

Did Working Families' Tax Credit work? The impact of in-work support on labour supply in Great Britain

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Abstract

In-work benefits are promoted as a way to make low-income families better off without introducing adverse work incentives. In 1999, the structure of in-work benefits in the UK changed, and their generosity almost doubled, through the introduction of Working Families' Tax Credit (WFTC). With micro-data from before and after its introduction, a structural model of labour supply and programme participation estimates that, by 2002, WFTC had increased labour supply of lone mothers by around 5.1 percentage points, slightly reduced labour supply of mothers in couples by 0.6 percentage points, and increased the labour supply of fathers in couples by 0.8 percentage points, compared with the programme that preceded it. Other tax and benefit reforms contemporaneous with WFTC acted to reduce the labour supply of parents, though. Without any form of in-work benefit in the UK, labour force participation by lone mothers would be around 45 percent, rather than the 55 per cent we now observe. Participating in family credit, the UK's in-work programme before October 1999, conferred a utility loss as well as a utility gain from the extra income, but this utility cost of participation was lower in the final year of WFTC than under previous programmes for lone mothers, and no

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different for individuals in couples: this in itself induced more lone mothers to work.

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1 Introduction

This paper provides an evaluation of the impact of Working Families' Tax Credit (WFTC) on the labour market behaviour of families with children in Great Britain. It makes use of data from all of WFTC's 42 month history, from October 1999 to March 2003.¹

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.

Non-participation in a transfer programme is typically rationalised through some implicit utility costs of participating. Both our data and our model are uninformative about the reasons why entitled individuals do not participate, but frequently cited arguments include lack of information, hassle costs, and claimant "stigma". Regardless of its cause, non-participation in income transfer programmes, whether work-contingent or not, is important for a number of reasons. First, it indicates how well a transfer programme is

¹In April 2003, support for families with children was reformed again when Child Tax Credit and Working Tax Credit were introduced, and WFTC, amongst other things, abolished. These new credits were more generous than the programmes they replaced, and more closely integrated with the annual income tax system. This paper does not attempt, though, to examine the impact of these reforms.

reaching its intended population, assuming that the intended population is “everyone who is entitled to it”.² 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. Second, transfer programmes only affect labour supply decisions if people actually participate in the programme: estimating labour supply responses to programmes assuming full participation will over-state their actual impact on labour supply.

The WFTC programme was not the first form of in-work support in Britain: in-work benefits for families with children have existed in the UK since 1971, and WFTC replaced a programme known as Family Credit (FC).³ The two key differences between WFTC and FC were its increased generosity, and the fact that WFTC was a payable tax credit administered by the Inland Revenue, rather than a traditional income-related cash benefit, administered by the Benefits Agency. Its introduction in October 1999 provides an excellent example to investigate programme participation in transfer programmes, and to build a more accurate picture of the labour supply preferences of families with children. WFTC was a national, entitlement-based, programme - all those who apply and satisfy the eligibility conditions receive it - so there is no ideal “control” group. In addition, WFTC was introduced at the same time as other changes to the tax and transfer system affecting families with children (see Section 2.1), meaning that comparisons of the labour market performance of, say, parents and non-parents will capture the impact of more than just WFTC (we discuss this more in Section 4.4. On the other hand, a (correctly specified) structural model can be used to predict the behaviour of the sample following an arbitrary tax and benefit reform. It can therefore be used to isolate the contribution to changes in labour supply caused by replacing FC with WFTC. Furthermore, such a model allows us to estimate what labour supply would be in the absence of any in-work benefit: in other words, we can estimate the

²Although governments may deliberately allow for utility costs of participating as an additional targeting mechanism; see, for example, Yaniv (1997) and Besley and Coate (1992).

³See Blundell and Hoynes (2003) for details of in-work credits in the UK, Hotz and Scholz (2003) for a history of the Earned Income Tax Credit in the US, and Gradus (2001) for recent developments in continental Europe.

impact on labour supply not only of the actual reform in 1999 replacing FC with WFTC, but also of the WFTC programme as a whole. 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), Gong and van Soest (2002), and van Soest *et al.* (2002). This paper presents a final set of estimates, utilising data through to March 2003, the full period that WFTC was in effect. An earlier paper (Brewer *et al.* (2003)) presented interim results with data only through March 2002. In addition, this paper utilizes an improved estimation technique that reflects more realistically the interaction between programme participation and labour supply decisions.

To anticipate our conclusions, we find that WFTC increased the employment rate of lone mothers by just over 5 percentage points from a base of around 50 percent. The effect on individuals in couples with children are more complicated: we find that WFTC reduced labour supply of women in couples with children by 0.57 percentage points, and increased the labour supply of men in couples with children by 0.75 percentage points from a base of 71 percent and 91 percent respectively.⁴ 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 employment rate of lone mothers by 3.72 percentage points, and reduce that of men and women in couples with children by 0.40 and 0.49 percentage points respectively. We also find that in-work benefits play a substantial role in encouraging lone parents to work: our model suggests that, without WFTC, employment rates amongst lone mothers would be 43%, rather than 55%, with much smaller impacts on two-adult families with children. The parameter estimates suggest that the implicit 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

⁴Here and throughout, "children" means children aged under 16, or aged under 19 and in full-time education: this matches the definition used in much of the UK's tax and transfer system. "Parents" is used as a short-hand for the adults who have responsibility for these children, irrespective of their biological relationship.

cost of participating in WFTC was lower for lone mothers than it was under Family Credit; for couples, it was the same.

