2003 without claimants' circumstances being reassessed: this feature is ignored in our model, and we do not think this will have any substantial impact on our results.

4.2 Results

4.2.1 First-stage regressions

As explained in Section 3, there are three first stage regressions: a wage equation, an equation describing childcare use, and an estimated distribution of the price of childcare.

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 in the employment equation. The results are shown in Table 18: the coefficients on years of education in the wage equation are plausible (implying returns of between 7 and 9 percentage points for each year of full-time education); those on age of the youngest child and modelled out-of-work income in the selection equation are also sensible.

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 mother or in a couple. For each group, we regressed hours of childcare used 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 Table 17. 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 mother, single earner couple or two-earner couple): results are shown in Table 16.

4.2.2 Estimates of the parameters of utility function

The main parameter estimates are given in Table 19 and Table 20.

We find that the estimated parameter values for this model are broadly consistent with economic theory. In particular, for lone mothers over 99% of lone mothers have positive marginal utility of net income at their observed state, and around four fifths have negative marginal utility of work. At their observed state, over 99% of couples have positive marginal utility of income, with over 90% of men and women having negative marginal utility of female and male hours.[21]

The (unobserved) fixed costs of working - which play an important role in explaining the overall rate of labour market participation in the model, and allow for a degree of separation in the implied extensive and intensive responses - are assumed to vary by the number of children, the age of youngest child, whether in Greater London and ethnicity. Amongst lone mothers, these costs are, unsurprisingly, found to be higher amongst those with younger children, are increasing in the number of children, and are much higher for individuals from an ethnic minority or who live in Greater London. These costs are mostly greater for full-time work than part-time work, except for the last two: for lone mothers, there is no significant London or ethnic minority effect when considering full-time work. On average, these work-related costs are found to be higher for individuals who do not work compared to those who do (£89 for the initial fixed cost compared to £68 for a working lone parent).

A similar picture of the work-related costs emerges for couples, but these fixed costs are lower on average (for part-time work, an average fixed cost of £24 for a non-working mother with a partner, and an average of £17 for working mothers with a partner).

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, an indicator for remaining in education beyond the compulsory school leaving age, and an indicator for being from an ethnic minority (sample means of these variables are given in Table 23). The age of youngest child dummies also affects the quadratic terms (X_{11}, X_{12} and X_{22}).

Unsurprisingly, there is greater preference for income, and less desire to work, the greater the number of children. Interpreting the impact of the age of the youngest child is difficult

[21] Table 24 compares the predicted and observed states for lone mothers, Table 25 does the same for couples.

because it enters both the linear and quadratic terms of the utility function. For lone mothers, the effect of mother's age on the preference for income is not well determined, but we do find that individuals with above-average age have a greater preference for work. Higher levels of education are associated with a lower valuation of income, and a higher valuation of work. Lone mothers from an ethnic minority have significantly lower preferences for income.

A similar picture exists for couples. Preferences for income decline with the mother's age. Mothers in ethnic minority couples have a lower preference for hours of work, and fathers in in ethnic minority couples have a stronger preference for hours worked; both of these effects are highly significant (note that the couples with children from ethnic minorities tend to be from different ethnic backgrounds from ethnic minority lone parents). As with lone mothers, there is a weaker desire to work, the greater the number of children, particularly for mothers.

4.2.3 Understanding the estimates relating to programme participation

Incomplete programme participation in FC/WFTC is rationalised in our model by assuming that there is an associated (fixed) utility cost of participating, although we cannot say whether this is due to hassle, information, difficulties with the claim form or psychological stigma. We assume that these FC/WFTC participation costs vary with age of parent, being from an ethnic minority, completion of post-compulsory education, and by time (we include indicator variables for each financial year). The utility cost of participating in FC/WFTC is found to be higher for older and better-educated parents. It is higher for lone mothers from ethnic minorities than white lone mothers, but lower for couples from ethnic minorities than white couples.

We also find evidence of changes in the programme participation cost over time. For lone mothers, the coefficients suggest that the programme participation cost rose in April 1996, before falling in every successive year except the first full year of WFTC, April 2000, when it rose. Only two of these year-on-year changes are significantly different from zero, but combinations of changes are significantly different from zero: the programme participation cost is significantly lower than its April 1995 level by April 1998 and in all successive years. More interestingly, though, we find that the programme participation cost rose in the first full year of WFTC, and then fell in the next two years. If we compare the programme participation of WFTC to that of FC in its last year, we cannot reject the hypothesis that programme participation costs did not change by 2000 and by 2001, but, by 2002, the programme participation of WFTC is almost statistically significantly lower than it was in the last year of FC, in April 1999 (p-value = 0.052).

For couples, we also find evidence of a general decline in the programme participation cost over time, although most of the coefficients are individually insignificantly different from zero (we cannot reject the hypotheses that the programme participation cost has not changed since 1995 in all years except 1998 and 2002). As with lone mothers, we find that the programme participation cost rose in the first full year of WFTC, and then fell in the next two years. But unlike lone mothers, we find that the programme participation cost of WFTC in 2000 and 2001 was higher than that of FC in its last year, but we cannot reject the hypothesis that they are the same by 2002. These results suggest that we would expect to find take-up rates to have fallen upon the introduction of WFTC, and then to have eventually increased to above (below) their levels under FC for lone mothers (couples) if levels of entitlements had remained constant (see Adam et al (2005)).

Our model can be used to calculate the monetary value of the programme participation cost of in-work support: we calculate this as the hypothetical value of entitlement at which there is no utility change from claiming an in-work benefit. Across all lone mothers, this has a mean weekly) value of £29.55, and it is lower, on average, amongst those who are receiving than those who are not (£25.75 compared with £40.43). These averages are the unconditional expected values of η term without considering any bound on u_η discussed in Section 3. The model accurately captures the observed take-up rate in our sample of 67 per cent.

The model is less good at capturing the observed take-up rate amongst couples with children. This is mainly because, having assigned individuals in couples to one of a small set of choices of hours worked, and assigned them a weekly earnings equal to their assumed hours worked per week multiplied by their modelled hourly wage, we over-estimate the proportion of couples with children who are entitled to FC/WFTC compared to an estimate based on the observed earnings and hours worked by individuals in couples with children. Accordingly, the modelled participation rate in FC/WFTC is only 33 per cent, compared to an estimates of around 50 per cent if entitlement were estimated based on observed hours and earnings. However, it should be emphasised that our model is accurate in predicting the proportion of couples who claim FC/WFTC, and so we are confident that the simulation results that follow are accurate. Because the inaccuracy comes in estimating the proportion of families who are entitled but not receiving, it is highly likely that we over-estimate the size of the programme participation cost of FC/WFTC: amongst those who are entitled to any FC/WFTC, it has an estimated average of £72, amongst those who are receiving, £60 (as above, these are the unconditional expected values of η term without considering any bound on u_η).

