Tax-Credit Policies for Low Income Families:
Impact and Optimality

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This research concerns the impact of tax and tax-credit reform on working decisions.

It looks at the impact and the ‘optimal’ design

Two questions:
– How should we measure the impact of tax and tax-credits on work decisions?
– How should we assess the optimality of tax and tax-credit proposals?

Focus on single mothers and the UK reforms
Tax Credit reforms in the UK

- Sequence of Tax Credit expansions
  - FC (family credit) before 2000, expanded early in 1990s
  - WFTC (working families tax credit) reform in 2000, and subsequent expansions in 2002
  - influenced by the success of the EITC expansion in the US
  - especially generous to families with young children
- WTC (working tax credit) and CTC (child tax credit) reform in 2004
  - extension of eligibility to individuals without children

The WFTC Reform

transfers per week for a min. wage lone parent
General form of Earned Income Tax Credits

- Credit depends on earnings and number of children:
  - Phase-in: credit is flat percentage of earned income or jump in at minimum hours threshold
  - Flat range: receive maximum credit
  - Phase-out: credit is phased out at a flat rate
- Credit based on family earnings
  - Creating ‘interesting’ incentives among couples

EITC Schedule in US – Single Parent Families, 2004

- Larger credit, covering higher earners for families with two or more children.
Can a WFTC type design be ‘optimal’?

- Does the WTFC represent an optimal transfer for low income families?
- New insights from optimal tax theory show some negative marginal tax rates can be an optimal design
- Labour supply estimation suggest extensive margin is more responsive to incentives than intensive margin
- This turns out to be a key observation for optimal tax design

Tax Credit Policies for Low Income Families

<table>
<thead>
<tr>
<th>After Tax Income</th>
<th>Negative Income Tax (NIT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>guaranteed income</td>
<td></td>
</tr>
<tr>
<td>break even point</td>
<td></td>
</tr>
<tr>
<td>‘top’ rate constrained by some political economy or taxable income elasticity argument</td>
<td></td>
</tr>
</tbody>
</table>

Earnings
The Analysis of Tax Credit Policies

In the research design reported here, the analysis of tax-credit policy is tackled in two steps:

- The first step is a positive analysis of how household work decisions respond. There are two empirical approaches - both prove useful:
  
  (a) A ‘quasi-experimental’ evaluation of the impact of historic reforms
  (b) A ‘structural’ estimation of individual behaviour based on a general discrete choice model

- The second step is the normative analysis or optimal policy analysis
A simple optimal design framework

- Two ‘new’ approaches
- solve directly given the microeconometric estimates of discrete choice behaviour and tax-benefit constraints
- take approximations in terms of underlying elasticities and welfare weights on different incomes – Diamond/Saez
- choose transfers and taxes ‘T’ to maximise welfare
- extend the standard Mirrlees framework to allow for responses at the extensive and intensive margin

A (simple) optimal tax framework

Suppose $U$ is the ‘utility’ of a single mother

$$U(c, h; X, \varepsilon)$$

from working $h$ hours with net income $c$, where $X$ are observable characteristics of her and her child and $\varepsilon$ represents unobserved characteristics.

Budget constraint:

$$c \equiv wh - T(w, h; X)$$

Choose $h$ from a set of discrete alternatives reflecting part-time work, full-time work etc.
A simple optimal tax/tax-credit framework

Social welfare, for single parents of type $X$

$$W = \sum_{i} \int \int \Gamma(u(w_i, h_i; X), h^*_i; X, \varepsilon))dF(\varepsilon)dG(w; X)$$

where $\Gamma$ is the social welfare transformation.