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. 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. These simulation results are also compared to the findings of other studies. Section 5 concludes.

2 The WFTC reform

2.1 Changes to support for families with children since 1999

Working Families' Tax Credit (WFTC) was introduced in October 1999, replacing a programme called Family Credit (FC), and it 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. Cohabiting couples were assessed jointly; formal marital status was irrelevant. Families fulfilling the work condition (to be eligible, a family needs to contain an adult who works 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 after-tax income.⁵ This threshold in WFTC is only slightly higher than the point at which workers are liable to income tax and national insurance contributions (payroll tax), and so many recipients of WFTC would find that each pound of earnings increased their net income by only 31 pence.⁶

WFTC was more generous than FC in five ways: it had higher credits, particularly those for young children; families could earn more before the credit was phased out; it had

⁵For many decades, the UK's tax credit and welfare benefits have made use of rules relating to the weekly hours worked by individuals. The hours conditions in welfare benefits and in-work support are aligned at 16 hours a week so that low-income families with children can never be eligible for both. This fact, combined with the 100 per cent withdrawal rate of welfare benefits, means that the majority of welfare recipients in the UK do not work.

⁶Brewer (2001) has more details of these effective marginal tax rates

Table 1: Parameters of FC/WFTC

	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

a lower withdrawal (phase out) rate; it had a significantly different system for supporting formal childcare costs, with a payable childcare tax credit of up to 70% of costs incurred (up to £150 a week for families with two or more children of any age); and all child maintenance payments from non-resident parents were disregarded as income. These factors meant that spending on WFTC rose to £4.6 billion by 2000/1 and £6.3 by 2002/3 compared to £2.4 billion on Family Credit in 1998/9 (all in cash terms; real rises of 85 % and 140 % using GDP deflators; see Figure 2.1 in Brewer and Browne (2005) for a longer time-series), and there was no attempt by the government to present the reform as revenue neutral. The key administrative changes from FC were two-fold. First, WFTC was administered by the tax authority (the Inland Revenue) rather than the organisation that administered welfare benefits (the Benefits Agency). Second, while FC was paid direct to recipients as a cash benefit, WFTC was paid by employers through the wage packet (unless a couple with children collectively decided that the non-working adult should be paid WFTC). The stated 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.⁷

WFTC, though, is by no means the whole story, when considering how labour supply

⁷See Brewer and Shephard (2004) and references therein.

is affected by tax and transfers. During the period under consideration, there were three other main ways that the UK tax and transfer system provided financial support to adults with dependent children: a flat-rate payment to all families unrelated to their income (known as child benefit); child allowances in welfare benefits (known as income support for lone parents, and income-related Jobseekers Allowance for couples); and a non-refundable income tax credit for parents (known as the children's tax credit).⁸

Furthermore, the tax and transfer system affecting low-income families with children experienced almost continual change between 1999 and 2003.⁹ The three main changes were: tax cuts, particularly for low-income taxpayers, through a cut in the basic rate of income tax from 23% to 22% and a real rise in the point at which payroll tax is payable; further real increases to entitlements to WFTC at several points between 2000 - 2002; large real increases in welfare benefits, particularly for those with children under 11.

The last of these is particularly important, and means that the recent UK experience of welfare reform affecting lone parents is very different from that of the US. Simplifying enormously, the US strategy in the 1990s combined an increased earned income tax credit with changes that made it harder for families to claim welfare (whether through time-limits, work requirements or sanctions) in order to produce a substantially stronger financial incentive for lone parents to work.¹⁰ On the other hand, the UK increased welfare benefits and in-work benefits for lone parents by similar amounts, and made hardly any changes to the rules surrounding welfare benefits: in the UK, lone parents remain free to claim welfare benefits with no obligation to engage in job search, education or work-related activities until their youngest child reaches 16.

⁸See Adam *et al.* (2002) for more details on child-contingent transfers in the UK. Some families also received other means-tested benefits providing assistance with rental housing costs and local taxes (known as housing benefit and council tax benefit respectively), and these interacted with WFTC in a way that meant that families receiving these other benefits gained less from the WFTC reform than otherwise-equivalent families not receiving these benefits.

⁹There were also some important changes between 1997 and 1999 which are not considered in this paper, such as a new 10% starting rate of income tax, reforms to national insurance contributions (payroll tax), and the introduction of a minimum wage. As stated above, we do not consider the changes in 2003.

¹⁰see Dickens and Ellwood (2003).

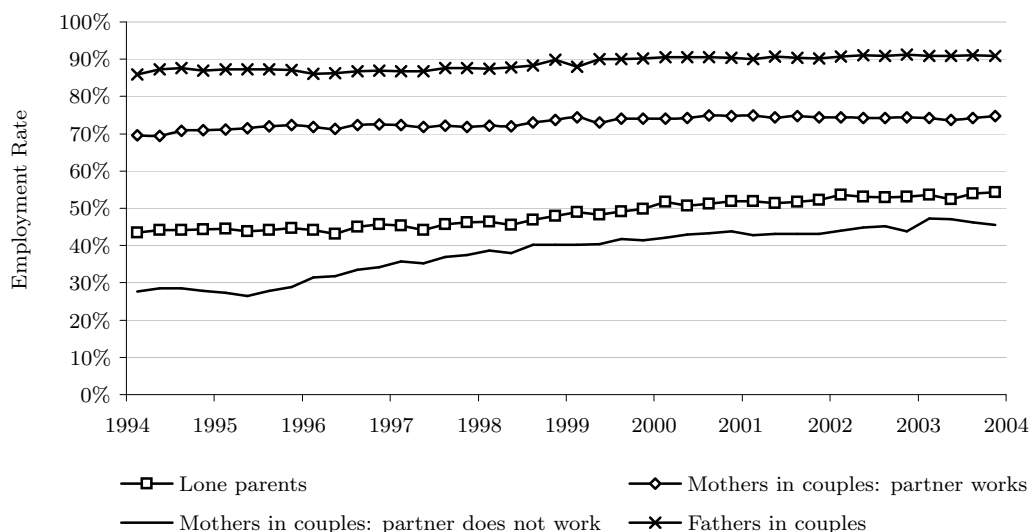
2.2 What was expected to happen when WFTC was introduced? What did happen?