4.3 Simulating the labour supply impact of WFTC

The parameters in Tables 19 and 20, 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 is that they can simulate the impact of tax and benefit changes.

As well as simulating the impact of WFTC, it is interesting 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; we have therefore simulated the impact of four reforms to the tax and benefit system:

1. replacing Family Credit as of April 1999 with WFTC as of April 2002, using parents observed in 2002/3.

2. replacing the tax and benefit system of April 1999 with the one in existence in April 2002, using parents observed in 2002/3.

3. replacing Family Credit as of April 1999 with WFTC as of April 2000, using parents observed in 2000/1.

4. replacing the tax and benefit system of April 1999 with the one in existence in April 2000, using parents observed in 2000/1.

In this paper, we focus on the first two simulations. We describe the first as being "the impact of WFTC"; however, it simulates a reform that was never actually carried out, and that is why we also report the results from the second simulation, which captures the combined impact of three years of tax and benefit reforms. The last two simulations were ones carried out in our earlier work, and we report some of these results for completeness. Full results from all simulations are available on request.

We carried out all four simulations both holding constant the level of the utility cost of receiving in-work support, and allowing it to change by the estimated parameters. The first set of simulations can be thought of as the impact of the package of reforms assuming that the estimated change in the utility cost of receiving in-work support is unconnected to the specific tax and benefit changes (*i.e.* it would have occurred had Family Credit not been replaced by WFTC); the second set have the interpretation that the move from Family Credit to WFTC directly changed the utility cost of receiving in-work support. When performing the simulations with an unchanged utility cost of receiving in-work support, we impose the utility cost of receiving in-work support estimated under WFTC on both tax systems.

The difference between the first and second reforms, and between the third and fourth reforms, represent the additional impact of the non-WFTC changes to taxes and benefits on labour supply once WFTC has been introduced. We tested whether the order in which we simulated the reforms made a difference to the results: it did not (full results available on request; such a difference might come about because WFTC interacts with the income tax and payroll tax system in the UK, and so its impact on labour supply will theoretically depend on the income and payroll tax parameters in existence at the time).

4.3.1 Lone Mothers

Table 1 and Table 2 report the impact of WFTC on the labour market choices of lone mothers.

As described in Section 3.7, the output from a simulation is a transition matrix giving the mean proportion of individuals in each cell, defined over the set of labour market choices. The full transition matrix is potentially a 12×12 matrix: six hours points, and the choice of whether to claim FC/WFTC (the actual size will depend upon eligibility at each hours point). In what follows, we report only a 3×3 matrix, with the states "non-participation", corresponding to the zero hours point, "part-time work", given by the hours points 10, 19, and 26, and "full-time work", given by 33 and 40 hours (we do not show the impact of the reforms on participation in WFTC). The diagonal elements of the 3×3 transition matrices correspond to the proportion of individuals' whose preferred labour market status does not change as we move between the two tax and benefit systems. The elements above the diagonal correspond to increases in labour supply; those below it correspond to decreases. As discussed in the start of Section 4.3, Table 1 includes the impact of the estimated change in the utility cost of claiming in-work support, and Table 2 does not.

Table 1 implies a statistically-significant increase in participation of 5.11ppt. Those entering work were split nearly equally between part-time and full-time work (2.36ppt to part-time, and 2.75ppt to full-time work). 1.10ppt of individuals moved from part-time work into full-time work, and 0.41ppt reduced their labour supply by moving from full-time to part-time work. Hours worked by lone mothers are estimated to increase by 14%, with average weekly hours worked by working lone mothers increasing by 2.7%, or 0.75 hours per worker.

A direct comparison of Table 1 and Table 2 shows the impact of the estimated fall in the utility cost of claiming in-work support on labour supply. Theoretically, the impact of such as fall on labour supply is ambiguous, just as an increase in an generosity of an in-work benefit has ambiguous effects. Our model suggests, however, that the fall in the utility cost of claiming in-work support increased the proportion of lone mothers in work

Table 1: Simulation Results, Lone Mothers, WFTC 1999-2002, change in "stigma"

		Post WFTC			
		Non Participation	Part Time	Full Time	Total
Pre WFTC	Non Participation	**49.56**	2.36	2.75	54.68
	Part Time	0.00	**22.44**	1.10	23.54
	Full Time	0.00	0.41	**21.37**	21.77
	Total	49.56	25.22	25.22	100.00

Change in participation rate	5.11	(0.68)
Average change in hours (unconditional)	1.78	(0.21)
Average change in hours (workers only)	0.75	(0.05)
Average hours under base system (unconditional)	12.42	(0.20)
Average hours under base system (workers only)	27.40	(0.16)

Estimated standard deviations given in brackets (calculated by drawing 100 times from the estimated distribution of the parameter vector). Applying grossing weights to our selected sample in 2002/3 gives a total of 1,487,345 lone mothers. This represents 81% of the total population of lone parents (see Appendix 15 for more details).

Table 2: Simulation Results, Lone Mothers, WFTC 1999-2002, no "stigma" change

		Post WFTC			
		Non Participation	Part Time	Full Time	Total
Pre WFTC	Non Participation	**49.56**	1.56	2.17	53.29
	Part Time	0.00	**23.30**	1.12	24.41
	Full Time	0.00	0.36	**21.93**	22.30
	Total	49.56	25.22	25.22	100.00

Change in participation rate	3.72	(0.70)
Average change in hours (unconditional)	1.37	(0.21)
Average change in hours (workers only)	0.69	(0.05)
Average hours under base system (unconditional)	12.83	(0.20)
Average hours under base system (workers only)	27.46	(0.16)

Applying grossing weights to our selected sample in 2002/3 gives a total of 1,487,345 lone mothers. This represents 81% of the total population of lone parents (see Appendix 15 for more details).

(by 1.39 ppts), and increased hours worked amongst those who choose to work.

The estimated preference parameters in Table 19 showed that the number of dependent children, and the age of the youngest child, are both important determinants of lone mothers' decision to work. Table 4 therefore disaggregates the simulation results on this basis, and Table 3 does the same for simulations that allow the utility cost of claiming in-work support to change. The top panels of both suggest that WFTC had a larger impact on lone mothers whose youngest child is aged 3 to 4 or 5 to 10 than it does on those whose youngest child is aged 11 or more or aged between 0 and 2. Similarly, the estimated effect is smaller for lone mothers with one child than those with more children.

Table 4 and Table 3 also summarises the result of the other three simulations (in the bottom three panels). Comparisons between the panels and between the tables show that:

- Changes to WFTC between April 2000 and April 2002 further increased the positive impact on lone mothers' labour supply beyond the changes between April 1999 and April 2000. Indeed, a comparison of the fourth and second panels of each both Table 4 and Table 3 shows us that the impact of all tax and benefit reforms between April 2000 and April 2002 was to increase, on average, the labour supply of lone mothers.