The tax structure $T(X)$ is chosen to maximise $W$, subject to:

$$\sum_{i} \int \int T(w_i, h_i; X)dF(\varepsilon)dG(w; X) = \bar{T}(X)(-R(X))$$

Simplified expressions - for intuition

- Suppose we distinguish between earnings groups
  - ‘no’ earners: group 0
  - ‘higher’ earners groups $i = 1, 2, \ldots$
- Suppose the social welfare weight is higher for group 0, and monotonically decreasing
- Choose taxes (and transfers) $T$ to maximise welfare
- Can derive expressions in terms of elasticities and social welfare weights across the income distribution
Simplified expressions

Optimal design gives:

\[
\frac{T_i - T_0}{c_i - c_0} = \frac{1 - g_i}{\zeta_i}
\]

where

- \( \zeta_i \) is the labour supply elasticity
- \(-T_i\) is the subsidy given to group \(i\)
- \(c_i\) is the net of tax income for that group
- \(g_i\) is the social welfare weight for group \(i\)
- and \(g_0 > 1\), with the weighted sum of \(g\)’s = 1

An Optimal Schedule

<table>
<thead>
<tr>
<th>After Tax Income</th>
<th>EITC ‘bubble’ region with (g &gt; 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earnings</td>
<td>region with (g &lt; 1)</td>
</tr>
</tbody>
</table>
Simplified expressions

e.g. for two groups:
\[
\frac{T_1 - T_0}{c_1 - c_0} = \frac{g_0 - 1}{\zeta_1}
\]

which leads to a standard NIT

An Optimal Schedule

After Tax Income

Earnings
The intensive and extensive margin

Suppose we now introduce an intensive and extensive margin

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

where

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

$$\zeta_i$$ is the intensive elasticity

and $$\eta_j$$ is the extensive elasticity

a ‘large’ extensive elasticity can ‘turn around’ the impact of social weights - implying a higher transfer to low wage workers than to those out of work – a tax-credit

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A ‘Typical’ Optimal Schedule

![Graph showing After Tax Income and Earnings with 'NIT adapted' EITC 'bubble']
The US Earned Income Tax Credit

- work eligibility
  - 16 or more hours per week
- family eligibility
  - children (in full time education or younger)
- income eligibility
  - if a family's net income is below a certain threshold, adult credit plus age-dependent amounts for each child
  - if income is above the threshold then the amount of credit is tapered away at 55% per extra pound of net income – previously 70%
The UK and US tax credit systems compared

- A puzzle on the relative impact of WFTC and EITC

The WFTC design

- Is this an ‘optimal’ design given efficiency and distributional considerations:
  - Is an hours eligibility rule optimal?
  - At what hours point should it be set?
  - Is the overall structure of the WFTC optimal?
Interactions with other taxes and benefits

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

WFTC interactions with other taxes and benefits in the UK

<table>
<thead>
<tr>
<th>Net earnings</th>
<th>Other income</th>
</tr>
</thead>
<tbody>
<tr>
<td>£0.00</td>
<td>£0.00</td>
</tr>
<tr>
<td>£50.00</td>
<td>£50.00</td>
</tr>
<tr>
<td>£100.00</td>
<td>£100.00</td>
</tr>
<tr>
<td>£150.00</td>
<td>£150.00</td>
</tr>
<tr>
<td>£200.00</td>
<td>£200.00</td>
</tr>
<tr>
<td>£250.00</td>
<td>£250.00</td>
</tr>
<tr>
<td>£300.00</td>
<td>£300.00</td>
</tr>
</tbody>
</table>

single parent on minimum wage
The interaction with other benefits

Assessing the design

- Requires a reliable structural simulation model that captures decisions and the budget constraint accurately
- Two components:
  - budget constraint is approximated by number of discrete points.
  - choose hours of work according to discrete choice model with hours options:
Weekly Hours Worked
Low Education Single Mothers (aged 18-45)

Weekly Hours Worked
Low Education Single Childless Women (aged 18-45)
Key features of a ‘realistic’ structural model

- budget constraint that allows for tax/benefit interactions
- discrete decisions over hours worked
- heterogeneity – demographics, ethnicity, unobs. het.
- fixed costs of work – obs. and unobs. het.
- stigma/hassle costs – take-up versus eligibility
- childcare costs
- do individuals behave this way?