Replacing FC with WFTC affected work incentives in complicated ways. For lone parents who were working fewer than 16 hours a week (including those doing no work at all), the introduction of WFTC unambiguously strengthened their financial incentive to work 16 or more hours a week. The effects on labour supply, though, were ambiguous for those who were previously receiving FC: the increased generosity of WFTC creates an income effect to reduce labour supply (but not below 16 hours a week), while the lower withdrawal rate creates a substitution effect that favours work. The newly-entitled individuals - those previously too rich to claim FC but poor enough to claim WFTC - see a worsening of incentives with both income effect and substitution effects acting to reduce labour supply (not below 16 hours a week). Couples with no earners will face an increased incentive to have at least one individual in work; second earners in couples will face an income effect away from work, since either the increased generosity of WFTC or new-found eligibility will raise family income. The direction of the substitution effect depends on whether the couple was previously receiving FC.

Changes in employment rates for parents are shown in Figure 1, taken from 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 a substantial increase in the proportion of lone parents working (albeit from a low base by international standards), rising from 43 to 54 per cent, and a (smaller) rise in the proportion of women in couples with children who work, concentrated among women whose partner is not working. The employment rate for men in couples with children has risen very slightly.

The number of recipients of in-work support increased markedly upon the introduction of WFTC, and continued to rise thereafter, at a much faster rate than seen under FC (see Inland Revenue, 2002). A year after its introduction, caseload had risen by 39%, although this reflects both the increased generosity that made more families entitled, as well as

Figure 1: Employment rate of parents



any moves from welfare to 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 (see DWP (2002)). Overall, the number of children in families on either out-of-work welfare benefits or FC/WFTC increased in the first two years of WFTC.¹¹

Official estimates of the programme participation rates for the main means-tested benefits in the UK are shown in Table 2. The Table shows that participation rates for WFTC have risen since 2000/1, so that, by 2001/2, participation in WFTC was higher amongst lone parents 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).

Table 2 also compares official estimates of participation in in-work benefits to welfare benefits in the UK: participation rates are higher (much higher for couples) for welfare benefits (ie, income support, income-related jobseekers allowance, and housing benefit) than for in-work benefit programmes (ie, family credit and WFTC): amongst lone parents, participation in welfare benefits is almost universal. It is this empirical finding that leads us to specify a structural model in 3.1 in which there is full participation in welfare benefits,

¹¹See Table 3 in Brewer, Clark and Wakefield (2002).

Table 2: Participation rates in welfare benefits and in-work benefits in the UK

	Lone Parents			Couples		
	FC/WFTC	IS	HB	FC/WFTC	IS	HB
2002/3	87	97	96	62	92	85
2001/2	85	97	98	62	93	85
2000/1	80	97	98	51	93	92
1998/9	81	98	99	58	92	93
1997/8	77	98	99	62	92	90
1996/7	81	98	99	68	94	92
1995/6	80	99	99	62	97	96
1994/5	80	98	99	61	93	91
1993/4	77	96	95	66	89	92

Notes: Figures shown are mid-points of stated ranges. Excludes full-time self-employed. No statistics available for FC or WFTC for 1999/2000.

Source: Inland Revenue (2002) and DWP (2001) and previous editions.

yet incomplete participation in in-work benefits. These surprisingly high participation rates might be explained by the lack of conditions that apply to welfare programmes in the UK: compared with other countries, the asset tests are minimal (and based on liquid financial assets only), and couples where one partner has a disability and all lone parents remain free to claim welfare benefits with no obligation to engage in job search, education or work-related activities until their youngest child reaches 16.

3 Methodology

3.1 A model of labour supply and programme participation

Our model, which is presented in more detail in Brewer *et al.* (2005), 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.

Separate models are estimated for lone mothers and couples: the detail of the former is given here, and that of the latter in Brewer *et al.* (2005). Individuals are assumed to maximise their utility function $u(h, y)$ subject to a budget constraint, determined by a fixed hourly wage and the tax and benefit system. The utility function is approximated with a second degree polynomial expansion in hours of work and net income. Given the considerable non-convexities in the budget constraint generated by the tax and transfer system, individuals are assumed to choose from a small subset of hours $\mathbf{h} = \{0, 10, 19, 26, 33, 40\}$, corresponding to the hours ranges 0, 1-15, 16-22, 23-29, 30-36 and 37+ respectively.¹² For each choice of hours, there is also an additive stochastic component ε_h assumed to follow a standard (Type-I) extreme-value distribution. This assumption is common: see Blundell *et al.* (1999) and Keane and Moffitt (1998). van Soest *et al.* (2002) discuss some possible interpretations of the errors (unobserved alternative-specific utility components, or errors in perception of the alternatives' utilities, for example); their main advantage is in providing positive probabilities that are continuous in the parameters.

