How should we use evidence in policy evaluation and simulation?
Evaluating Earned Income Tax Credit Policies

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Abstract

We examine the labour market impact of the Working Families Tax Credit - an earned income tax credit programme introduced in 2000 for low income families with children in the UK. Labour supply of lone mothers is modelled as a discrete choice among a finite set of hours alternatives. We allow for fixed costs, program participation and childcare. The reliability of the structural model is assessed by simulating the difference-in-differences moment using the tax credit reform. The structural model is used to examine the optimality of the tax credit design and uncover the implied social welfare weights.

Aim: to evaluate the impact and assess the optimality of employment tax-credit reforms

- Central position in EU labour market policy debate
  - Tax Credit expansions for lone parents
  - WFTC expansion in the UK, 1999/2000

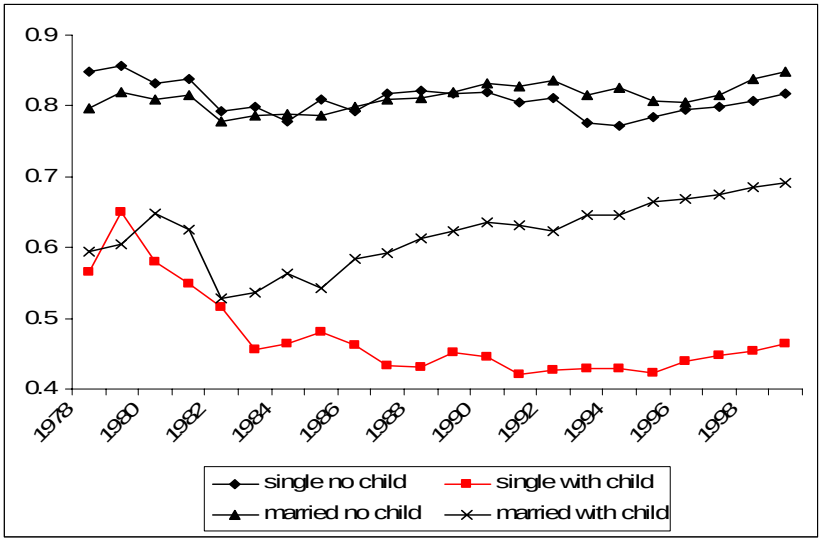
Puzzle: WFTC about twice as generous as the US EITC but with only half the impact

- focus on lone mothers
  - couples - targeting and collective labour supply
- examine the impact/design of further expansions

Layout of the paper:

- Policy Context
- Structure of the reforms/treatment
- Ex-post evaluation of historic reforms
- Ex-ante structural evaluation model
- Robustness of ex-ante model
- Optimality of reforms with heterogeneous responses
- Impact on new tax credit policy in Britain
- Just dip into certain specific features

Figure 1: Pre-reform Employment Trends for Women in the UK (1978 – 1999)



Blundell and Hoynes (2004)

WFTC: in class of *earned income tax credit* policies

- Focus on a 'work condition'
- Highlight distinction between extensive and intensive margins in empirical labor supply and optimal tax literature

Questions?

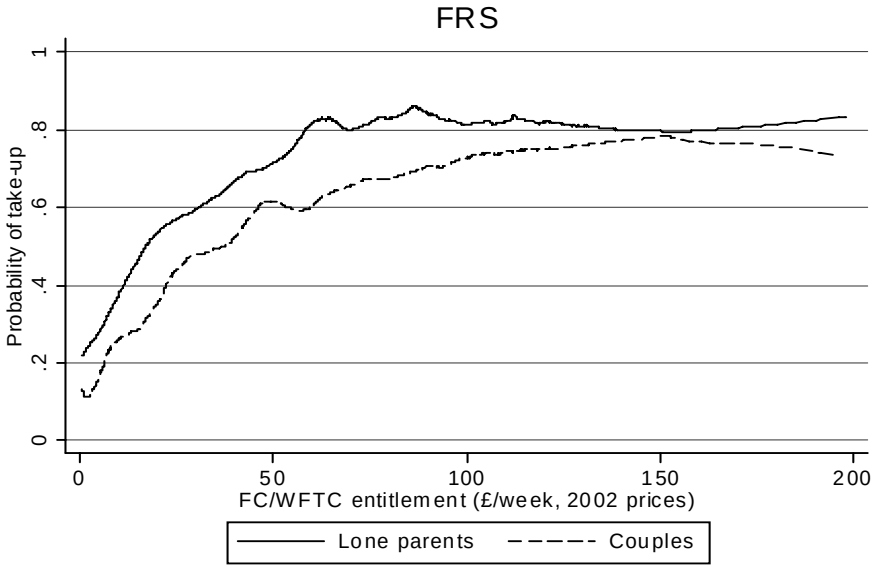
- How should we evaluate the impact of the reform?
- Can such tax-credits and their expansion optimal?
- If yes, what is the optimal design?

The WFTC reform(s):

- influenced by the EITC expansion in the US
- 2000 reform: expanded the generosity
  - Especially generous to families with young children.
  - (ex-ante) evaluation in 2000
- 2004 reform: further expansion in generosity
  - extension of eligibility to individuals without children
  - ex-ante evaluation
    - raises new issues about design
    - impact across different groups
    - time limits etc.

Figure 2: Take-up and WFTC

Variation in take-up probability with entitlement to FC/WFTC



Three criteria for eligibility in WFTC:

- work eligibility
  - 16 or more hours per week
- family eligibility
  - children in full time education or pre-school
- income eligibility
  - family net income below a certain threshold given by an adult credit plus age-dependent amounts for each child
  - once income is above the threshold then the amount of credit is tapered away at 55% per extra pound of net income – previously 70%