Specifying a structural labour supply model

- For lone parents say, utility function defined over net income and hours:
  \[ U(h, y_h) = u(h, y_h) + \epsilon_h \]
  - Where \( \epsilon_h \) is a discrete hours choice specific error
  - Approximate function by:
    \[ U(h, y_h) \approx \alpha_{11} y_h^2 + \alpha_{22} h^2 + \alpha_{12} y_h h + \beta_1 y_h + \beta_2 h + \epsilon_h \]
  - Heterogeneity enters model through \( \alpha \) and \( \beta \)
    - observed and unobserved heterogeneity
Specifying a structural labour supply model

- lone parents choose hrs/wk point

\[ h \in \{0, 10, 19, 26, 33, 40\} \]

- to maximise utility. With extreme value errors:

\[
\Pr[h = h_j] = \exp \left\{ U(h_j, y_{h_j}) \right\} / \sum_{i=0}^{19} \exp \left\{ U(h_i, y_{h_i}) \right\}
\]

- Model additionally allows for:
  - Unobserved work-related (fixed) costs, \( WRC \)
  - Childcare costs, \( CC \)
  - Programme participation (hassle or ‘stigma’) costs, \( P \)

Take-up and WFTC

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

- Data from 1995-2003 (Family Resources Survey)
  - 1995-1999: pre-reform estimation data (ex-ante)
  - 2002-2003: ‘post-reform’ validation sample
  - Use complete sample for ex-ante analysis of 2004 and more recent reform proposals

Structural Model Elasticities

(a) Youngest Child Aged 11-18

<table>
<thead>
<tr>
<th>Earnings</th>
<th>Density</th>
<th>Extensive</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.3966</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>0.1240</td>
<td>0.5029</td>
<td>0.5029</td>
</tr>
<tr>
<td>140</td>
<td>0.1453</td>
<td>0.7709</td>
<td>0.3944</td>
</tr>
<tr>
<td>220</td>
<td>0.1723</td>
<td>0.7137</td>
<td>0.2344</td>
</tr>
<tr>
<td>300</td>
<td>0.1618</td>
<td>0.4920</td>
<td>0.0829</td>
</tr>
</tbody>
</table>

Participation elasticity 1.1295
Structural Model Elasticities

(c) Youngest Child  Aged  0-4

<table>
<thead>
<tr>
<th>Earnings</th>
<th>Density</th>
<th>Extensive</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.5942</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>0.1694</td>
<td>0.2615</td>
<td>0.2615</td>
</tr>
<tr>
<td>140</td>
<td>0.0984</td>
<td>0.6534</td>
<td>0.1570</td>
</tr>
<tr>
<td>220</td>
<td>0.0767</td>
<td>0.5865</td>
<td>0.1078</td>
</tr>
<tr>
<td>300</td>
<td>0.0613</td>
<td>0.4984</td>
<td>0.0834</td>
</tr>
</tbody>
</table>

Participation elasticity 0.6352

- Check the robustness of the structural model by the ability to simulate the impact of the WFTC reform

Structural Evaluation Simulation Results:
WFTC Expansion

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

Notes: Simulated on FRS data; Standard errors in italics.
All: 5.12 without change in take-up – key impact effect
Adult and Child Elements of the WFTC

<table>
<thead>
<tr>
<th>Adult</th>
<th>Child Awards by Age</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>child</td>
</tr>
<tr>
<td></td>
<td>0 to 10</td>
</tr>
<tr>
<td>Mar-99</td>
<td>£58.80</td>
</tr>
<tr>
<td>Oct-99</td>
<td>£56.60</td>
</tr>
<tr>
<td>Mar-00</td>
<td>£56.60</td>
</tr>
<tr>
<td>Jun-01</td>
<td>£61.90</td>
</tr>
<tr>
<td>Jun-02</td>
<td>£64.40</td>
</tr>
</tbody>
</table>

Increase 19.70% 66.40% 20.50% 0.00%

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

Impact of WFTC reform on lone parent, 2 children

Notes: Two children under 5. Assumes hourly wage of £4.10, no housing costs or council tax liability and no childcare costs.
Child Rates of *Income Support*