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

From this net income measure we deduct unobserved fixed work-related costs and childcare expenditure costs, and denote this new income measure as $\tilde{y}_{h,P} = \tilde{y}_h + P \cdot \Psi_h$. Note that we are assuming that childcare expenditure does not depend upon whether or not the individual participates in FC/WFTC for a given choice of hours.

Fixed work-related costs are the actual and psychological costs that an individual has

¹²Blundell and MaCurdy (2000) give the arguments for modelling labour supply with a discrete choice model: the main advantage is that it easily permits the highly non-convex budget constraints created by welfare benefits and in-work support.

to pay to get to work. They are modelled as a fixed weekly cost at positive values of working time, with an additional cost if individuals work 30 or more hours.¹³ 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. We follow Blundell *et al.* (1999, 2000) by allowing for childcare costs explicitly, assuming a linear relationship between hours of childcare per child and hours of work h . This relationship is allowed to vary with the number and age of children.¹⁴ Finally, incomplete programme participation in WFTC is rationalised with (additive) costs to participating, η .

Incorporating all these features of the model, the utility function is:

$$\begin{aligned} u(h, \tilde{y}_{h,P}, P) &= U(h, \tilde{y}_{h,P}) - \eta \\ &= \alpha_{11}\tilde{y}_{h,P}^2 + \alpha_{22}h^2 + \alpha_{12}\tilde{y}_{h,P}h + \beta_1\tilde{y}_{h,P} + \beta_2h - P \cdot \eta \end{aligned} \quad (1)$$

Heterogeneity enters in several places. The programme participation cost is assumed to be $\eta = X_\eta\beta_\eta + u_\eta$, where X_η reflects demographic and other household characteristics, and u_η unobserved heterogeneity. Similarly, observed heterogeneity affects all the α and β parameters, the childcare expenditure costs, and the fixed work-related costs. Unobserved heterogeneity affects the linear income and hours terms, childcare expenditure costs, and work-related costs, denoted by u_y , u_h , u_{cc} and u_f respectively.

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

¹³Empirically, 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 Meyer (2004)).

¹⁴As a first approximation, the relationship is estimated 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 conditional on their labour supply.

equivalent to the condition $u_\eta < \Omega_U$, where:

$$\Omega_U = U(h_j, \tilde{y}_{h_j} + \Psi_{h_j}) - U(h_j, \tilde{y}_{h_j}) - X_\eta \beta_\eta \quad (2)$$

Given our assumptions concerning the distribution of the additive state specific error ϵ_h we are able to derive an explicit expression for the choice probabilities. For given random components $\mathbf{u} = (u_w, u_y, u_h, u_{cc}, u_f)$ this is given by:

$$\Pr(h = h_j, P = p | \mathbf{X}, \mathbf{u}) = \frac{\exp\{u(h_j, \tilde{y}_{h_j} + p \cdot \Psi_{h_j}, P = p)\}}{\sum_{k=1}^J \max[\exp\{u(h_k, \tilde{y}_{h_k}, P = 0)\}, E_{h_k} \cdot \exp\{u(h_k, \tilde{y}_{h_k} + \Psi_{h_k}, P = 1)\}]} \quad (3)$$

Where E_h is an indicator equal to one if the individual is entitled to in-work support when working h hours. Letting $\mathbf{u}_{-u_\eta} = (u_w, u_y, u_h, u_f, u_{cc})$ and using equation (3), the log-likelihood function may then be written as:

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

In estimation, the integrals in the log-likelihood are approximated using simulation methods (see Train (2003)), integrating out the random preferences by drawing a number of times from the distribution (we use 10 draws), and computing the mean pseudo-likelihood

across these realisations. The unobserved preference heterogeneity terms are assumed independently normally distributed, and we approximate the distribution of childcare prices with 6 discrete mass points.¹⁵ 10 draws is fewer than other studies that have used simulated ML, but this partially offset by our relatively large sample (13,000 lone parents, 70,000 adults in couples). Having conditioned on a first-stage estimation of wage rates, the standard deviation of the wage disturbance is fixed at the first-stage estimate, 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.¹⁶

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 women choose between 5 states with positive hours of work; FC/WFTC participation costs are identified 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 programme in participation costs.

¹⁵Blundell *et al.* (1999) discuss the possibility of allowing for correlation among the unobservable components in their discrete model of labour supply, and the considerable difficulty in practice in identifying them.

¹⁶In Keane and Moffitt (1998), both the standard deviation of the extreme value errors and one other parameter are fixed in a way that makes the extreme value error “small” so that it acts as a numerical smoothing device, rather than a feature of the structural model; we do not adopt this approach.

3.2 Simulating policy reforms

The estimated parameters can be used to simulate the impact of policy reforms. The first step is to estimate a choice probability distribution (over the combination of hours and programme participation) for each individual under a given tax and transfer system: we do this by numerically averaging over the unobserved components in the model. To simulate the impact of a change in the tax and benefit system, we use the same numerical draws to compute the choice probabilities under both tax and benefit systems, and combine these into a matrix of transition probabilities over the choices. This gives us the (estimated) expected value of the transition matrix given the parameter estimates, where the expectation is over all random components. Confidence intervals around these expectations can be estimated, reflecting that the parameters in our model are not known with certainty, by repeatedly drawing from the estimated asymptotic distribution of the parameters, and re-calculating the expected value of the transition matrix. These standard errors are typically found to be very small (see Table 4 for lone mothers): this apparent precision in the simulated responses to a policy reform (which is only valid if our model is correctly specified) reflects that the 40 or so structural parameters are estimated relatively accurately with our large sample. Given this, most of the standard errors associated with the simulated policy reforms are omitted from the presentation of results for brevity.