Figure 3: The US Earned Income Tax Credit and the UK WFTC compared

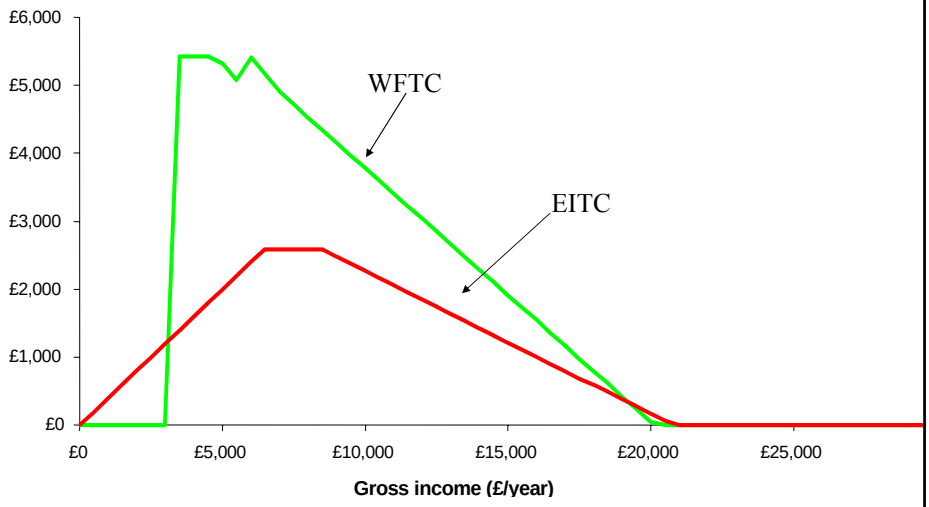


Figure 4: The Expansion in Generosity in the 2000 Reform

transfers per week for a min. wage lone parent

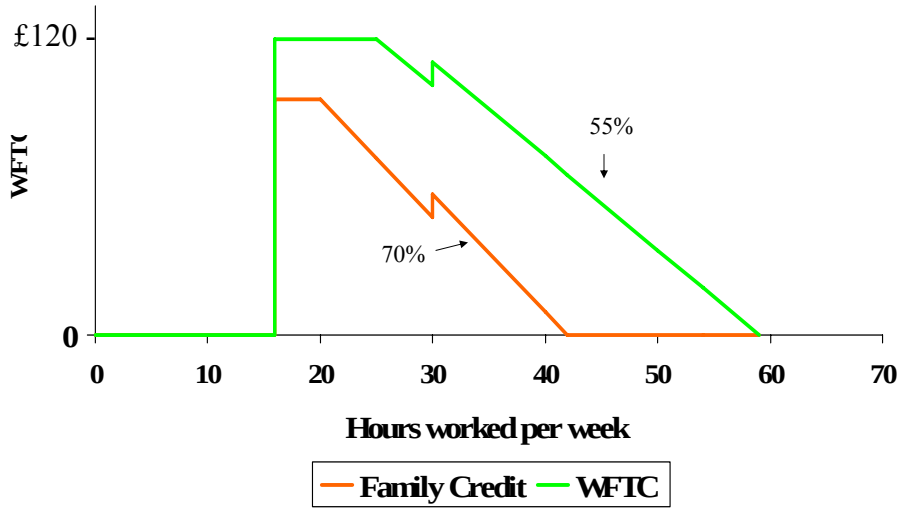


Table 2.1: Adult and Child Elements of the WFTC

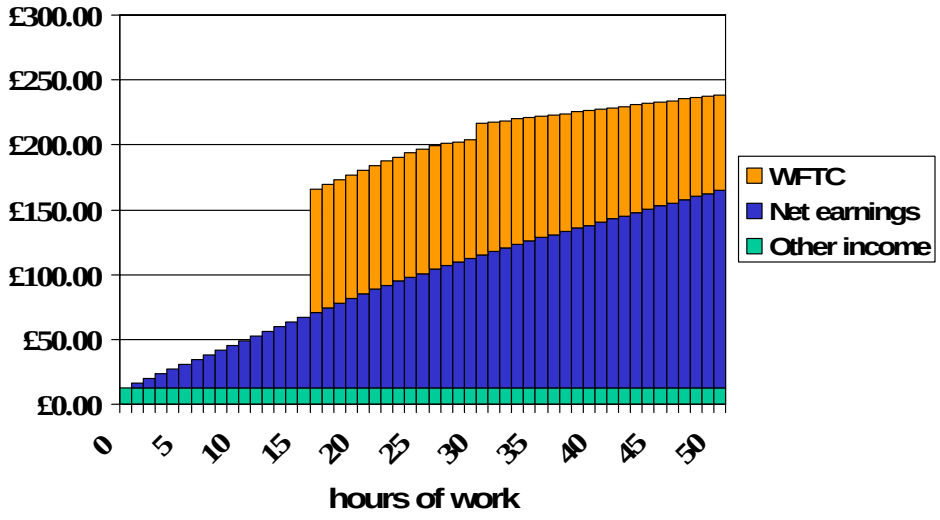
	Adult	Child Awards by Age		
		child 0 to 10	child 11 to 15	child 16 to 18
Mar-99	£58.80	£16.40	£22.60	£28.00
Oct-99	£56.60	£21.50	£22.60	£28.00
Mar-00	£56.60	£22.60	£22.60	£28.00
Jun-01	£61.90	£27.30	£27.30	£28.00
Jun-02	£64.40	£27.30	£27.30	£28.00
Increase	19.70%	66.40%	20.50%	0.00%

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

Unlike the US EITC the credit is based on net (rather than gross) family income

- interaction with other benefits and taxes matter
  - differing size of the 'treatment' across eligibles
- coincident reforms to Income Support (IS)
  - different direction of these reforms to US
- not all eligibles take-up credit
  - stigma/information
  - reduces marginal rates at higher incomes
  - average impact is 'intention to treat' parameter

Figure 5: WFTC interactions with other taxes and benefits in the UK (single parent on minimum wage)



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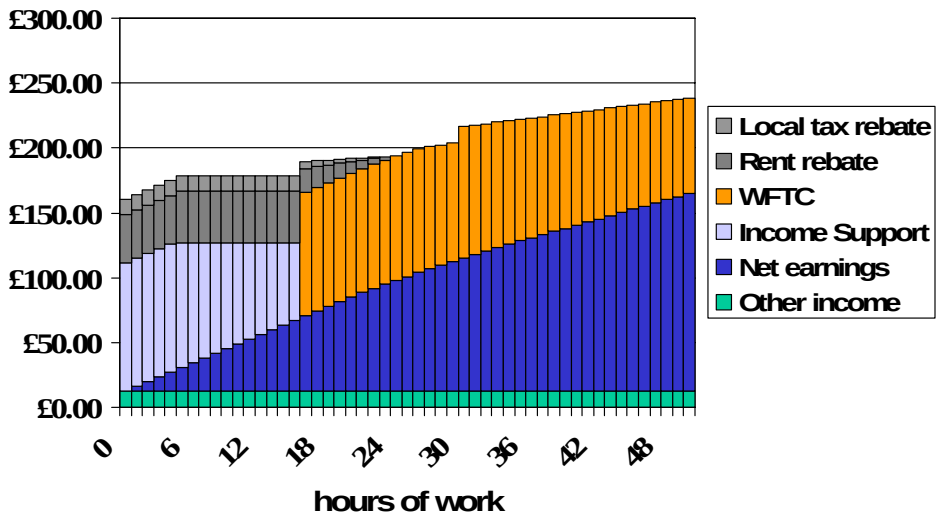


Figure 7(a): Weekly Hours Worked

Low Education Single Mothers (aged 18-45)

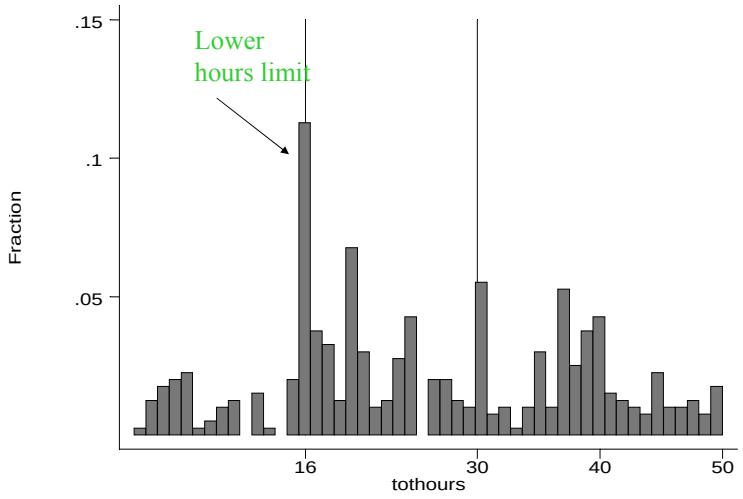


Figure 7(b): Weekly Hours Worked

Low Education Single Childless Women (aged 18-45)