- Allowing for the non-WFTC reforms reduces the estimated positive impact on labour market participation and on hours worked. This means that the positive impact of WFTC on lone mothers' labour supply was partially offset by the contemporaneous tax and benefit reforms, both between April 1999 and April 2000, and between April 2000 and April 2002.

- In the two simulations that compare the tax system of April 2002 with that of April 1999, allowing the utility cost of in-work support to change increases the estimated positive impact on labour market participation and on hours worked. In the two simulations that compare 2000 with 1999, allowing the utility cost of in-work support to change lowers the estimated positive impact on labour market participation and on hours worked. This pattern directly reflects the estimated changes in the utility cost of in-work support shown in Table 19, which show that the utility cost rose in

2000 compared to 1999, and then fell.

Table 3: Simulation Results: Lone mothers, various reforms, change in "stigma"

		All	Age of youngest child				Number of children		
			0-2	3-4	5-10	11+	1	2	3+
WFTC, 99-02	Change in participation rate (ppt)	5.11	3.99	6.00	6.15	4.26	4.62	5.82	5.18
	Average change in hours worked								
	Unconditional	1.78	1.18	1.88	2.15	1.69	1.67	1.99	1.67
	Workers only	0.75	0.85	0.97	1.05	0.61	0.62	0.91	1.25
All, 99-02	Change in participation rate (ppt)	3.66	1.31	3.43	4.65	4.18	3.59	3.96	3.25
	Average change in hours worked								
	Unconditional	1.20	0.36	1.01	1.49	1.50	1.22	1.27	0.98
	Workers only	0.36	0.11	0.36	0.49	0.36	0.33	0.41	0.51
WFTC, 99-00	Change in participation rate (ppt)	1.84	1.15	2.08	2.39	1.58	1.59	2.18	1.95
	Average change in hours worked								
	Unconditional	0.71	0.37	0.72	0.92	0.71	0.66	0.80	0.68
	Workers only	0.43	0.37	0.58	0.57	0.34	0.39	0.45	0.69
All, 99-00	Change in participation rate (ppt)	0.60	−0.52	0.22	0.94	1.30	0.58	0.70	0.47
	Average change in hours worked								
	Unconditional	0.31	−0.11	0.14	0.42	0.62	0.33	0.33	0.24
	Workers only	0.31	0.09	0.25	0.34	0.34	0.31	0.30	0.40

Table 4: Simulation Results: Lone mothers, various reforms, no "stigma" change

		All	Age of youngest child				Number of children		
			0-2	3-4	5-10	11+	1	2	3+
WFTC, 99-02	Change in participation rate (ppt)	3.72	2.72	4.44	4.63	3.02	3.31	4.32	3.75
	Average change in hours worked								
	Unconditional	1.37	0.83	1.46	1.72	1.28	1.28	1.55	1.24
	Workers only	0.69	0.66	0.88	0.96	0.55	0.60	0.82	0.98
All, 99-02	Change in participation rate (ppt)	2.18	−0.15	1.89	3.01	2.90	2.22	2.37	1.77
	Average change in hours worked								
	Unconditional	0.77	−0.05	0.60	1.02	1.10	0.82	0.81	0.52
	Workers only	0.33	−0.04	0.28	0.042	0.33	0.33	0.34	0.31
WFTC, 99-00	Change in participation rate (ppt)	2.55	1.79	2.86	3.15	2.23	2.28	2.91	2.65
	Average change in hours worked								
	Unconditional	0.92	0.55	0.94	1.14	0.92	0.87	1.01	0.88
	Workers only	0.45	0.45	0.64	0.62	0.35	0.40	0.48	0.81
All, 99-00	Change in participation rate (ppt)	1.29	0.16	0.96	1.66	1.93	1.25	1.4	1.19
	Average change in hours worked								
	Unconditional	0.51	0.08	0.35	0.63	0.82	0.53	0.53	0.45
	Workers only	0.34	0.17	0.31	0.37	0.35	0.31	0.33	0.51

4.3.2 Individuals in couples

There are a number of ways in which our results for parents in couples can be presented. The full transition matrix is potentially 36×36. Below, we present three ways of summarising this: we look at simplified transition matrices separately for women and men, and then we display some simplified intra-family dynamics showing changes in the distribution of employment within families.

We present these tables only for the simulation that shows the impact of WFTC between 1999 and 2002. Because the estimated change in the utility cost of in-work support for couples between 1999 and 2002 is almost zero, we only show the results that allow for this change: results which hold the utility cost of in-work support constant differed in the second decimal place, if at all.

Mothers in couples

Simulation results for married women are presented in Table 5.

Table 5: Simulation Results, Mothers in couples, WFTC 1999-2002, change in "stigma"

		Post WFTC			
		Non Participation	Part Time	Full Time	Total
Pre WFTC	Non Participation	**27.79**	0.21	0.05	28.05
	Part Time	0.52	**36.62**	0.04	37.18
	Full Time	0.31	0.11	**34.35**	34.77
	Total	28.62	36.94	34.44	100.00

Change in participation rate		
Overall	-0.57	(0.06)
Partner Working	-0.64	
Partner Not Working	0.06	
Average change in hours (unconditional)	-0.17	(0.02)
Average change in hours (workers only)	-0.02	(0.01)
Average hours under base system (unconditional)	19.86	(0.09)
Average hours under base system (workers only)	27.60	(0.33)

Applying grossing weights to our selected sample in 2002/3 gives a total of 7,425,470 individuals in couples. This represents 72% of the total population of couples (see Appendix 15).

Table 5 implies that WFTC changed participation of mothers in couples by -0.57ppt, 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 (we condition upon their partner's predicted employment status before WFTC is introduced). For 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 -0.64ppt for this group. However, WFTC is predicted to increase very slightly (0.06ppt) the participation rate of women whose partners are not working.

Fathers in couples

We find that WFTC has a small net positive effect of 0.73ppt on the participation of married men (see Table 6). This includes a very small proportion of individuals (0.09ppt) who reduce their labour supply.

When we disaggregate this change by the employment status of their partner, we find that most of the movement is amongst fathers whose partner was predicted to not work without WFTC. However, our model also suggests that WFTC led to a small rise in the participation rate of men whose partners did work under FC.

Average hours worked by workers declines slightly, but average hours worked overall rises because the increase in employment dominates.

Employment patterns within families

In our model for couples, labour supply decisions are made simultaneously to maximise family utility. This raises the possibility of some interesting intra-family dynamics.