4 Labour supply estimates, and results of policy simulations

4.1 Data

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

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.¹⁷ 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.¹⁸

4.2 Results

There are three first stage regressions: a wage equation, an equation describing childcare use, and an estimated distribution of the price of childcare: these are outlined in the appendix.

The main preference parameter estimates are presented in Table 19 and 20 of Brewer *et al.* (2005), and are briefly discussed below. Amongst lone mothers, the (unobserved) fixed costs of working are estimated to be higher amongst those with younger children, increasing in the number of children, and much higher for individuals from an ethnic minority or who live in Greater London. The mean work-related costs for individuals who do not work is £89 a week, compared with £68 for working lone mothers; this reflects a difference in observable characteristics, not selection on unobservables. The determinants of work-related costs for women in couples are qualitatively similar, but lower on average (for part-time work, the mean fixed cost is £24 a week for mother who are not working, and £17 for those that do work).

Both the linear coefficients for income and hours are allowed to vary with the number of children, the age of the youngest child, the parents' age, remaining in education beyond the compulsory school leaving age, and with being from an ethnic minority; age of youngest

¹⁷A sample selected solely on age led to simulated responses to WFTC that were little different.

¹⁸Section 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.

child also affects the quadratic terms. There is greater preference for income, and less desire to work, the greater the number of children. 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. 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 ethnic minority couples have a stronger preference for hours worked; both of these effects are highly significant (the ethnic origin of non-white couples with children in Great Britain tends to be different from that of non-white lone parents). There is a weaker desire to work, the greater the number of children.

These estimated parameter values are broadly consistent with economic theory: 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 hours of work.

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. More importantly, there is strong evidence of changes over time: for lone mothers, the programme participation cost is estimated to have risen in April 1996, before falling in every successive year except the first full year of WFTC, when it rose. While only two of these year-on-year changes are individually significantly different from zero, the programme participation cost is significantly different (lower) from its April 1995 level in every year since 1998. We cannot reject the hypothesis that the programme participation cost of WFTC in its first two years (2000 and 2001) was the same as in the last year of FC (1998), but the participation cost in 2002 is significantly different (lower) at the 10% level.

We also find evidence of a general decline in the programme participation cost over time

amongst couples with children, although most of the year-on-year variation is 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, when it is lower). 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. Unlike lone mothers, we find that the programme participation cost of WFTC in 2000 and 2001 was significantly higher than that of the last year of FC, but, by 2002, we cannot reject the hypothesis that they are the same.

Table 3 compares the actual hours distribution with the predicted distribution, mean weekly hours worked, and the FC/WFTC programme participation rate in the first and last years of our sample. The model is able to capture the rise in labour force participation, mean hours worked and programme participation, although it is not completely accurate at predicting the distribution of hours worked amongst those who are in work.¹⁹

Table 3: Lone mothers, distributions of predicted and actual hours

	1995 actual	1995 predicted	2002 actual	2002 predicted
Not working	63.1	62.0	48.2	49.6
1 -15	6.7	8.0	4.6	7.6
16-22	7.4	6.4	14.8	8.4
23-29	4.5	6.8	6.9	9.0
30-36	6.9	6.2	8.5	9.2
37+	11.4	10.6	17.1	16.1
Average hours worked	10.0	10.1	15.2	14.2
FC/WFTC participation rate	62.0	59.0	74.0	77.0

Note: Authors' calculations from the FRS; see text for details of sample selection and labour supply model.

¹⁹Some studies that use discrete models of labour supply to simulate the labour supply response to tax changes advocate a form of calibration to ensure that the predicted distribution of hours matches the observed distribution of hours when performing simulations: see Creedy and Kalb (2005). Such calibration made almost no difference to our simulations of the impact of WFTC on the labour supply of lone mothers.

4.3 Simulating the impact of WFTC

As Section 2 argued, the ongoing changes to the tax and transfer system affecting low-income families with children through 1998 to 2003 make it very difficult to point to a stable post-reform period, and so this paper presents several simulation results. The specific reforms that we simulate are:

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.
5. removing (not replacing) WFTC as of April 2002 from the tax and benefit system of April 2002, using parents observed in 2002/3.

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 report the results from the second simulation, which captures the combined impact of three years of tax and benefit reforms. We also report the impact of the first year of WFTC, because there were substantial increases in the generosity of WFTC after its introduction. 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.

Finally, we simulate the impact of entirely removing WFTC from the tax and transfer system, although this reform is anything but a marginal change, and is akin to an out-of-sample prediction. In all simulations, we estimated a variant that held constant the cost

of participating in FC/WFTC: this can be thought of as the impact of some set of reforms assuming that the estimated change in the FC/WFTC participation cost between 1998 and 2002 would have occurred had Family Credit not been replaced.

4.3.1 Lone mothers

Table 4 shows the transition matrix for lone mothers after replacing Family Credit (as of April 1999) with WFTC (as of April 2002) with the states “not working”, “part-time work” (between 1 and 29 hours a week) and “full-time work” (30 or more hours a week). There is a statistically-significant 5.11ppt rise in the proportion working (from a base of 45.32%). 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 are estimated to increase by 14%, with average weekly hours worked by those working increasing by 2.7%, or 0.75 hours per worker. Disaggregating the simulation results shows that WFTC had a larger impact on lone mothers whose youngest child is aged between 3 and 10 than it does on those whose youngest child is either younger or older. Similarly, the estimated effect is smaller for lone mothers with one child than those with more children: see Table 3 of Brewer *et al.* (2005).