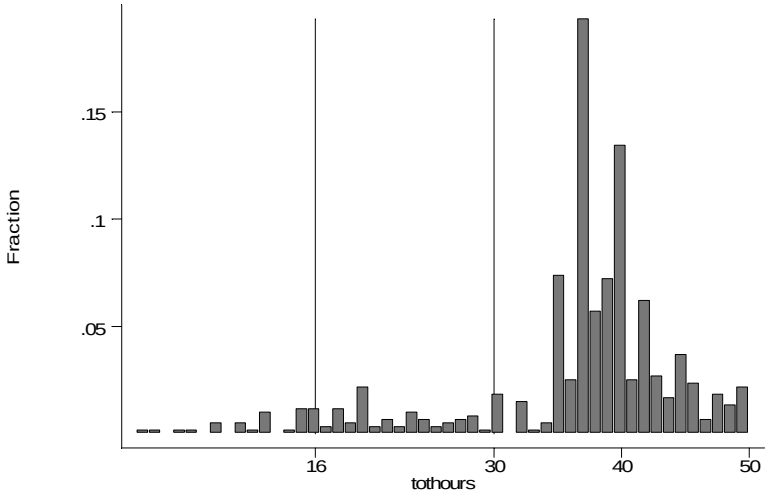
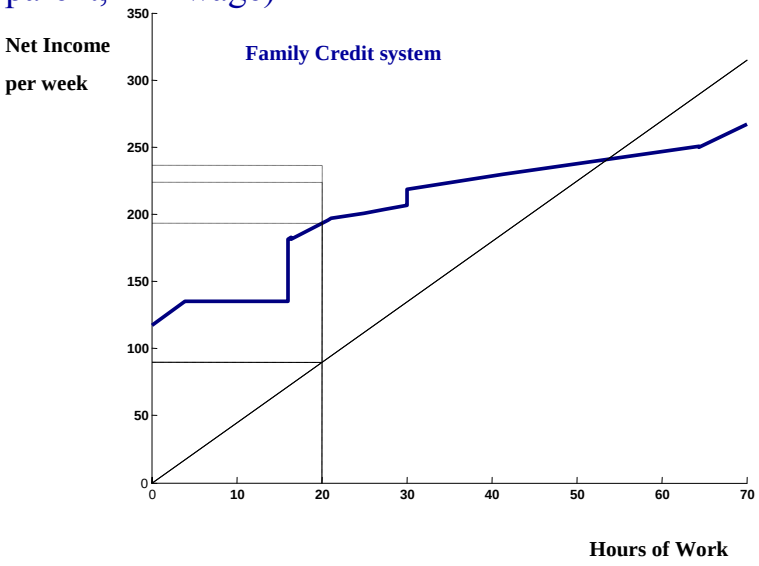


Figure 6: Transfers and Taxes under Family Credit (lone parent, min wage)



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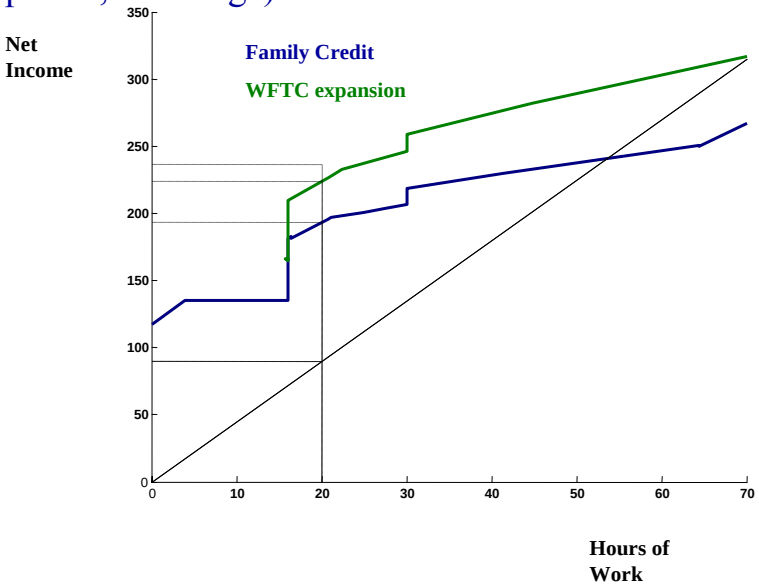

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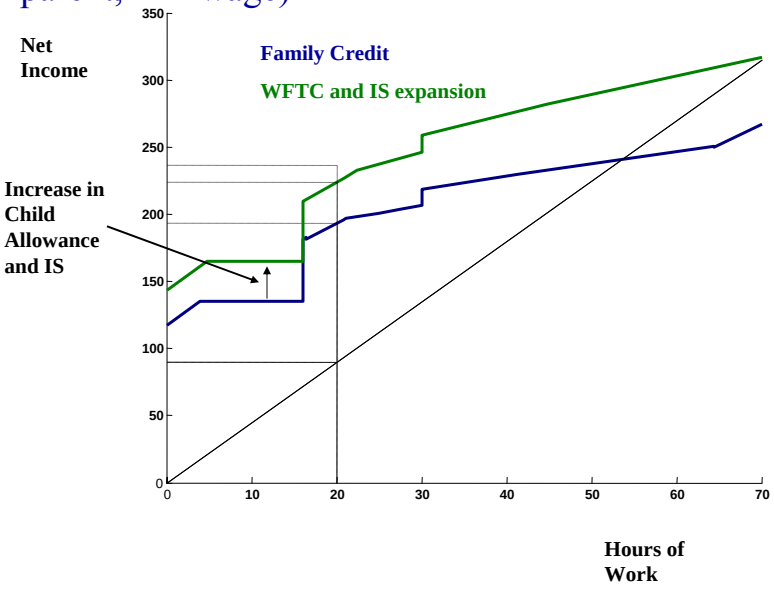


Table 2.2: Child Rates of Income Support

	child 0 to 10	child 11 to 15	child 16 to 18
Mar-99	£21.90	£28.00	£33.50
Oct-99	£27.00	£28.00	£33.50
Mar-00	£28.40	£28.40	£33.80
Mar-01	£33.00	£33.00	£33.80
Oct-01	£34.50	£34.50	£35.40
Mar-02	£34.50	£34.50	£35.40
Increase	57.50%	23.30%	5.70%

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

How should we assess the impact of the expansion in the tax-credit?