To keep the exposition as simple as possible, in what follows, we consider only whether each individual is working or not, thus giving four possible states for a couple. The 4×4

Table 6: Simulation Results: Men in couples, WFTC 1999-2002, change in "stigma"

		Post WFTC Non Participation	Participation	Total
Pre WFTC	Non Participation	**9.22**	0.82	10.04
	Participation	0.09	**89.84**	89.96
	Total	9.31	90.69	100.00

Change in participation rate		
Overall	0.73	(0.06)
Partner Working		0.19
Partner Not Working		2.11
Average change in hours (unconditional)	0.28	(0.02)
Average change in hours (workers only)	-0.03	(0.01)
Average hours under base system (unconditional)	37.65	(0.07)
Average hours under base system (workers only)	41.85	(0.02)

Applying grossing weights to our selected sample in 2002/3 gives a total of 7,425,470 individuals in couples. This represents 72% of the total population of couples (see Appendix 15).

matrix of transition probabilities is displayed in Table 7, 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, $(1, 0)$ refers to couples where only the man works, and $(1, 1)$ refers to families where both adults work.

Table 7 shows that WFTC led to a statistically-significant shift in the work status of individuals in couples so that fewer couples have no earners or two earners, and more have one earner and one full-time carer. Our model predicts a rise in the proportion of couples who have one earner of 1.12ppt, or a 4 per cent rise in the number of couples with children who have one earner and one full-time carer.

Disaggregation by number and age of children

Results that disaggregate the changes by the number of dependent children, and the age of the youngest child, are presented in Table 8. These show that the increase in labour supply amongst fathers is greater (in percentage point terms) amongst those with young

Table 7: Simulation Results: Intra-family Dynamics, WFTC 1999-2002, change in "stigma"

		Post WFTC				
		(0,0)	(1,0)	(0,1)	(1,1)	Total
Pre WFTC	(0,0)	**5.61**	0.48	0.03	0.12	6.24
	(1,0)	0.00	**21.70**	0.01	0.09	21.80
	(0,1)	0.00	0.15	**3.58**	0.07	3.80
	(1,1)	0.00	0.68	0.08	**67.40**	68.16
	Total	5.61	23.01	3.70	67.68	100.00

Change in proportion of		
Couples that are workless	-0.64	(0.07)
Couples with one earner	1.12	(0.14)
Couples with two earners	-0.48	(0.06)

Estimated standard deviations in brackets. Applying grossing weights to our selected sample in 2002/3 gives a total of 7,425,470 individuals in couples. This represents 72% of the total population of couples (see Appendix 15).

children and those with large families. Amongst women, reductions in labour supply are more likely to be found amongst those with large families, and amongst those with younger children (except for women whose partners do not work). The combined effect is that the shift towards one earner couples, from both workless and two-earner couples, is greatest (in ppt terms) amongst larger families, and amongst families with young children.

Results from other simulations

The tables so far have shown the effect of WFTC on individuals in couples. In Table 9, we show the equivalent set of results from the simulation that compares the April 1999 and April 2002 tax systems. As discussed above, because the utility cost of in-work support hardly changed between 1999 and 2002, it makes almost no difference whether we allow it to change or not when performing the simulation; we show results from the case where we do allow it to change.

In Tables 10 to 13, we show the results from simulations that compare April 1999 with April 2000, showing impacts both with and without the estimated change in the utility cost of in-work support.

Comparisons between the tables show that:

- Table 8 confirms what Table 5 and 6 showed: on average, WFTC increased labour supply (both participation rates and average hours worked) amongst men, and reduced it amongst women. However, when we add the non-WFTC reforms between 1999 and 2002, the overall effect is to reduce labour supply, on average, amongst both men and women in couples. While WFTC alone encouraged couples to have one earner and one full-time carer, all reforms between April 1999 and April 2002 encourage couples to have no or one earners rather than two (compare Tables 8 and 9).

- A similar result can be seen when looking at the impact of non-WFTC reforms between April 1999 and April 2000: the non-WFTC reforms acted to reduce labour supply of both men and women in couples, and mean that the combined impact of WFTC and other reforms is to reduce hours worked amongst parents in couples, and increase the proportion of couples with children where no adult works (compare, for example, Tables 12 and 13).

- Changes to WFTC between April 2000 and April 2002 had a similar impact on the labour supply of couples with children as did the changes between April 1999 and April 2000: the pattern of results in Table 8 is the same as that in Table 12, but with the former showing effects larger in magnitude.

- As already discussed, allowing the utility cost of in-work support to change makes almost no difference to the results of simulations that compare April 1999 and April 2002 because we estimate that the utility cost of in-work support in 2002 was almost identical to its level in 1999. This is not the case when comparing April 1999 and April 2000, however. Allowing the utility cost of in-work support to change attenuates the key results: in other words, allowing for the utility cost of WFTC to rise on its introduction reduces both the increase in labour supply amongst men and the reduction in labour supply amongst women.

Table 8: Simulation Results: Couples with children, WFTC 1999-2002, change in “stigma”

	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	0.75	1.45	1.02	0.54	0.06	0.27	0.54	2.25
Men, partner working	0.19	0.42	0.37	0.17	−0.02	0.06	0.14	0.75
Men, partner not working	2.11	2.79	2.32	1.83	0.44	1.02	1.61	4.24
Women, overall	−0.57	−0.74	−0.85	−0.60	−0.23	−0.33	−0.61	−1.02
Women, partner working	−0.64	−0.90	−0.91	−0.65	−0.26	−0.37	−0.67	−1.24
Women, partner not working	0.06	0.37	−0.32	−0.13	0.09	0.14	0.06	0.01
Change in % of families who are								
Workless	−0.64	−1.28	−0.81	−0.45	−0.10	−0.26	−0.48	−1.91
Single-earner	1.12	1.85	1.55	0.96	0.38	0.58	1.03	2.59
Two-earner	−0.48	−0.57	−0.64	−0.51	−0.28	−0.32	−0.55	−0.68
Average predicted change in hours								
Men, overall (unconditional)	0.28	0.55	0.39	0.20	0.02	0.10	0.19	0.87
Men, overall (conditional)	−0.03	−0.06	−0.05	−0.03	−0.01	−0.02	−0.03	−0.08
Women, overall (unconditional)	−0.17	−0.20	−0.26	−0.19	−0.08	−0.11	−0.18	−0.29
Women, overall (conditional)	−0.02	−0.02	−0.07	−0.03	−0.01	−0.02	−0.02	−0.06

4.4 Grossing-up our results to the population of parents

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 A.

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 14 we present our estimates of the actual change in participation rates for the main two simulations, using the sample weights contained in the FRS and assuming that those individuals dropped from our sample used for estimation do not respond to tax and benefit changes. Our simulations suggest that WFTC increased labour market participation amongst parents by 81,000 workers, two thirds of whom were women, and reduced the number of workless families with children by 99,000. However, the combined effect of all reforms between 1999 and 2002 was to increase labour market participation amongst parents by only 22,000, and reduce the number of workless families with children by 43,000.