Summary results from this and simulations of other reforms affecting lone mothers are shown in Table 5. The initial impact of WFTC is simulated to increase the proportion working by 1.84ppt: nearly two-thirds of the overall impact of WFTC was due to changes made after its introduction. The non-WFTC reforms affecting lone parents in this period acted to reduce labour supply: those between April 1999 and April 2002 reduced the positive employment impact by 1.45ppt, with the most important change being the increases to welfare benefits (see Section 2.1).

The table also presents results when programme participation costs are held constant (in other words, that assume that the estimated change in programme participation costs was not caused by the WFTC reform). In the simulations that compare the tax system of 2002 with that of 1999, allowing the utility cost of in-work support to change increases

Table 4: Lone Mothers, WFTC 1999-2002

		Post WFTC			
		Not working	Part Time	Full Time	Total
Pre WFTC	Not working	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 employment 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)

Note: Authors' calculations from the FRS; see text for details of sample selection and labour supply model. Estimated standard deviations given in brackets (calculated by drawing 100 times from the estimated distribution of the parameter vector)

Table 5: Simulation results: lone mothers, various reforms

	WFTC 99-02	WFTC 99-00	All Reforms 99-02	All Reforms 99-00	Abolish WFTC
<i>Change in employment rate (ppt)</i>					
Change in WFTC participation costs	5.11	1.84	3.66	0.60	-11.45
No change in WFTC participation costs	3.72	2.55	2.18	1.29	
<i>Change in average conditional hours</i>					
Change in WFTC participation costs	0.75	0.43	0.36	0.31	-1.02
No change in WFTC participation costs	0.69	0.45	0.33	0.34	
<i>Change in average unconditional hours</i>					
Change in WFTC participation costs	1.78	0.71	1.20	0.31	-3.62
No change in WFTC participation costs	1.37	0.92	0.77	0.51	

Note: Authors' calculations from the FRS; see text for details of sample selection and labour supply model. The simulated employment rate, and average level of conditional and unconditional hours in April 2002 for lone mothers was 50.44%, 28.15 hours and 14.20 hours respectively.

the estimated positive impact on employment and on hours worked, but in those that compare 2000 with 1999, allowing the utility cost of in-work support to change lowers the estimated positive impact on employment and on hours worked: this pattern directly reflects the estimated changes in the costs of programme participation, which show that the programme participation cost initially rose when WFTC was introduced, and then fell.

The final simulation removes WFTC from the tax and transfer system of 2002/3: this is predicted to reduce the employment rate by 11.45ppt, and lower conditional and unconditional hours of work. The magnitude of this estimate is line with expectations given that WFTC cost over twice as much as FC by 2002.

4.3.2 Couple families with children

Table 6 presents results for adults in couples with children.²⁰ WFTC is predicted to have reduced the employment rate of women in couples very slightly, with a change of -0.57ppt from a base of 71.95%. This result was the net impact of two offsetting factors: WFTC is simulated to have increased the employment rate of for women whose partner is not working very slightly (+0.06ppt), but to have reduced the proportion working amongst women whose partner is in work (-0.64ppt). For men in couples, the WFTC is simulated to have increased the employment rate by 0.75ppt from a base of 89.96%; as with women, the positive impact comes from those men previously not working whose partner does not work (+2.11ppt).

Table 6 compares this with the other simulations. As with lone mothers, the magnitude of the simulated changes to WFTC in its final year is greater than those to WFTC in its first year; unlike with lone mothers, none of the changes in labour supply is large, and they are smaller for women than men. As with lone parents, the non-WFTC reforms acted to offset the change in labour supply due to WFTC; the most important of these non-WFTC changes was the increase in the generosity of welfare benefits, available in the UK to both two-parent families with children and lone parents. The table also gives results when

²⁰Selected transition matrices, together with some more detailed results and disaggregations, are presented in Tables 5-13 of Brewer *et al.* (2005).

programme participation costs are held constant (in other words, that assume that the estimated change in programme participation costs was not caused by the WFTC reform): this has no impact on the simulations in 2002, because our estimates are that the cost of participating in WFTC in 2002 were the same as participating in FC in 1999.

Finally, the simulations suggest that abolishing WFTC completely would reduce the employment rate of fathers in couples by 1.10ppt, and increase the employment rate of mothers in couples by 0.73ppt. The magnitude of these employment changes is about 140% of the impact of those due to the incremental reform between April 1999 and April 2002. The provision of in-work support seems much less important in encouraging labour supply from individuals in couples with children than it is for lone mothers, although it is still a potentially important redistributive tool.

4.3.3 Aggregate responses: by how much did employment rise?

We can estimate the change in aggregate labour market participation amongst adults with dependent children caused by WFTC, by using the sample (grossing) weights in the original survey, and by assuming that those individuals excluded from our estimates do not respond at all: see Table 7. Our simulations suggest that WFTC increased labour market participation by 81,000 workers, two thirds of whom were women. However, the combined effect of all tax and benefit reforms between 1999 and 2002 was to increase labour market employment amongst parents by only 22,000 (less than 0.1 percent of the UK workforce), primarily because WFTC was only part of a concerted anti-poverty package that included large increases in welfare payments to one-adult and two-adult families with dependent children.