- No pure experiment
- Ex-post evaluation
  - Quasi-experimental evaluation strategy
- Ex-ante evaluation
  - 'Structural' evaluation model
    - 'necessary' for simulating 2004 expansion
    - 'necessary' for assessing optimality
- use an appropriate mix of both strategies

To assess optimality

- Use Mirrlees optimal tax approach
- Suppose we wish to allocate £R to low income lone parents, how best should we do this?
- Need *robust* estimates of preferences
  - at least elasticities at *extensive* and *intensive* margins – Saez approximation.
- Given elasticities, we can pose the question:
  - is the WFTC expansion 'optimal' for reasonable social welfare weights?
  - are there obvious aspects for improvement?

Robustness of the ex-ante evaluation model:

- Compare structural evaluation model (simulated likelihood) estimated on pre-reform data to quasi-experimental ex-post evaluation
- The idea is to simulate the quasi-experimental estimate (moment)
  - difference-in-differences α_{DD}

Ex-post evaluation: WFTC reform in 2000

- comparing outcomes of (potentially) eligible versus those who are not eligible
- identify average impact on eligibles by *assuming* a structure on unobservables
  - separability
  - common trends across groups
  - invariance in group heterogeneity over time
    - *conditional* on a set of (matching) covariates X
- can structurally simulate the moments underlying the diff-in-diff estimator anyway.

Difference-in-Differences

Let G^{-1} be the inverse probability function, and $T=1$ denote eligibility and $t=1$ after the program, we consider:

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

then use G to identify $\alpha_{DD}(X)$ and the empirical distribution of X for $T=1,t=1$ to recover the average impact on the eligibles α_{DD} *(JEEA, 2004)*

- cubic polynomial for propensity scores for each of the comparison groups.
- estimate impact using predicted outcome for three non-treatment cases for each of the matched treated observations

Table 2.4: Difference-in-Differences Results

Single Women	**Marginal Effect**	**Standard Error**	**Sample Size**
Family Resources Survey	**3.57**	***0.81***	**74,959**
Labour Force Survey	**3.81**	***0.33***	**233,208**

Data: Spring 1996 – Spring 2003.

Drop: Summer 1999 – Spring 2000 inclusive; individuals aged over 45.

Outcome: employment. Average impact x 100, employment percentage.

Matching Covariates: age, education, region, ethnicity,..

Sensitivity analysis

- Alternative groups
  - low education: 5.4 (0.61)
    - larger response on a lower base
  - Youngest child aged < 5: 3.13 (0.51)
  - Youngest child aged 5-10: 4.60 (0.54)
- Choice of pre-treatment years
  - results are robust to changing the pre-treatment time window
  - 'hypothetical' reform on pre-reform years
    - Spring 1997: treatment effect: .07 *(.11)*

Structural analysis

- Data from 1995-2003 - FRS
  - 1995-1999: pre-reform estimation data (ex-ante)
  - 2001-2003: 'post-reform' validation sample
    - model does not reject provided 'take-up' is allowed to vary endogenously
  - Use complete sample for ex-ante analysis of 2004 reforms
- Variation: geographic, time, precise rules.
  - Tax and benefit system (accurate income/benefits)
  - Housing costs/benefits (local variation)
  - Local taxation

Key features of the structural model

main elements:

- budget constraint – tax/benefit interactions and take-up
- preferences – discrete hours; flexible utility specification
- heterogeneity – demographics, ethnicity, etc; unobs. het.
- fixed costs of work – obs. and unobs. het.
- stigma/hassle costs – take-up versus eligibility; unobs. het.
- childcare costs

  - mixed-multinomial specification across discrete choices over ranges of hours.

Net Income Schedule and Prog. Part. (Take-up)

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

let $E_h = 1(\Psi_1 > 0)$
be an indicator of entitlement at hours h.
P=1 if participate in program

additional term: $\eta = X_\eta \beta_\eta + u_\eta$ 'cost' of receiving in-work support

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

important in evaluation of a reform which increases generosity

Program Participation

Utility 'cost' of receiving in-work support

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

claim Ψ_1 in FC/WFTC at hours h_j if:

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

utility cost among those who choose to claim WFTC must not exceed the utility gain from receipt of WFTC transfer income relative to non-receipt:

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

$$u_\eta < \Omega_U \quad \text{where} \quad \Omega_U = U(h_j, \tilde{y}_{h_j} + \Psi_1 - C) - U(h_j, \tilde{y}_{h_j} - C) - X_\eta \beta_\eta$$

Choice probabilities:

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

$$\frac{\exp\{U(h_j, \tilde{y}_{h_j} + p \cdot \Psi_{h_j}, P=p)\}}{\sum_{k=1}^{J} \max[\exp\{U(h_k, \tilde{y}_{h_k}, P=0)\}, E_{h_k} \cdot \exp\{U(h_k, \tilde{y}_{h_k} + \Psi_{h_k}, P=1)\}]}$$

where $\mathbf{u} = (u_w, u_y, u_h, u_{cc}, u_f)$

Probability specification and likelihood

$$\log L = \sum_i \log \int_{u_{-u_\eta}} [\int_{u_\eta \le \Omega_U} \prod_j \Pr(h = h_j, P = 1|X,u)^{1(h=h_j,E_{h_j}=1,P=1)} f(u_\eta) du_\eta$$
$$+ \int_{u_\eta > \Omega_U} \prod_j \Pr(h = h_j, P = 0|X,u)^{1(h=h_j,E_{h_j}=1,P=0)} f(u_\eta) du_\eta$$
$$+ \int_{u_\eta} \prod_j \Pr(h = h_j, P = 0|X,u)^{1(h=h_j,E_{h_j}=0)} f(u_\eta) du_\eta$$
$$] f(u_{-u_\eta}) du_{-u_\eta}$$

where

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

Evaluation of the ex-ante model

Let D=1 summarise the policy is in place {T=1,t=1} and let $\Pr[h > 0|X,D = 1]$ be the simulated probability of average impact of reform employment from the structural model

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

requires integrating over the unobserved heterogeneity in the structural model (then integrate over empirical dist of X)

Can also simulate $\alpha_{DD}(X)$ using the structural model. $\alpha_{DD}^{SEM}(DD)$

Comparing simulated DD parameter with the actual DD parameter provides an assessment of the SEM.

Evaluation of the ex-ante model

- The *simulated* diff-in-diff parameter from the structural evaluation model is precise and does not differ significantly from the diff-in-diff estimate
- Compare *simulated diff-in-diff moment* with *diff-in-diff*
  - .29 (.73), chi-square p-value .57
- Consider additional moments
  - education: low education: 0.33 (.41)
  - youngest child interaction
    - Youngest child aged < 5: .59 (. 51)
    - Youngest child aged 5-10: .31 (.35)

Table 2.7(a) : Structural Evaluation Results WFTC Expansion by Age of Youngest Child

	All	y-child 0 to 2	y-child 3 to 4	y-child 5 to 10	y-child 11 to 18
Change in employment rate:	5.95	3.09	7.56	7.54	4.96
	0.74	*0.59*	*0.91*	*0.85*	*0.68*
Average change in hours:	1.79	0.71	2.09	2.35	1.65
	0.2	*0.14*	*0.23*	*0.34*	*0.2*

Notes: Simulated on FRS data; Standard errors in italics.