Table 9: Simulation Results: Couples with children, All reforms 1999-2002, change in "stigma"

	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	−0.40	−0.47	−0.68	−0.50	−0.06	0.06	−0.48	−1.17
Men, partner working	−0.55	−0.79	−0.92	−0.67	−0.10	−0.06	−0.62	−1.74
Men, partner not working	−0.01	−0.06	−0.19	0.09	0.14	0.42	−0.10	−0.39
Women, overall	−0.49	−0.61	−1.13	−0.62	0.08	0.11	−0.54	−1.72
Women, partner working	−0.52	−0.68	−1.12	−0.64	0.08	0.12	−0.55	−1.94
Women, partner not working	−0.26	0.05	−1.28	−0.41	0.06	0.03	−0.40	−0.41
Change in % of families who are								
Workless	0.31	0.37	0.60	0.32	0.10	0.01	0.34	0.88
Single-earner	0.27	0.34	0.60	−0.49	−0.21	−0.18	0.34	1.13
Two-earner	−0.58	−0.71	−1.20	−0.81	0.11	0.17	−0.68	−2.01
Average predicted change in hours								
Men, overall (unconditional)	−0.21	−0.26	−0.34	−0.26	−0.06	−0.01	−0.25	−0.56
Men, overall (conditional)	−0.05	−0.08	−0.07	−0.05	−0.03	−0.03	−0.06	−0.09
Women, overall (unconditional)	−0.06	−0.11	−0.26	−0.11	0.08	0.16	−0.08	−0.48
Women, overall (conditional)	0.10	−0.08	−0.05	0.08	0.14	0.16	−0.09	−0.09

Table 10: Simulation Results: Couples with children, WFTC 1999 - 2000, change in "stigma"

	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	0.46	0.87	0.68	0.34	0.07	0.14	0.37	1.30
Men, partner working	0.19	0.33	0.36	0.20	0.04	0.08	0.16	0.62
Men, partner not working	1.05	1.46	1.20	0.76	0.20	0.36	0.84	2.10
Women, overall	−0.32	−0.43	−0.51	−0.36	−0.08	−0.20	−0.34	−0.53
Women, partner working	−0.33	−0.51	−0.49	−0.34	−0.08	−0.31	−0.20	−0.60
Women, partner not working	−0.25	0.03	−0.68	−0.51	−0.02	−0.19	−0.36	−0.25
Change in % of families who are								
Workless	−0.35	−0.72	−0.48	−0.21	−0.05	−0.10	−0.27	−1.01
Single-earner	0.56	1.00	0.79	0.45	0.11	0.26	0.50	1.24
Two-earner	−0.21	−0.28	−0.31	−0.24	−0.06	−0.16	−0.23	−0.23
Average predicted change in hours								
Men, overall (unconditional)	0.18	0.33	0.26	0.13	0.02	0.06	0.14	0.50
Men, overall (conditional)	−0.02	−0.03	−0.03	−0.02	−0.00	−0.01	−0.02	−0.04
Women, overall (unconditional)	−0.10	−0.13	−0.14	−0.11	−0.03	−0.06	−0.11	−0.15
Women, overall (conditional)	−0.02	−0.04	−0.03	−0.02	−0.01	−0.01	−0.02	−0.05

Table 11: Simulation Results: Couples with children, All reforms 1999-2000, change in "stigma"

	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	−0.73	−1.25	−0.96	−0.78	−0.03	−0.44	−0.75	−1.27
Men, partner working	−0.67	−1.25	−0.97	−0.78	−0.04	−0.38	−0.73	−1.27
Men, partner not working	−0.89	−1.26	−0.95	−0.78	0.05	−0.65	−0.80	−1.26
Women, overall	−0.53	−0.85	−0.84	−0.65	0.09	−0.17	−0.57	−1.16
Women, partner working	−0.71	−0.87	−0.79	−0.60	0.10	−0.12	−0.56	−1.20
Women, partner not working	−0.75	−0.67	−1.32	−1.09	−0.09	−0.68	−0.66	−0.96
Change in the % of families who are								
Workless	0.63	1.11	0.84	0.59	0.06	0.37	0.62	1.15
Single-earner	0.01	−0.11	0.12	0.25	−0.18	−0.13	0.08	0.12
Two-earner	−0.64	−1.00	−0.96	−0.84	0.12	−0.24	−0.70	−1.27
Average predicted change in hours								
Men, overall (unconditional)	−0.31	−0.54	−0.42	−0.33	−0.01	−0.18	−0.32	−0.54
Men, overall (conditional)	0.01	−0.02	−0.02	−0.00	−0.00	0.00	−0.01	−0.01
Women, overall (unconditional)	−0.10	−0.21	−0.17	−0.14	0.10	0.02	−0.11	−0.30
Women, overall (conditional)	0.07	0.01	−0.06	0.04	0.09	0.09	0.06	−0.04

Table 12: Simulation Results: Couples with children, WFTC 1999 - 2000, no change in "stigma"

	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	0.60	1.19	0.85	0.41	0.06	0.19	0.45	1.73
Men, partner working	0.17	0.36	0.36	0.16	−0.01	0.02	0.14	0.69
Men, partner not working	1.54	2.10	1.65	1.20	0.40	0.70	1.20	2.96
Women, overall	−0.40	−0.53	−0.60	−0.43	−0.13	−0.24	−0.41	−0.67
Women, partner working	−0.45	−0.65	−0.62	−0.45	−0.16	−0.27	−0.47	−0.78
Women, partner not working	−0.02	0.17	−0.40	−0.23	0.25	0.01	−0.09	−0.19
Change in % families who are								
Workless	−0.52	−1.05	−0.68	−0.34	−0.10	−0.20	−0.39	−1.44
Single-earner	0.84	1.43	1.10	0.70	0.27	0.46	0.75	1.82
Two-earner	−0.32	−0.38	−0.42	−0.36	−0.16	−0.26	−0.35	−0.38
Average predicted change in hours								
Men, overall (unconditional)	0.22	0.45	0.32	0.15	0.02	0.07	0.17	0.67
Men, overall (conditional)	−0.03	−0.05	−0.04	−0.02	−0.01	−0.02	−0.02	−0.06
Women, overall (unconditional)	−0.12	−0.15	−0.16	−0.12	−0.05	−0.07	−0.12	−0.18
Women, overall (conditional)	−0.01	−0.03	−0.02	−0.01	−0.01	−0.00	−0.02	−0.03

Table 13: Simulation Results: Couples with children, All reforms 1999 - 2000, no change in "stigma"