4.4 How do these responses compare with other studies?

Given our estimates of the labour supply impact of WFTC come from a structural model, it is important to ask how they compare to other studies. There are three types of studies that we can compare these results to:

Table 6: Simulation Results: Couples with children

	WFTC 99-02	WFTC 99-00	All Reforms 99-02	All Reforms 99-00	Abolish WFTC	
Mothers in couples	<i>Change in employment rate (ppt)</i>					
	Change in WFTC participation costs	-0.57	-0.32	-0.49	-0.53	0.73
	No change in WFTC participation costs	-0.57	-0.40	-0.49	-0.62	
	<i>Change in average conditional hours</i>					
	Change in WFTC participation costs	-0.02	-0.02	0.10	0.07	0.01
	No change in WFTC participation costs	-0.02	-0.01	0.10	0.07	
	<i>Change in average unconditional hours</i>					
	Change in WFTC participation costs	-0.17	-0.10	-0.06	-0.10	0.20
	No change in WFTC participation costs	-0.17	-0.12	-0.06	-0.12	
Fathers in couples	<i>Change in employment rate (ppt)</i>					
	Change in participation costs	0.75	0.46	-0.40	-0.73	-1.10
	No change in participation costs	0.75	0.60	-0.40	-0.62	-1.10
	<i>Change in average conditional hours</i>					
	Change in participation costs	-0.03	-0.02	-0.05	0.01	0.06
	No change in participation costs	-0.03	-0.03	-0.05	-0.01	0.06
	<i>Change in average unconditional hours</i>					
	Change in participation costs	0.28	0.18	-0.21	-0.31	-0.41
	No change in participation costs	0.28	0.22	-0.21	-0.27	-0.41

Note: Authors' calculations from the FRS; see text for details of sample selection and labour supply model. The simulated employment rate, and average level of conditional and unconditional hours in April 2002 for mothers in couples was 71.38%, 27.58 hours and 19.69 hours respectively. The respective figures for fathers in couples were 90.69%, 41.82 hours and 37.93 hours.

Table 7: Grossed-up employment responses

	Lone mothers	Mothers in couples	Men in couples	Total number
WFTC, 1999 - 2002	75,000	-21,000	27,000	81,000
All Reforms, 1999 - 2002	55,000	-18,000	-15,000	22,000

Note: Authors' calculations from the FRS; see text for details of sample selection and labour supply model. Based on grossing weights supplied with the data, and rounded to the nearest thousand.

1. ex ante estimates of the impact of WFTC, also based on a structural model of labour supply.
2. ex post estimates of the impact of WFTC, exploiting the natural experiment.
3. estimates of the impact of in-work benefits in other countries.

We explore these below.

4.4.1 Ex ante evaluations of WFTC

Blundell *et al.* (1999, 2000) (hereafter BDMM) undertake an ex ante evaluation of WFTC, using a methodology which this study has developed. The two key differences between BDMM and this paper are that:²¹

- BDMM estimate the model using data collected before WFTC was introduced. As a consequence, they assumed that the utility cost of participating in WFTC would be no different from that of FC; this paper uses data from before and after WFTC, and so can estimate the change in the utility cost of participating in WFTC.
- BDMM estimated the labour supply response to the WFTC as introduced in October 1999; this paper estimates the response to the more generous WFTC of April 2000 and April 2002.

BDMM concluded that WFTC would increase labour market participation of lone mothers by 2.2 percentage points, and reduce the labour market participation of mothers in couples by 0.6 percentage points, and have no net effect on men in couples. We estimated our labour supply model only on data observed before WFTC, and simulated the impact of WFTC as introduced in October 1999 assuming no change in the utility costs of participating in FC/WFTC in an attempt to replicate the simulations in BDMM: this concluded that the WFTC would increase labour market participation of lone mothers by 2.7 percentage points, and the closeness of these two results suggests that the main reasons for the difference in the main conclusions of the two papers are that BDMM could not predict

²¹There are also small differences in the stochastic specification and choice of explanatory variables.

the change in the utility cost of participation, nor that WFTC would become even more generous so soon after its introduction. It also highlights the advantage of ex post studies: they allow changes in programme participation costs to be identified from the data, and these changes appear particularly important empirically for lone mothers in the UK.

An earlier version of this paper (Brewer *et al.* (2003)) presented estimates of the impact of WFTC on lone mothers' labour supply that were slightly larger than those reported here. The differences partly arise from changes to the stochastic specification, but are mostly arise because the pattern of changing programme participation costs over time (discussed in Section 4.2) had not been estimated in Brewer *et al.* (2003).

4.4.2 Other ex post evaluations of WFTC

Other studies have evaluated the labour market impact of WFTC and contemporaneous reforms, making use of a natural experiment design. Those available at the time of writing are:

- Blundell *et al.* (2005) (hereafter BBS)
- Francesconi and van der Klauw (2004) (hereafter FvdK)
- Leigh (2004) (hereafter Leigh)
- Gregg and Harkness (2003) (hereafter GH).

BBS and Leigh examine the impact on lone parent and two-parent families; FvdK and GH examine only lone parent families. All papers identify the impact of WFTC and related reforms by comparing (changes in) labour market outcomes of adults with dependent children with (changes in) labour market outcomes of adults without; the studies vary in their choice of data-sets, timeframe, and explanatory variables. An important point that follows from this evaluation design is that these studies cannot be informative about the impact of WFTC: they can tell us only about the combined impact of WFTC and contemporaneous changes in the tax and benefit and welfare systems affecting families with children.