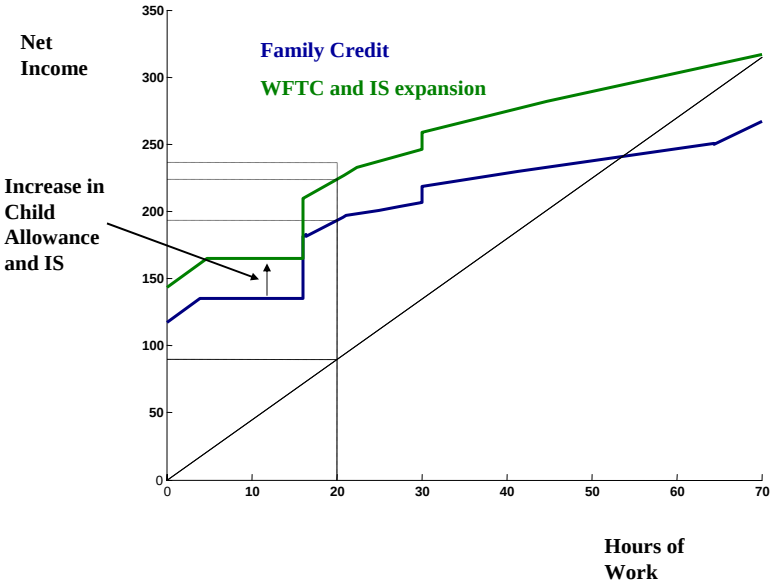
All: 5.12 without change in take-up

Table 2.7(b) : Structural Evaluation Results **All Reforms** by Age of Youngest Child

	All	y-child 0 to 2	y-child 3 to 4	y-child 5 to 10	y-child 11 to 18
Change in employment rate:	3.86	0.65	4.53	4.83	4.03
	0.84	*0.6*	*0.99*	*0.94*	*0.71*
Average change in hours:	1.02	0.01	1.15	1.41	1.24
	0.23	*0.21*	*0.28*	*0.28*	*0.22*

Notes: Simulated on FRS data; Standard errors in italics.

Transfers and Taxes under the WFTC Expansion (lone parent, min wage)



Evaluation of the ex-ante model

- small average treatment on treated effect appears to be due to interaction of WFTC with other taxes/ benefits *and* rise in Income Support.
- rather than 'small' response elasticities:
  - extensive elasticity .81 (.13)
  - intensive elasticity .31 (.09)

Is the design 'optimal'?

- Assume we want to redistribute '£R' to low ed. lone parents, what is the 'optimal' way to do this?
- Recover optimal tax/credit schedule in terms of earnings
  - use approximation in terms of extensive and intensive elasticities at different earnings
  - also complete Mirrlees optimal tax computation
- Given elasticities at extensive and intensive margin, we can pose the question:
  - is the WFTC expansion 'optimal' for reasonable social welfare weights?

Table 2.5: Elasticities by 'Earnings' Class/(Hours)

Earnings Class	1 (10)	2 (19)	3 (26)	4 (33)	5 (40)
Extensive	0.376 (.129)	0.425 (.072)	0.460 (.056)	0.649 (.053)	0.555 (.035)
Intensive		0.240 (.091)	0.181 (.072)	0.148 (.071)	0.097 (.054)

Notes: Earnings class corresponds to the hours classes in Table for a min wage single parent.
For single parent earning minimum wage by hours/earnings class.

Optimal Structure

- Suppose we distinguish two groups
  - 'low' or 'no' earners: group 0
  - 'higher' earners: group 1
- Suppose the social welfare weight is higher for low earners, group 0
- Choose transfers and taxes T to maximise welfare

Optimal design gives

$$\frac{T_1 - T_0}{c_1 - c_0} = \frac{(g_0 - 1)}{\zeta_1}$$

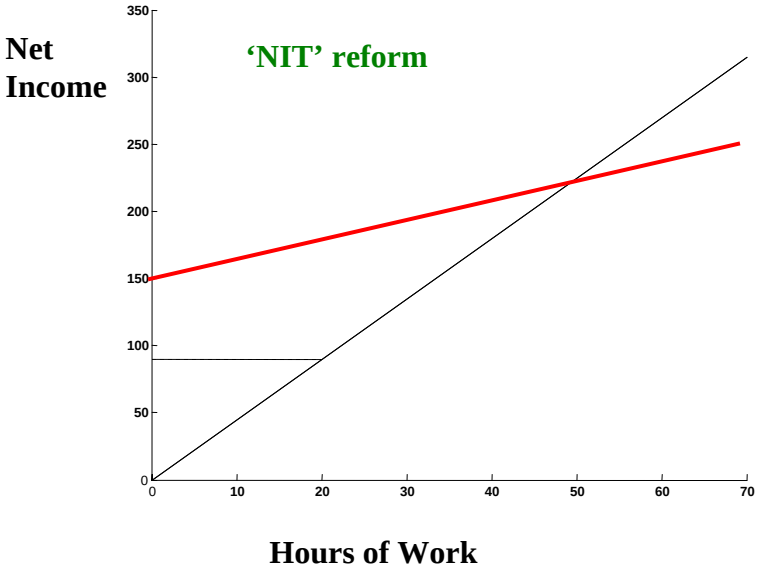
ζ_i is the labour supply elasticity

g_0 is the social welfare weight

$-T$ is the subsidy given to that group

c is the net of tax income for that group

Optimal Structure



Suppose we distinguish ‘non-employed’, ‘low earners’ and ‘higher’ earners, 0, 1, 2 .. etc

$$\frac{T_i - T_{i-1}}{c_i - c_{i-1}} = \frac{1}{\zeta_i} \sum_{j=i}^{I} \left[1 - \hat{g}_j \right]$$

where

$$\hat{g}_j = g_j + \eta_j \, k$$

ζ_i is the intensive elasticity, η_j is the extensive elasticity

note that a ‘large’ extensive elasticity can ‘turn around’ the impact of social weights - implying an optimal tax credit structure – e.g. a higher transfer to lower skilled workers than to those out of work.

