A lifetime perspective on the incentive and distributional effects of the UK tax system

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Preliminary – comments welcome
Motivation

- Welfare policies aim to redistribute at minimum efficiency cost
- Reforms typically justified by static arguments and evidence
- But annual inequality is very different to lifecycle inequality
  - Inequality exacerbated in annual snapshot
  - No distinction between inter- and intrapersonal redistribution
  - Difficult to disentangle variation from different sources: permanent individual differences, predictable lifecycle changes, decisions motivated by dynamic considerations, and transitory shocks
- Distortions mismeasured in a static framework
  - Labour supply and education choices partly driven by dynamic considerations
What we do

Today:

- How progressive is the UK tax and benefit system from annual and lifecycle perspectives?
- How has it changed over time?
- What are the implications for inequality and its sources?

Project also addresses:

- How does tax and benefit system affect work incentives over lifecycle?
Literature: redistribution and inequality

• Annual inequality higher than lifecycle inequality
• Annual inequality reduced more by tax and benefit system (Liebman, 2002, Bjorklund and Palme, 1997; Bengtsson et al, 2011)
• Much redistribution is across lifecycle rather than individuals (Bovenberg et al, 2008; O’Donoghue, 2001; Bartels, 2011)
• Retirement pensions possibly most important component of transfers across lifecycle (van de Ven, 2005)
• Majority (50-90%) of inequality due to initial conditions (Huggett et al, 2011; Storesletten et al, 2004; Keane and Wolpin, 1997)
How we do it

• Lifecycle model of female education, employment and saving choices
• Focus is on families containing a woman
• Female decisions sensitive to family circumstances and market conditions, including policy environment
• Careful modelling of employment, earnings and family composition
• Detailed model of UK tax and benefit system
  – Held fixed throughout life
What we leave out

- Retirement is simplified
  - Deterministic retirement age and end of life
  - Retirement excluded from analysis of tax and benefit system

- Taxes and benefits
  - Taxation of capital
  - Indirect taxation
  - Disability

- Endogenous male behavioural responses
Model: overview of female lifecycle

Life in four stages:

1. Initial conditions
   - Wealth and ability

2. Education (up to 18/21)
   - Secondary, A-levels or university (determines type of human capital)

3. Working life (18/21-59)
   - Labour supply {0hrs, 20hrs, 40hrs} and consumption
   - Partnering and childbearing

4. Retirement (60-69)
   - Consumption only
Model: dynamics of female earnings

- **Wage equation**

  \[ w_{sia} = \ln W_s + \alpha_s \ln(e_{ia} + 1) + v_{sia} \]

  - Log wage
  - Market wage rate
  - Experience
  - Productivity

  \[ v_{sia} = \rho v_{sia-1} + u_{sia} \]

- **Experience accumulation**

  \[ e_{ia+1} = e_{ia} (1 - \delta_s) + \delta_{sPT} 1[l_{ia} = 20] + \delta_{sFT} 1[l_{ia} = 40] \]

  - Depreciation rate
  - PT accumulation rate
  - FT accumulation rate
Model: dynamics of family income

- (Exogenous) family formation dynamics
  - Children
    - At most 1 child
    - Arrival probability depends on female age, education and presence of partner
    - Departure with certainty when child reaches age 18
  - Partners
    - Characterised by education, employment status and wage
    - Arrival probability for male with given education depends on female age and education
    - Departure probability depends on female age, presence of child and male education
Model: dynamics of family income

- Male wage equation and selection into employment
  \[ w_{s^{m}_{ia}}^m = \ln W_{s^{m}_{ia}}^m + \alpha_{s^{m}_{ia}}^m \ln (a - 18) + \nu_{s^{m}_{ia}}^m \]
  
  \[ \nu_{s^{m}_{ia}}^m = \rho_{v_{s^{m}_{ia-1}}^m} + u_{s^{m}_{ia}}^m \]
  \[ u_{s^{m}_{ia}}^m \sim N(0, \sigma_{u_{s^{m}_{ia}}}^2) \]
  \[ \nu_{s^{m}_{ia}}^m \sim N(0, \sigma_{v_{s^{m}_{ia}}}^2) \]