	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	−0.62	−0.66	−0.63	−0.39	0.09	−0.17	−0.40	−0.69
Men, partner working	−0.70	−0.78	−0.74	−0.48	−0.02	−0.25	−0.45	−0.87
Men, partner not working	−0.44	−0.53	−0.45	−0.13	0.60	0.05	−0.28	−0.50
Women, overall	−0.62	−0.50	−0.60	−0.41	0.02	−0.17	−0.33	−0.72
Women, partner working	−0.64	−0.63	−0.69	−0.49	−0.05	−0.21	−0.42	−0.95
Women, partner not working	−0.47	0.39	0.23	0.34	0.81	0.21	0.57	0.55
Change in % of families who are								
Workless	0.47	0.55	0.47	0.23	−0.06	0.12	0.29	0.53
Single-earner	0.30	0.06	0.29	0.34	0.01	0.10	0.15	0.35
Two-earner	−0.77	−0.61	−0.76	−0.57	0.05	−0.22	−0.44	−0.88
Average predicted change in hours								
Men, overall (unconditional)	−0.27	−0.30	−0.28	−0.18	0.03	−0.08	−0.18	−0.32
Men, overall (conditional)	−0.01	−0.03	−0.02	−0.01	−0.00	−0.01	−0.02	−0.04
Women, overall (unconditional)	−0.12	−0.12	−0.15	−0.11	0.05	−0.01	−0.07	−0.21
Women, overall (conditional)	0.07	0.02	−0.00	−0.00	0.05	0.06	0.02	−0.06

Table 14: Grossed-up Participation Responses (to nearest thousand)

	Lone Mothers	Women in couples (with children)	Men in couples (with children)	Total
WFTC, 1999 - 2002	75,000	−21,000	27,000	81,000
All Reforms, 1999 - 2002	55,000	−18,000	−15,000	22,000

5 Conclusion

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. 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.

We find that over its lifetime, WFTC increased labour supply of lone mothers by 5.11 percentage points. The effect on individuals in couples are more complicated: we find that WFTC reduced labour supply of mothers in couples by 0.57 percentage points, and increased the labour supply of fathers in couples by 0.75 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 81,000 extra workers, two thirds of whom are female, and to a reduction in the number of workless families with children of almost 100,000.

However, other contemporaneous changes to the tax and benefit system affecting families with children acted, on balance, to reduce the labour supply of parents: we estimate that the combined impact of all tax and benefit changes between April 1999 and March 2003 was to increase the labour supply of lone mothers by 3.72 percentage points, and reduce that of men and women in couples by 0.40 and 0.49 percentage points respectively; overall, these correspond to an increase in participation of 22,000 individuals, and a reduction in the number of workless families with children of 43,000. These large differences show the significance of analysing changes to the tax and benefit system as a whole.

We find that the cost of participating in the UK's in-work support programme initially rose when WFTC was introduced, perhaps reflecting a lack of information amongst families who became entitled to in-work support for the first time, but it then fell in successive years so that, by 2002, the cost of participating in WFTC was lower for lone mothers than it was under Family Credit; for couples, it was the same. These changes themselves have induced more parents to work.

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), although much of the difference is that the original study did not anticipate how generous WFTC would eventually turn out to be. Since this project began, other studies have been published which evaluate the labour market impact of WFTC *ex post* using a difference-in-difference approach. These studies are discussed in Brewer and Shephard (2004) and we do not discuss them here.

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Appendices

A 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 2002/3. This provides a sample of X 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 relatively large impact on the sample of couples with children, and a smaller impact on the sample of lone parents (see Table 15). 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 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 15 (for example, estimates of the aggregate changes in 2000/1 for lone parents would be multiplied by 1/0.83, and couples by 1/0.72).

Table 15: Sample Selection: FRS, 2002/03

	Lone Parents	Couples with Children
Total	1,834,927	10,255,272
Pensioner	10,231	84,172
Total Working Age	1,834,696	10,171,100
of whom are not working	902,791	2,093,948
of whom are working	921,905	8,077,152
Self-employed	64,378	1,747,160
F-T education	8,928	24,534
Disability benefit	134,243	770,132
SMP/SSP	17,373	203,804
Lone fathers	112,429	-
Remaining Individuals	1,487,345	7,425,470
of whom are not working	725,696	1,358,607
of whom are working	761,649	6,066,863
Remaining individuals		
Proportion of all	81%	72%
Proportion of non-pensioners	82%	73%
Proportion of non-workers	80%	65%
Proportion of workers	83%	75%

B Tables

Table 16: Distribution of childcare costs, all children

Lone Mothers		Couples with children	
Childcare band	Proportion	Childcare band	Proportion
1	55.3%	1	46.9%
2	10.3%	2	12.2%
3	10.3%	3	12.2%
4	10.3%	4	12.2%
5	10.3%	5	12.2%
6	3.6%	6	4.2%

Note: Authors' tabulations from sample described in text.

Table 17: Childcare hours model

Number of children and	Constant		Hours of mother		Working father		Number of	R^2
age of youngest child	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Observations	measure
Lone Mothers								
1 child, youngest aged under 3	8.55	1.14	0.68	0.04	-	-	345	0.46
2 children, youngest aged under 3	3.91	1.61	0.69	0.06	-	-	179	0.42
2+ children, youngest aged under 3	4.60	1.80	0.41	0.07	-	-	78	0.30
1 child, youngest aged 3 or over	7.47	0.76	0.35	0.02	-	-	1295	0.15
2 children, youngest aged 3 or over	6.95	0.74	0.20	0.02	-	-	822	0.08
2+ children, youngest aged 3 or over	4.27	1.18	0.22	0.04	-	-	290	0.10
Couples with children								
1 child, youngest aged under 3	0.16	1.83	0.76	0.02	3.72	1.73	1893	0.43
2 children, youngest aged under 3	3.58	2.40	0.52	0.02	1.10	2.31	1407	0.28
2+ children, youngest aged under 3	-2.49	2.57	0.40	0.03	4.32	2.45	404	0.25
1 child, youngest aged 3 or over	3.99	1.78	0.38	0.02	0.14	1.64	2131	0.13
2 children, youngest aged 3 or over	1.81	1.28	0.23	0.01	1.57	1.23	2962	0.12
2+ children, youngest aged 3 or over	2.18	1.80	0.15	0.02	1.01	1.67	855	0.06

Note: Authors' tabulations from sample described in text.