<table>
<thead>
<tr>
<th>child</th>
<th>child</th>
<th>child</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 10</td>
<td>11 to 15</td>
<td>16 to 18</td>
</tr>
<tr>
<td>Mar-99</td>
<td>£21.90</td>
<td>£28.00</td>
</tr>
<tr>
<td>Oct-99</td>
<td>£27.00</td>
<td>£28.00</td>
</tr>
<tr>
<td>Mar-00</td>
<td>£28.40</td>
<td>£28.40</td>
</tr>
<tr>
<td>Mar-01</td>
<td>£33.00</td>
<td>£33.00</td>
</tr>
<tr>
<td>Oct-01</td>
<td>£34.50</td>
<td>£34.50</td>
</tr>
<tr>
<td>Mar-02</td>
<td>£34.50</td>
<td>£34.50</td>
</tr>
</tbody>
</table>

Increase 57.50% 23.30% 5.70%

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

**Impact of WFTC & increases in welfare benefit on lone parent, 2 children**

- Notes: Two children under 5. Assumes hourly wage of £4.10, no housing costs or council tax liability and no childcare costs.
Structural Evaluation Simulation Results:
All Reforms

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>y-child 0 to 2</th>
<th>y-child 3 to 4</th>
<th>y-child 5 to 10</th>
<th>y-child 11 to 18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in employment rate:</td>
<td>3.68</td>
<td>0.65</td>
<td>4.53</td>
<td>4.83</td>
<td>4.03</td>
</tr>
<tr>
<td></td>
<td>0.84</td>
<td>0.6</td>
<td>0.99</td>
<td>0.94</td>
<td>0.71</td>
</tr>
<tr>
<td>Average change in hours:</td>
<td>1.02</td>
<td>0.01</td>
<td>1.15</td>
<td>1.41</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>0.23</td>
<td>0.21</td>
<td>0.28</td>
<td>0.28</td>
<td>0.22</td>
</tr>
</tbody>
</table>

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

Robustness of the structural model:

- Compare structural model simulations based on estimated parameters to quasi-experimental ex-post evaluation
- The idea is to simulate the quasi-experimental estimate (moment)
- Comparing work decisions of eligible versus those who are not eligible before and after the reform
- Identify average employment 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
Employment rates of single women in the UK

![Graph showing employment rates of single women in the UK]

**Difference-in-Differences: Lone Mothers Employment**

<table>
<thead>
<tr>
<th>Single Women</th>
<th>Marginal Effect</th>
<th>Standard Error</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Resources Survey</td>
<td>3.57</td>
<td>0.81</td>
<td>74,959</td>
</tr>
<tr>
<td>Labour Force Survey</td>
<td>3.81</td>
<td>0.33</td>
<td>233,208</td>
</tr>
</tbody>
</table>

Drop: Summer 1999 – Spring 2000 inclusive; individuals aged over 45.
Outcome: employment. Average impact x 100, employment percentage.
Matching Covariates: age, education, region, ethnicity,..
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)

What of the ‘optimal’ design?

• Given the structural discrete choice estimates and the implied elasticities at extensive and intensive margin, we can pose the question:
  – what is the optimal tax and transfer schedule?
  – is the WFTC+ ‘optimal’ for reasonable social welfare weights?

\[ \Gamma(U \mid \theta) = \frac{1}{\theta} \{(\exp U)^\theta - 1\} \]

• When \( \theta \) is negative, the function favours the equality of utilities; We solve the schedule for a series of values – central estimates us -0.2
Should there be an hours eligibility condition or ‘bonus’?

- Is it optimal to have a ‘minimum hours’ eligibility?
- If we can have a 16 hours condition, what should it look like?
- Is 16 the optimal choice?