Optimal Structure

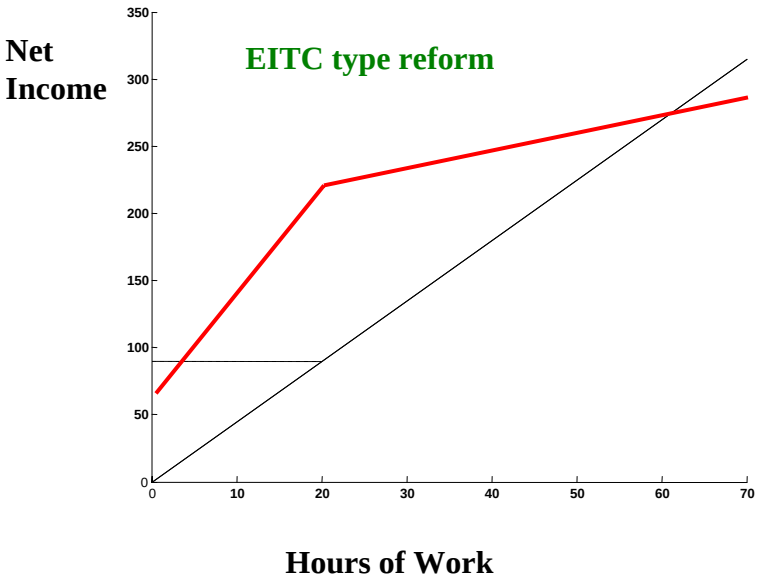


Table 2.8: Implied Social Welfare Weights by 'Earnings' Class

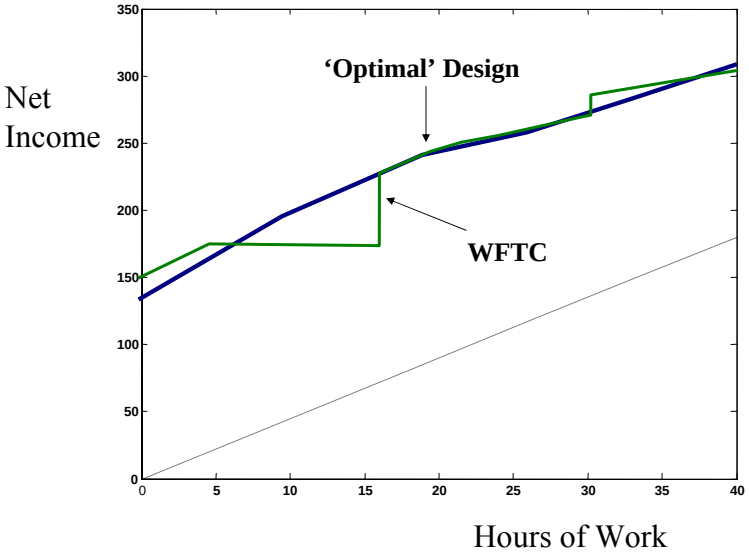
Earnings Class	0	1 (10)	2 (19)	3 (26)	4 (33)	5 (40)
WFTC with IS	1.27	.90	1.11	.93	1.02	.80
WFTC alone	1.10	.93	1.06	.92	1.02	.81

Lone parent; child aged 4.

- 'Almost' monotonically declining social welfare weights make the reform optimal
  - non-monotonicities correspond to 'peculiar' hours conditions
- Weight g_0 in actual UK reform higher than a pure earned income tax-credit expansion
- Choose monotonic declining weights =>

Figure 9: Optimal Transfers and Taxes and WFTC

Lone parent; child aged 4.



Also implement the Mirrlees scheme directly over heterogeneous utilities

$$\max_T W = \sum_i \int_{\beta,w} \int_{\epsilon} \Gamma(u(w_i h_i^* - T(w_i, h_i^* | Z_i), h_i^* | X_i \beta_i, \epsilon)) dF(\epsilon) dG(\beta, w)$$

$$\sum_i \int_{\beta,w} \int_{\epsilon} T(w_i, h_i^* | Z_i) dF(\epsilon) dG(\beta, w) = \overline{T}$$

Allow four linear segments

$$\Gamma(U|\theta) = \tfrac{1}{\theta} \times \{(\exp U)^{\theta} - 1\}$$

$$\theta = -0.2$$

Figure 10(a): Optimal Transfers and Taxes and WFTC

(Lone parent; child aged 4)

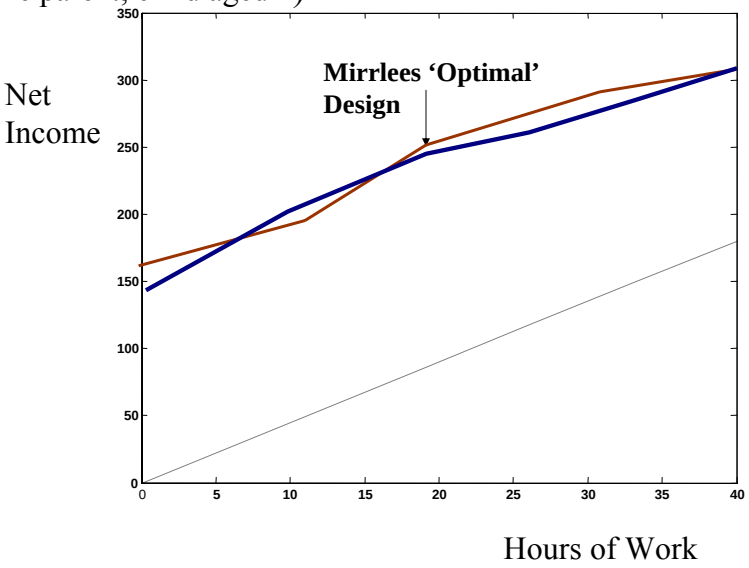
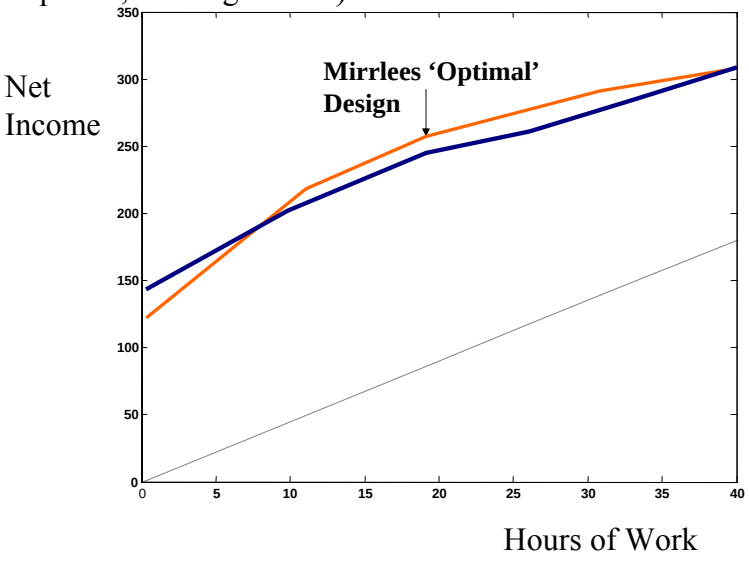


Figure 10(b): Optimal Transfers and Taxes and WFTC

(Lone parent; child aged 5-10)



Summary

- Empirically robust elasticities and knowledge of the full tax and benefit system can can easily reconcile EITC and WFTC 'puzzle'.
- Developed a structural evaluation model with take-up and unobserved heterogeneity
- Can justify the WFTC expansion even with social welfare weights that decline monotonically with income – except for hours conditions.
- Contrast with implicit social welfare weights for the EITC expansions in the US.
- Evaluate the 2004 WTC/CTC expansions UK for individuals with and *without* children

Adequacy of the specification

- line-up structural model with quasi-experiment treatment effects
- work experience and wages?
  - Gladden and Tamer (2000)
  - Grogger (2005)
  - Card and Hyslop (2004)
- program impact on gross wages?
- couples?
  - targeting in collective labour supply models
- childcare? ; impact on fertility?