Table 18: Wage Equations

	Lone Mothers		Women in Couples		Men in Couples	
	Estimate	z	Estimate	z	Estimate	z
Wage equation‡						
Age Completed Education	0.069	15.490	0.087	47.690	0.069	38.540
Age§	0.110	3.560	0.119	2.550	0.054	3.810
Age Squared§	−0.242	−2.840	−0.002	−0.390	0.000	−2.360
Age Cubed§	0.176	2.310	0.000	−1.350	0.000	1.240
Non-white†	−0.015	−0.510	−0.162	−25.110	−0.388	−9.580
Home owner†	0.291	16.680	0.264	44.300	0.412	25.190
(Age - Year) Cubed§					0.000	−3.640
Constant	−1.313	−3.520	−1.931	−7.250		
Selection equation‡						
Net income at 0 hours	−0.002	−10.350	−0.001	−10.350	−0.001	−10.230
Age Completed Education	0.115	14.980	0.059	16.060	0.047	15.310
Age§	0.173	3.030	0.125	2.900	0.141	3.180
Age Squared§	−0.333	−2.060	−0.216	−1.810	−0.205	−2.170
Age Cubed§	0.162	1.090	0.043	0.400	0.000	0.790
Non-white†	−0.099	−2.160	−0.600	−20.360	−0.557	−19.030
Home owner†	0.845	29.660	0.774	39.190	1.112	37.040
(Age - Year) Cubed§					−0.000	−7.280
Constant	−5.258	−8.120	−3.517	−6.130		
Age of Youngest Child: 1†	0.283	4.070	0.316	9.730	0.015	0.330
Age of Youngest Child: 2†	0.366	5.340	0.426	12.590	0.074	1.530
Age of Youngest Child: 3†	0.519	7.500	0.487	13.630	0.131	2.510
Age of Youngest Child: 4†	0.660	9.470	0.647	17.040	0.043	0.800
Age of Youngest Child: 5†	0.739	10.310	0.864	21.110	0.041	0.720
Age of Youngest Child: 6†	0.832	11.380	0.869	20.040	0.066	1.110
Age of Youngest Child: 7†	0.886	11.810	0.991	22.530	0.111	1.830
Age of Youngest Child: 8†	0.917	11.930	1.094	23.900	0.124	2.000
Age of Youngest Child: 9†	0.853	10.940	1.148	24.390	0.053	0.840
Age of Youngest Child: 10†	0.909	11.510	1.208	24.850	0.111	1.710
Age of Youngest Child: 11†	1.038	12.610	1.286	25.510	0.190	2.820
Age of Youngest Child: 12†	1.075	12.940	1.306	25.380	0.157	2.340
Age of Youngest Child: 13†	1.194	14.030	1.358	26.160	0.298	4.260
Age of Youngest Child: 14†	1.373	15.410	1.396	25.500	0.189	2.750
Age of Youngest Child: 15†	1.347	14.580	1.520	26.750	0.344	4.700
Age of Youngest Child: 16†	1.389	14.330	1.524	25.160	0.339	4.270
Age of Youngest Child: 17†	1.569	12.990	1.558	23.390	0.263	3.180
Age of Youngest Child: 18†	1.716	11.550	1.455	18.100	0.140	1.400
Children Health Problems: 1†	−0.111	−3.520				
Children Health Problems: 2†	−0.236	−3.320				
Children Health Problems: 3†	−0.269	−1.230				
Children Health Problems: 4†	−0.218	−0.480				
No. of Children with Health Problems			−0.082	−4.760	−0.125	−5.910
Rho	0.072		0.288		0.599	
Sigma	0.456		0.513		0.501	
Lambda	0.033		0.147		0.300	
Sample size		13511		33282		33393
Censored sample		7505		10381		3188
Log likelihood		-11159		-34264		

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 †. Equations denoted lone mothers and mothers in couples were estimated by maximum likelihood, but men in couples was estimated using the Heckman two-step procedure.

Table 19: Parameter Estimates: Lone Mothers

	Parameter	Estimate	Standard Error	z	$P > \lvert z \rvert$
α_{11}:	Constant	-0.239		6.50	
	Youngest Child 0-2	0.247		4.49	
	Youngest Child 3-4	0.186		3.31	
	Youngest Child 5-10	0.009		0.18	
α_{22}:	Constant	0.234		10.05	
	Youngest Child 0-2	-0.036		0.68	
	Youngest Child 3-4	-0.134		2.46	
	Youngest Child 5-10	-0.041		1.21	
α_{12}:	Constant	-0.004		1.52	
	Youngest Child 0-2	-0.021		5.04	
	Youngest Child 3-4	-0.006		1.40	
	Youngest Child 5-10	0.001		0.18	
β_1:	Constant	0.264		14.37	
	Age (DM)	-0.054		1.76	
	Age Squared (DM)	0.007		1.79	
	Education 16	0.006		0.98	
	Youngest Child 0-2	-0.081		3.65	
	Youngest Child 3-4	-0.060		2.49	
	Youngest Child 5-10	-0.013		0.63	
	Number of Children	0.002		0.40	
	Non-white	-0.047		4.10	
	Random Term (SD)	0.000		0.000	
β_2:	Constant	-0.118		9.26	
	Age (DM)	0.101		10.20	
	Age Squared (DM)	-0.012		9.74	
	Education 16	0.028		15.86	
	Youngest Child 0-2	0.029		1.25	
	Youngest Child 3-4	0.041		1.70	
	Youngest Child 5-10	0.003		0.18	
	Number of Children	-0.006		2.66	
	Non-white	-0.003		0.59	
	Random Term (SD)	0.000		0.000	
η:	Constant	0.552		7.30	
	Observed after April 1996	0.061		0.70	
	Observed after April 2997	-0.056		0.60	
	Observed after April 1998	-0.267		2.90	
	Observed after April 1999	-0.060		0.59	
	Observed after April 2000	0.095		0.99	
	Observed after April 2001	-0.096		1.42	
	Observed after April 2002	-0.190		2.81	
	Age (DM)	-0.389		1.66	
	Age Squared (DM)	0.085		2.66	
	Education 16	0.320		6.41	
	Non-white	0.205		2.49	
	Random Term (SD)	1.077		27.07	
FC_1:	Constant	39.07		5.18	
	Youngest Child 0-2	57.80		3.28	
	Youngest Child 3-4	38.01		2.37	
	Youngest Child 5-10	9.79		0.92	
	Number of Children	6.56		1.95	
	Non-white	46.60		3.62	
	London	54.85		9.89	
	Random Term (SD)	0.000		0.000	
FC_2:	Constant	18.18		2.96	
	Youngest Child 0-2	43.38		2.09	
	Youngest Child 3-4	-0.568		0.04	
	Youngest Child 5-10	19.16		2.11	
	Number of Children	7.909		1.91	
	Non-white	-55.92		3.83	
	London	-21.26		3.23	
	Maximised Log Likelihood				-17702.4
	Observations				12729

Note: 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 20: Parameter Estimates: Couples