An Optimal Schedule, Youngest Child Aged 0-4
An Optimal Schedule, Youngest Child Aged 11-18

Weekly earnings

March 2002 prices

No hours rule
16 hours rule

An Optimal Schedule, Youngest Child Aged 11-18

Weekly earnings

March 2002 prices

No hours rule
16 hours rule
Optimal hours rule
An Optimal Schedule, Youngest Child Aged 0-4

An Optimal Schedule, Impact on Hours worked, Youngest Child Aged 5-10
Social Welfare Weights

The impact of welfare weights: Youngest Child Aged 5-10
**Implications?**

- Resolved the US-EITC, UK-WFTC puzzle
- WFTC/IS type schedule looks optimal overall

But

- Age of children matter
  - Only reduce current marginal tax rates on participation for parents with children of school age
- Hours rules can be optimal
  - No hours conditioning for mothers with youngest child less than 5, higher hours condition for mothers with older child.
- Administration and integration

---

**Extensions: ….**

- What of work experience and wages?
- Indeed what is the long-term program impact on gross wages?
- Couples decision making?
  - UK has moved to individual income taxation but in-work tax credits are family income based
  - targeting in collective labour supply models
- What impact on fertility and family formation?
Reform impacts on budget constraints for mother in couple

Notes: Two children under 5. Assumes hourly wage of £4.10, no housing costs or council tax liability and no childcare costs.
The first earner in the couple is assumed to earn £300 per week in 2002 prices.

Experience and Wages

• Work experience and earnings?
  – Card and Hyslop (2004)
  – SSP Canadian single parents
• ERA results for the UK?
SSP experiment: dynamic effects on employment rates?

SSP experiment: dynamic effects on wages and productivity?
Extensions: More to do….

- The *Integrated Family Supplement*?
  - The ‘IFS’
- Mirrlees Review…
  - [www.ifs.org.uk/mirrleesreview](http://www.ifs.org.uk/mirrleesreview)

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**Some References:**


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Table A1: Sample Descriptives for Single Women

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No child</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>0.753</td>
<td>0.762</td>
<td>0.769</td>
<td>0.770</td>
<td>0.774</td>
<td>0.767</td>
<td>0.775</td>
</tr>
<tr>
<td>Non-white</td>
<td>0.073</td>
<td>0.077</td>
<td>0.080</td>
<td>0.084</td>
<td>0.091</td>
<td>0.098</td>
<td>0.102</td>
</tr>
<tr>
<td>Left education before 16</td>
<td>0.078</td>
<td>0.072</td>
<td>0.062</td>
<td>0.057</td>
<td>0.052</td>
<td>0.047</td>
<td>0.043</td>
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<tr>
<td>Left education at 16 or 17</td>
<td>0.394</td>
<td>0.381</td>
<td>0.375</td>
<td>0.375</td>
<td>0.363</td>
<td>0.353</td>
<td>0.356</td>
</tr>
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<td>London and South-East</td>
<td>0.341</td>
<td>0.350</td>
<td>0.349</td>
<td>0.347</td>
<td>0.354</td>
<td>0.360</td>
<td>0.352</td>
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<tr>
<td>Rented accommodation</td>
<td>0.343</td>
<td>0.353</td>
<td>0.358</td>
<td>0.340</td>
<td>0.339</td>
<td>0.350</td>
<td>0.346</td>
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<td>Observations</td>
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<td>24410</td>
<td>23987</td>
<td>22558</td>
<td>23517</td>
<td>22846</td>
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<tr>
<td>Child</td>
<td></td>
<td></td>
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<td></td>
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<td>Work</td>
<td>0.417</td>
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<td>0.444</td>
<td>0.464</td>
<td>0.477</td>
<td>0.487</td>
<td>0.496</td>
</tr>
<tr>
<td>Age</td>
<td>32.330</td>
<td>32.580</td>
<td>32.655</td>
<td>32.863</td>
<td>33.181</td>
<td>33.280</td>
<td>33.288</td>
</tr>
<tr>
<td>Non-white</td>
<td>0.100</td>
<td>0.099</td>
<td>0.091</td>
<td>0.098</td>
<td>0.106</td>
<td>0.112</td>
<td>0.111</td>
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<tr>
<td>Left education before 16</td>
<td>0.209</td>
<td>0.196</td>
<td>0.189</td>
<td>0.169</td>
<td>0.154</td>
<td>0.161</td>
<td>0.155</td>
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<tr>
<td>Left education at 16 or 17</td>
<td>0.632</td>
<td>0.627</td>
<td>0.633</td>
<td>0.635</td>
<td>0.646</td>
<td>0.641</td>
<td>0.637</td>
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<tr>
<td>London and South-East</td>
<td>0.285</td>
<td>0.285</td>
<td>0.285</td>
<td>0.293</td>
<td>0.294</td>
<td>0.303</td>
<td>0.301</td>
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<tr>
<td>Rented accommodation</td>
<td>0.686</td>
<td>0.704</td>
<td>0.708</td>
<td>0.696</td>
<td>0.697</td>
<td>0.694</td>
<td>0.676</td>
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<tr>
<td>Number of kids</td>
<td>1.783</td>
<td>1.785</td>
<td>1.791</td>
<td>1.784</td>
<td>1.778</td>
<td>1.776</td>
<td>1.794</td>
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<tr>
<td>Observations</td>
<td>14613</td>
<td>14172</td>
<td>14550</td>
<td>14343</td>
<td>13572</td>
<td>14097</td>
<td>13996</td>
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</tbody>
</table>
Net Income schedule:

\[ y_{hP} = wh + I - t(wh, I) - C_h + \Psi_0(w, h, I) + P\Psi_1(w, h, I) \]

or \[ y_{hP} = \tilde{y}_{hP} + P\Psi_1(w, h, I) \]

the tax-credit payment function \( \Psi_1(w, h, I) \) depends on:
- hours (through the hours condition of entitlement)
- other income \( I \)
- demographic characteristics \( X \)

Take-up

Utility ‘cost’ of receiving in-work support

\[ \eta = X_\eta \beta_\eta + u_\eta \]

claim \( \Psi_1 \) in FC/WFTC at hours \( h_j \) if:

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

where \( C \) is the fixed cost of work. The utility cost among those who are eligible for WFTC at hours \( h_j \) and choose to claim WFTC must not exceed the utility gain from receipt of WFTC transfer income relative to non-receipt:

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

\[ u_\eta < \Omega_U \quad \text{where} \quad \Omega_U = U(h_j, \tilde{y}_{h_j} + \Psi_1 - C) - U(h_j, \tilde{y}_{h_j} - C) - X_\eta \beta_\eta \]
Preferences and Take-Up

Preferences:

\[ U_P(h, y_{hp}, P, C) = a_{11}(\gamma_{h} + P \cdot \Psi_{1} - C)^2 + a_{12}(\gamma_{h} + P \cdot \Psi_{1} - C) \cdot h + \beta_{1}(\gamma_{h} + P \cdot \Psi_{1} - C) + \beta_{2}h + \epsilon_{hp} - (P \cdot E_{h}) \cdot \eta \]

\[ = U(h, \gamma_{h} + P \cdot \Psi_{1} - C) - (P \cdot E_{h}) \cdot \eta \]

where \( E_{h} = 1(\Psi_{1} > 0) \) is an indicator of eligibility at hours \( h \),

\( C \) represents the ‘fixed cost’ of work

and \( \eta = X_{\eta}\beta_{\eta} + u_{\eta} \) is ‘cost’ of receiving in-work support.

The introduction of these additional terms is important in evaluation of a reform which increases generosity

Stochastic specification

Stochastic Preferences

\[ \beta_{1} = X_{1}\beta_{1x} + u_{y} \]
\[ \beta_{2} = X_{2}\beta_{2x} + u_{h} \]
\[ a_{11} = X_{11}a_{11x} \]
\[ a_{22} = X_{22}a_{22x} \]
\[ a_{12} = X_{12}a_{12x} \]

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

\[ C(h,X_f,X_{cc},p_c,u_f) = WRC_1 \cdot I_{h1} + WRC_2 \cdot I_{h2} + p_c \cdot h_{cc} \]
\[ = (X_f \beta_{f1} + u_f) \cdot I_{h1} + (X_f \beta_{f2}) \cdot I_{h2} + p_c \cdot G(h|X_{cc}) \]

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 \( X_{cc} \).