The new tax credits:

- Child Tax Credit (CTC): no work condition
  - increase in generosity and combined child elements in IS
- Working Tax Credit (WTC): work condition
  - increase the generosity to workers with children
  - ex-ante prediction of further 1.8 increase in employment
- WTC for childless single people and couples
  - lower rate
  - only people aged over 25 and working 30 hours or more
  - lower social welfare weight for workers without children
- Opens debate on time limits – tax-credits may under insure by over providing static incentives

Figure 11: The new tax credit expansion (2004/2005)

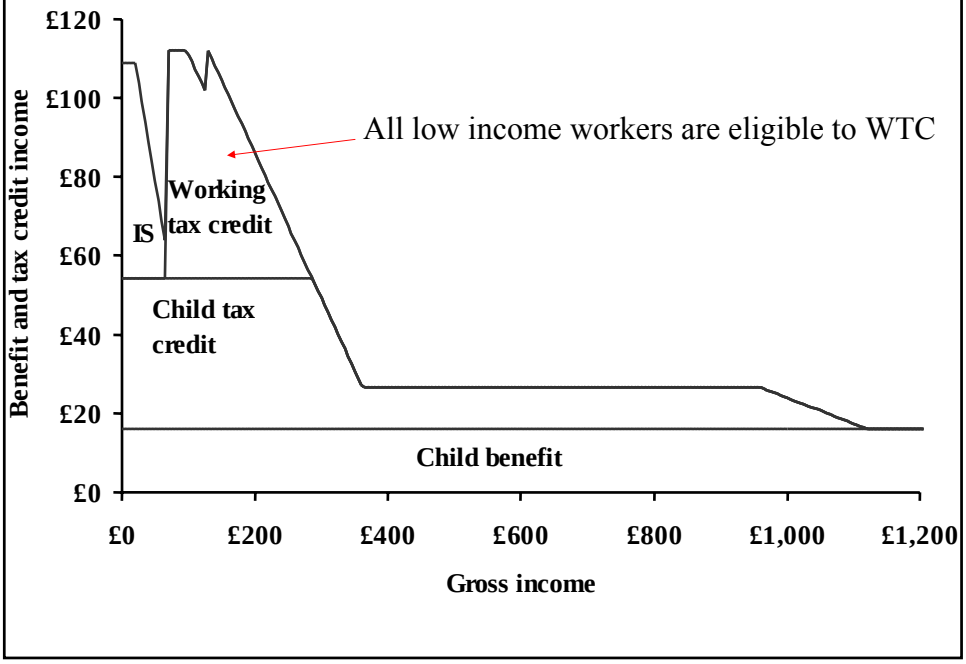


Figure 12: Transfers/Taxes for the WTC Expansion
(lone parent, child aged 4, min wage)

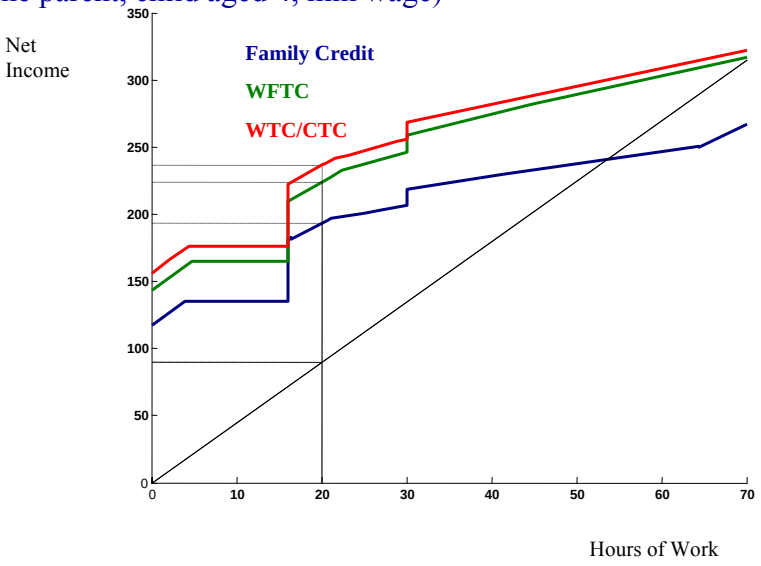
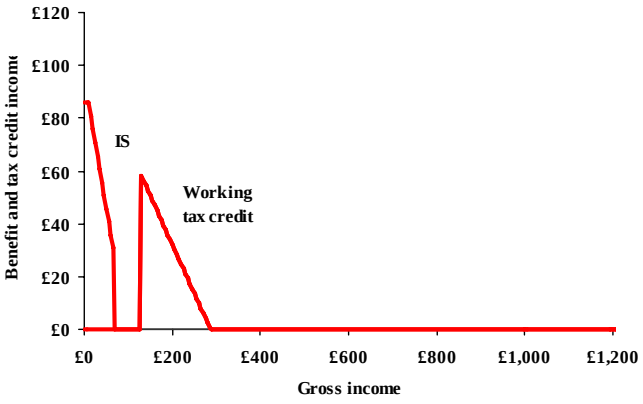


Figure 13: Transfers/Taxes for the WTC Expansion
(without child)



Ex-ante evaluation of the new tax credits expansion

- Estimate structural model on 95-03 data to evaluate for April 2004 reform
  - model works well provided take-up effects are incorporated
- The ex-ante estimated treatment impact is 1.68 percentage point increase in employment for lone mothers
- Implied social welfare weights:
  - similar for families (parents)
  - less progressive for singles (no children) (as in EITC)
- Higher weights for workers and full-time work may:
  - acknowledge experience effects unrecognised by individuals

Summary

- Empirically robust elasticities and knowledge of the full tax and benefit system can can easily reconcile EITC and WFTC 'puzzle'.
- Developed a structural evaluation model with take-up and unobserved heterogeneity
- Can justify the WFTC expansion even with social welfare weights that decline monotonically with income – except for hours conditions.
- Contrast with implicit social welfare weights for the EITC expansions in the US.
- Evaluate the 2004 WTC/CTC expansions UK for individuals with and *without* children

Adequacy of the specification

- line-up structural model with quasi-experiment treatment effects
- work experience and wages?
  - Gladden and Tamer (2000)
  - Grogger (2005)
  - Card and Hyslop (2004)
- program impact on gross wages?
- couples?
  - targeting in collective labour supply models
- childcare? ; impact on fertility?