The headline estimates of the size of the impact of WFTC and contemporaneous changes on the labour market participation of lone parents varies across these studies from 1 ppt to 7 ppt; the comparable estimates from this paper lie comfortably in the middle of this range: Table 5 reported that WFTC and related reforms are estimated to have increased lone mothers' labour supply by 0.6 ppt by 2000 and 3.7 ppt by 2002. A careful comparison of these studies is provided in Brewer and Browne (2005), which concludes that much of the large differences in the headline estimates can be explained in the choice of time periods studies (because the impact of WFTC on lone parents' labour market participation grew over time as it became more generous) and choice of outcome variable (working at all versus working 16 or more hours a week; the impact of WFTC on the latter will always be greater, because the design of WFTC means that it never encourages lone parents to work fewer than 16 hours a week).

4.4.3 Evaluations of other in-work benefits

The most comparable in-work benefit to the WFTC, and one whose labour supply impact has been evaluated with comparable techniques, is the earned income tax credit (EITC) in the US. How do the results in this paper compare to what is known about the EITC? There is, of course, no reason to expect similar behavioural responses to different in-work benefits from two different groups in different labour markets; one very important difference between WFTC and EITC is that per-family expenditure on WFTC is around four times as high as it is for EITC: see Figure 10 of Brewer (2001).

A thorough review of studies of the impact of EITC on labour force participation (LFP) is found in Hotz and Scholz (2003), especially Table 3.4. Several studies have found that increases in the generosity of the EITC increased LFP amongst lone parent families. The most comprehensive study of the impact on adults in two-adult families with children found that EITC expansions slightly increased LFP amongst men in such families, but reduced it among women. These three findings are qualitatively the same as our findings for WFTC; but this may be unsurprising given that these findings are also consistent with predictions from standard classical labour supply models.

The consensus of the impact on EITC on hours worked is that “it appears to have a small negative effect on hours worked by those in the labour force, but some studies ... suggest that the aggregate hours effect of the EITC, once participation effects are accounted for, is positive.” (p183). This study has shown that, after accounting for changes in LFP, the impact of WFTC on hours worked is positive for lone mothers and men in two-adult families, but negative for women in two-adult families; amongst those in the labour force, it is positive, on average, for lone mothers, and negative, on average, for those in two adult families. The impact on hours is ambiguously theoretically, so there is less reason to expect the same results.

Many of the studies of the impact on EITC on LFP have used different expansions of the EITC, so comparing their estimates of the impact is not always informative; Hotz and Scholz (2003) therefore calculate elasticities, finding that “LFP elasticities with respect to net-of-tax income [in work] reported in Table 3.4 range from 0.69 to 1.16, and could be as large as 1.7 for former and current welfare participants.” (p183). In our data, WFTC raised mean net incomes of working lone parents by £16.24 a week from a base of £250.22, and it increased LFP by 3.33 percent²² on a base of 50.44 percent: the relevant elasticity implied by the WFTC reform is therefore $(0.0333/0.5044)/(16.24/250.22) = 1.02$. It is not clear that these elasticities should be similar for lone parents in the US and UK given that the income available to lone parents who do not work - and therefore the financial gain to work - is so different; the elasticity of LFP with respect to the financial gain to work implied by the WFTC reform is 0.28.²³

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,

²²3.33 is the simulated impact if programme participation costs are held constant.

²³These elasticities are 1.00 and 0.29 if we define “labour force participation” as working 16 or more hours a week. By way of comparison, Immervoll *et al.* (2005) calibrate their calculation of the marginal efficiency cost of redistribution with participation elasticities of 0.4 for individuals in the bottom quintile of the distribution, and 0.3 for those in the second quintile.

and we illustrate this by modelling the decision to claim FC/WFTC simultaneous with the labour supply decision. Furthermore, by using micro-data from before and after a major reform to in-work benefits, we have shown how changes in programme participation costs - whether brought about through changes in administration methods or of public perception - in themselves can have discernible impacts on labour supply.

We have shown the success of WFTC in encouraging labour supply, particularly of lone parents. Over its short lifetime, WFTC increased the employment rate of lone mothers by 5.11 percentage points compared with the programme it replaced, and with no form of in-work benefit at all, we estimate that labour force participation would fall considerably, from around 55 percent to 45 percent.

The impact of WFTC on individuals in couples are more complicated: WFTC slightly reduced the employment rate of mothers in couples by 0.57 percentage points, and slightly increased that of fathers in couples by 0.75 percentage points. Across both family types, these estimates correspond to an aggregate effect of around 81,000 extra workers, two thirds of whom are female.

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.

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 employment rate 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 employment of 22,000 individuals, just a quarter of the WFTC impact in isolation, reinforcing the importance of analysing changes to the tax and benefit system as a whole, rather than focusing on a single reform. These results are broadly in

line with those that have used natural experiment (difference-in-difference) techniques to estimate the impact of the set of changes to taxes, benefits and other welfare reforms on parents' labour force participation.

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Appendices

A First-stage regressions

Sample means of explanatory variables are shown in Table 8 below.

The wage equation included proxies of human capital and demand-side factors and year dummies; identification comes from including age of the youngest child and the net income

Table 8: 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 2 if Brewer *et al.* (2005). Monetary amounts 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 †.

that the benefit unit would obtain if no adult in the family were working in the employment equation. 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 (full regression results are presented in Brewer *et al.* (2005).)

For our childcare equations, we defined 12 groups according to the number of children (1, 2, 3 or more), 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. 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). Again, for full results, consult Brewer *et al.* (2005).