	Parameter	Estimate	Standard Error	z	$P > \|z\|$
α_{11}:	Constant	0.005		0.61	
	Youngest Child 0-2	−0.055		3.66	
	Youngest Child 3-4	−0.043		2.48	
	Youngest Child 5-10	−0.059		5.07	
α_{22}^{f}:	Constant	0.191		13.92	
	Youngest Child 0-2	0.040		1.93	
	Youngest Child 3-4	0.006		0.24	
	Youngest Child 5-10	−0.071		3.70	
α_{22}^{m}:	Constant	−0.098		9.44	
	Youngest Child 0-2	−0.089		6.16	
	Youngest Child 3-4	−0.063		3.42	
	Youngest Child 5-10	−0.053		3.60	
α_{22}^{fm}:	Constant	−0.053		5.56	
	Youngest Child 0-2	−0.077		5.43	
	Youngest Child 3-4	−0.075		4.31	
	Youngest Child 5-10	−0.086		6.35	
α_{12}^{f}:	Constant	−0.004		4.76	
	Youngest Child 0-2	0.000		0.24	
	Youngest Child 3-4	0.000		0.05	
	Youngest Child 5-10	0.004		3.24	
α_{12}^{m}:	Constant	−0.007		4.95	
	Youngest Child 0-2	0.007		3.36	
	Youngest Child 3-4	0.007		3.10	
	Youngest Child 5-10	0.010		5.23	
β_1:	Constant	0.320		40.15	
	Youngest Child 0-2	0.011		0.84	
	Youngest Child 3-4	0.012		0.78	
	Youngest Child 5-10	0.016		1.51	
	Mother's age (DM)	−0.259		9.02	
	Mother's age Squared (DM)	0.029		7.82	
	Father's age (DM)	0.013		0.52	
	Father's age Squared (DM)	−0.002		0.54	
	Mother's education 16	−0.040		8.97	
	Father's education 16	−0.067		14.30	
	Number of Children	0.001		0.56	
	Non-white	−0.003		0.51	
	Random Term (SD)	0.004		2.88	
β_2^{f}:	Constant	−0.103		13.89	
	Youngest Child 0-2	−0.036		3.33	
	Youngest Child 3-4	−0.034		2.63	
	Youngest Child 5-10	0.011		1.09	
	Mother's age (DM)	0.114		9.94	
	Mother's age Squared (DM)	−0.015		9.92	
	Father's age (DM)	−0.010		1.03	
	Father's age Squared (DM)	0.001		0.60	
	Mother's education 16	0.009		5.04	
	Father's education 16	0.015		7.54	
	Number of Children	−0.009		5.14	
	Non-white	0.021		4.29	
	Random Term (SD)	0.000		0.03	
β_2^{m}:	Constant	0.030		6.62	
	Youngest Child 0-2	0.031		4.61	
	Youngest Child 3-4	0.017		2.09	
	Youngest Child 5-10	0.003		0.44	

Table 20: Parameter Estimates: Couples (continued)

	Parameter	Estimate	Standard Error	z	$P > \|z\|$
	Mother's age (DM)	0.096		10.31	
	Mother's age Squared (DM)	−0.011		8.88	
	Father's age (DM)	0.004		0.48	
	Father's age Squared (DM)	−0.002		2.52	
	Mother's education 16	0.015		8.66	
	Father's education 16	0.003		1.70	
	Number of Children	−0.001		1.63	
	Non-white	−0.009		4.43	
η:	Constant	2.065		16.27	
	Observed after April 1996	−0.016		0.12	
	Observed after April 1997	−0.161		1.26	
	Observed after April 1998	−0.225		1.98	
	Observed after April 2000	0.274		2.68	
	Observed after April 2001	−0.057		0.55	
	Observed after April 2002	−0.145		1.44	
	Mother's age (DM)	0.219		0.54	
	Mother's age Squared (DM)	0.007		0.13	
	Father's age (DM)	0.393		1.19	
	Father's age Squared (DM)	−0.048		1.14	
	Mother's education 16	0.283		3.77	
	Father's education 16	0.270		3.04	
	Non-white	−0.178		2.15	
	Random Term (SD)	1.226		37.38	
FC_1^f:	Constant	4.047		1.20	
	Youngest Child 0-2	1.326		0.32	
	Youngest Child 3-4	−7.340		1.54	
	Youngest Child 5-10	−4.659		1.12	
	London	32.970		13.84	
	Non-white	47.257		11.27	
	Number of Children	2.977		2.67	
	Random Term (SD)	0.150		0.80	
FC_2^f:	Constant	15.757		6.07	
	Youngest Child 0-2	2.998		0.80	
	Youngest Child 3-4	−7.340		1.25	
	Youngest Child 5-10	−5.468		0.17	
	London	−0.593		1.65	
	Non-white	−16.166		3.56	
	Number of Children	4.156		2.81	
	Maximised Log Likelihood				-75674.9
	Observations				31403

Note: 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 21: Parameters of FC/WFTC please update to 2002/3 including the changes that happened mid-way through that year

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

Table 22: WFTC and Family Credit take-up rates

	Lone Parents		Couples	
	As % caseload	As % expenditure	As % caseload	As % expenditure
2002/3	87	92	62	76
2001/2	85	88	62	74
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 23: Sample means of main variables

Variable	Lone mothers		Couples	
	Mean	s.d.	Mean	s.d.
Greater London†	0.146	-	0.101	-
Youngest Child 0-2†	0.239	-	0.291	-
Youngest Child 3-4†	0.149	-	0.139	-
Youngest Child 5-10†	0.348	-	0.298	-
April 2000†	0.418	-	0.402	-
April 2001†	0.867	-	0.277	-
April 2002†	0.730	-	0.143	-
Non-white†	0.103	-	0.093	-
Number of Children	1.759	0.924	1.872	0.867
Female Education†	0.293	-	0.462	-
Female Age§	0.000	0.826	0.000	0.731
Female Age Squared§	0.000	5.832	0.000	5.444
Female Predicted Wage	5.402	2.262	6.384	2.969
Female Weekly Hours	12.563	16.652	19.022	16.641
Male Education†	-	-	0.401	-
Male Age§	-	-	0.000	0.780
Male Age Squared§	-	-	0.000	6.263
Male Weekly Hours	-	-	41.163	16.989
Male Predicted Wage	-	-	10.288	6.141

Derived from FRS 1994/5-2002/3 using selection criteria as detailed in Appendix 15. 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. Education variables denote post-compulsory education. Discrete variables are denoted by †.

Table 24: Predicted and Observed States: Lone Mothers

Hours Point	Observed (%)	Predicted (%)
0	55.7	56.0
10	6.2	7.6
19	11.0	7.3
26	5.5	7.8
33	6.9	7.7
40	14.8	13.6
Take-up Rate	66.5	67.3

Table 25: Predicted and Observed States: Couples, with children

Female Hours Point	Male Hours Point	Observed (%)	Predicted (%)
0	0	6.6	7.2
10	0	0.5	2.2
19	0	0.8	0.4
26	0	0.4	0.4
33	0	0.4	0.5
40	0	1.2	0.9
0	37	10.3	10.0
10	37	4.5	4.3
19	37	5.6	4.2
26	37	3.5	4.8
33	37	4.4	4.4
40	37	7.3	8.0
0	45	14.9	15.7
10	45	7.1	7.4
19	45	8.7	6.6
26	45	6.1	7.0
33	45	6.0	6.0
40	45	12.0	10.0
Take-up Rate		34.6	32.3