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Table A1: Sample Descriptives

		1996	1997	1998	1999	2000	2001	2002
No children	Work	0.753	0.762	0.769	0.770	0.774	0.767	0.775
	Age	26.789	26.906	26.799	26.957	27.104	27.317	27.450
	Non-white	0.073	0.077	0.080	0.084	0.091	0.098	0.102
	Left education before 1	0.078	0.072	0.062	0.057	0.052	0.047	0.043
	Left education at 16 or 1	0.394	0.381	0.375	0.375	0.363	0.353	0.356
	London and South-East	0.341	0.350	0.349	0.347	0.354	0.360	0.352
	Rented accommodation	0.343	0.353	0.358	0.340	0.339	0.350	0.346
	Observations	26243	24463	24410	23987	22558	23517	22846
Children	Work	0.417	0.425	0.444	0.464	0.477	0.487	0.496
	Age	32.330	32.580	32.655	32.863	33.181	33.280	33.288
	Non-white	0.100	0.099	0.091	0.098	0.106	0.112	0.111
	Left education before 1	0.209	0.196	0.189	0.169	0.154	0.161	0.155
	Left education at 16 or 1	0.632	0.627	0.633	0.635	0.646	0.641	0.637
	London and South-East	0.285	0.285	0.285	0.293	0.294	0.303	0.301
	Rented accommodation	0.686	0.704	0.708	0.696	0.697	0.694	0.676
	Number of kids	1.783	1.785	1.791	1.784	1.778	1.776	1.794
	Age of youngest child	6.187	6.249	6.272	6.414	6.592	6.612	6.676
	Observations	14613	14172	14550	14343	13572	14097	13996

Net Income schedule for the program:

P: program participation

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

Tax — Transfers

the program payment function $\Psi(w,h,I,P|Z_\Psi)$ depends on:

- hours (through the hours condition of entitlement)
- investment income I,
- participation P in the tax-credit program,
- and household characteristics Z_Ψ

Net Income Schedule and Prog. Part. (Take-up)

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

let $E_h = 1(\Psi_1 > 0)$
be an indicator of entitlement at hours h.
P=1 if participate in program

additional term: $\eta = X_\eta \beta_\eta + u_\eta$ 'cost' of receiving in-work support

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

important in structural simulation of increasing generosity

Stochastic specification and discrete hours

discrete hours alternatives: $h \in \{h_1, \ldots, h_J\}$

Stochastic Preferences

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

Fixed costs of work

$$WRC_1 = X_{f1} \beta_{f1} + u_f$$
$$WRC_2 = X_{f2} \beta_{f2}$$

Childcare Costs

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

At price p_c for an hour of childcare per child

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

To estimate the childcare price per child p_c, we compute the empirical distribution of hourly child-care costs for various groups of working mothers defined by their family status and number and age of children X_{cc}.

Program Participation

Utility 'cost' of receiving in-work support

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

claim Ψ_1 in FC/WFTC at hours h_j if:

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

utility cost among those who choose to claim WFTC must not exceed the utility gain from receipt of WFTC transfer income relative to non-receipt:

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

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

Probability specification and likelihood

$$\log L = \sum_i \log \int_{u_{-u_\eta}} [\int_{u_\eta \leq \Omega_U} \prod_j \Pr(h = h_j, P = 1|X,u)^{1(h=h_j, E_{h_j}=1, P=1)} f(u_\eta) du_\eta$$
$$+ \int_{u_\eta > \Omega_U} \prod_j \Pr(h = h_j, P = 1|X,u)^{1(h=h_j, E_{h_j}=1, P=0)} f(u_\eta) du_\eta$$
$$+ \int_{u_\eta} \prod_j \Pr(h = h_j, P = 1|X,u)^{1(h=h_j, E_{h_j}=0)} f(u_\eta) du_\eta$$
$$] f(u_{-u_\eta}) du_{-u_\eta}$$

where

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

Table A2: Structural Evaluation Model: Parameter Estimates

	Parameter	Estimate	Standard Error	z	$P > \|z\|$
α_{11}:	Constant	−0.321	0.044	−7.290	0.000
	Youngest Child 0-2	0.210	0.074	2.844	0.004
	Youngest Child 3-4	0.212	0.065	3.244	0.001
	Youngest Child 5-10	−0.059	0.061	−0.969	0.332
α_{22}:	Constant	0.308	0.027	11.317	0.000
	Youngest Child 0-2	0.024	0.062	0.385	0.700
	Youngest Child 3-4	−0.152	−0.031	−2.401	0.016
	Youngest Child 5-10	−0.031	0.037	−0.833	0.405
α_{12}:	Constant	0.010	0.004	2.693	0.007
	Youngest Child 0-2	−0.019	0.005	−3.541	0.000
	Youngest Child 3-4	−0.015	0.006	−2.427	0.015
	Youngest Child 5-10	0.005	0.005	1.099	0.272

β_1:	Constant	0.327	0.023	14.538	0.000
	Age	−0.027	0.047	−0.579	0.563
	Age Squared	0.003	0.006	0.546	0.585
	Education 16	−0.015	0.009	−1.677	0.093
	Youngest Child 0-2	−0.085	0.037	−2.270	0.023
	Youngest Child 3-4	−0.046	0.035	−1.320	0.187
	Youngest Child 5-10	0.012	0.030	0.399	0.690
	Number of Children	0.012	0.007	1.889	0.059
	Non-white	−0.068	0.017	−3.966	0.000
	Random Term (SD)	0.004	0.009	0.400	0.689
β_2:	Constant	−0.213	0.015	−13.993	0.000
	Age	0.106	0.012	8.708	0.000
	Age Squared	−0.012	0.002	−7.334	0.000
	Education 16	0.034	0.003	13.188	0.000
	Youngest Child 0-2	0.017	0.027	0.614	0.539
	Youngest Child 3-4	0.062	0.028	2.197	0.028
	Youngest Child 5-10	−0.011	0.020	−0.553	0.581
	Number of Children	−0.012	0.003	−3.565	0.000
	Non-white	0.016	0.009	1.878	0.060
	Random Term (SD)	0.000	0.002	0.000	1.000

continues...

η:	Constant	−0.252	0.061	−4.120	0.000
	October 1999	0.024	0.113	0.213	0.832
	April 2000	−0.210	0.116	−1.809	0.071
	Age	−0.349	0.386	−0.905	0.365
	Age Squared	0.119	0.054	2.214	0.027
	Education 16	0.767	0.085	9.060	0.000
	Non-white	0.399	0.148	2.699	0.007
	Random Term (SD)	0.215	0.103	2.085	0.037
FC_1:	Constant	8.955	6.978	1.283	0.199
	Youngest Child 0-2	42.298	14.532	2.911	0.004
	Youngest Child 3-4	32.760	12.810	2.557	0.011
	Youngest Child 5-10	5.542	8.984	0.617	0.537
	Number of Children	3.015	2.836	1.063	0.288
	Non-white	38.256	13.018	2.939	0.003
	London	48.089	4.593	10.469	0.000
	Random Term (SD)	5.304	3.140	1.689	0.091
FC_2:	Constant	13.963	5.576	2.504	0.012
	Youngest Child 0-2	21.091	14.245	1.481	0.139
	Youngest Child 3-4	−4.638	11.045	−0.420	0.675
	Youngest Child 5-10	13.364	7.747	1.725	0.085
	Number of Children	4.558	3.476	1.311	0.190
	Non-white	−33.931	12.492	−2.716	0.007
	London	−13.858	5.952	−2.328	0.020
	Maximised Log Likelihood				-15564.720
	Observations				11594

Note: Standard errors are calculated analytically from the Simulated Maximum