Choice probabilities:

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

where \( u = (u_w, u_y, u_h, u_{cc}, u_f) \)
Likelihood specification

These preferences, fixed costs, childcare costs and stigma cost expressions provide the choice probabilities:

\[ \Pr(h = h_j, P = p \mid X, u) \]

From which we construct the sample log likelihood:

\[
\log L = \sum \log \left[ \int_{u_{-\eta}} \int_{u_{\eta} \in \Omega_U} \prod_{j} \Pr(h = h_j, P = 1 \mid X, u) 1^{(h = h_j, \mathcal{E}_{h_j} = 1, P = 1)} f(u_{\eta}) du_{\eta} 
+ \int_{u_{\eta} \in \Omega_U} \prod_{j} \Pr(h = h_j, P = 0 \mid X, u) 1^{(h = h_j, \mathcal{E}_{h_j} = 1, P = 0)} f(u_{\eta}) du_{\eta} 
+ \int_{u_{\eta}} \prod_{j} \Pr(h = h_j, P = 0 \mid X, u) 1^{(h = h_j, \mathcal{E}_{h_j} = 0)} f(u_{\eta}) du_{\eta} \right] f(u_{-\eta}) du_{-\eta}
\]

where \( u_{-\eta} = (u_w, u_y, u_h, u_f, u_{cc}) \)
### Structural Evaluation Model: Parameter Estimates

| Parameter               | Estimate | Standard Error | z      | P > |z| |
|-------------------------|----------|----------------|--------|-----|-----|
| \(\alpha_{11}\): 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     | -0.050   | 0.061          | -0.969 | 0.332 |

| \(\alpha_{22}\): Constant | 0.308    | 0.027          | 11.317 | 0.000 |
| Youngest Child 0-2      | 0.024    | 0.002          | 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 |

| \(\alpha_{12}\): Constant | 0.010    | 0.004          | 2.093  | 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 |

| \(\beta_1\): 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  | 0.060 |
| Non-white               | -0.068   | 0.017          | -3.966 | 0.000 |
| Random Term (SD)        | 0.004    | 0.009          | 0.400  | 0.680 |

| \(\beta_2\): 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          | 13.185  | 0.000 |
| Youngest Child 0-2      | 0.017    | 0.027          | 0.614   | 0.530 |
| Youngest Child 3-4      | 0.002    | 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...
Award increased by 70% of childcare expenses up to £135 (£200) 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

Childcare expenses up to £60 (£100) for 1 (more than 1) child under 12 disregarded when calc income

<table>
<thead>
<tr>
<th>$\eta$:</th>
<th>Constant</th>
<th>0.252</th>
<th>0.061</th>
<th>-4.120</th>
<th>0.000</th>
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<tr>
<td>October 1999</td>
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<td>-1.809</td>
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<tr>
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<td>0.103</td>
<td>2.085</td>
<td>0.037</td>
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</tbody>
</table>

$FC_1$: Constant | 8.955 | 6.078 | 1.283 | 0.199 |
Youngest Child 0-2 | 42.298 | 14.532 | 2.911 | 0.004 |
Youngest Child 3-4 | 32.760 | 12.819 | 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 | 3.149 | 1.069 | 0.091 |

$FC_2$: Constant | 13.963 | 5.576 | 2.504 | 0.012 |
Youngest Child 0-2 | 21.604 | 14.245 | 1.481 | 0.139 |
Youngest Child 3-4 | -4.638 | 11.045 | -0.420 | 0.675 |
Youngest Child 5-10 | 13.963 | 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
Changes in marginal tax rates: all working parents
Marginal rates at the bottom remain high

An Optimal Schedule, no hours condition
An Optimal Schedule, Youngest Child Aged 5-10

The Structure of the Constraint, top-rate 50%