- Detailed model of tax and benefit system (FORTAX)
  - Mostly 2006 tax and benefit system
  - Taxes: income tax, NI, council tax
  - Benefits: child benefit, maternity grant, tax credits, income support, housing benefit, council tax benefit, free school meals
Model: decision-making environment

- Risk averse individuals faced with uncertainty
  - Own productivity (health)
  - Family dynamics: partnering/separation, child bearing
  - Partner employment and income

- No insurance market
  - Only implicit insurance through human capital, savings and public policy

- Credit constraints
  - So public policy may facilitate transfers across lifecycle

- Decisions taken to maximise expected lifetime utility

\[
V_a (X_{ia}) = \max \left\{ \prod_{b=1}^{A} \beta^{b-a} U(c_{ib}, l_{ib}; X_{ib}) \mid X_{ia} \right\}
\]
Model: data and estimation

All results below are based on data simulated by the model
- Lifecycles simulated for lots of imaginary individuals given initial conditions
- Simulating an individual involves:
  - Drawing exogenous shocks (e.g. for productivity, family composition, ability)
  - Using the model to determine the choices the individual will make at each age

What guarantees that the simulated data mimics patterns in the real data?
- Model designed to be able to capture key features of real data
- Parameters chosen to make simulated data look as like real data as possible

Real data: BHPS unbalanced panel of 5,300 females over 16 waves, 1991–2006
- 12% in all 16 waves, 56% in six waves or fewer; 17% observed starting working life

Estimation by method of simulated moments (MSM)
- Calculate moments of real data
- Calculate same moments of simulated data
- Use minimisation routine to minimise distance between real and simulated moments
Model fit (1): Female wage rates

Female Wage Rate
Percentiles 10, 25, 50 75 and 90

Low education
A-levels and equivalent
University education

Percentiles 10, 25, 50 75 and 90
Female Wage Rate
data sim
Model fit (2): Female earnings

Female Earnings
Percentiles 10, 25, 50, 75 and 90

Low education

A-levels or equivalent

University education

Percentiles 10, 25, 50, 75 and 90

Female Earnings data sim

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Model fit (3): Gross income distributions

Equivalised gross annual family income
Sample window

Low education
A-levels or equivalent
College education

Gross income

data simulations

density: ginc_pc

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Model fit (4): gross income across the lifecycle

Equivalised family LC gross income
by female education and age

mean

st deviation

data, s=1
simulation, s=1
data, s=2
simulation, s=2
data, s=3
simulation, s=3
Model fit (5): gross income mobility

Transitions for equivalised gross family income; consecutive years

<table>
<thead>
<tr>
<th>Real data</th>
<th>Quintile 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Quintile 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile 1</td>
<td>0.801</td>
<td>0.165</td>
<td>0.025</td>
<td>0.007</td>
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</tr>
<tr>
<td>2</td>
<td>0.109</td>
<td>0.650</td>
<td>0.196</td>
<td>0.039</td>
<td>0.006</td>
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<tr>
<td>3</td>
<td>0.023</td>
<td>0.127</td>
<td>0.627</td>
<td>0.200</td>
<td>0.023</td>
</tr>
<tr>
<td>4</td>
<td>0.005</td>
<td>0.028</td>
<td>0.141</td>
<td>0.644</td>
<td>0.182</td>
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<tr>
<td>Quintile 5</td>
<td>0.002</td>
<td>0.006</td>
<td>0.021</td>
<td>0.108</td>
<td>0.863</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Simulated data</th>
<th>Quintile 1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Quintile 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile 1</td>
<td>0.801</td>
<td>0.157</td>
<td>0.037</td>
<td>0.004</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.118</td>
<td>0.688</td>
<td>0.161</td>
<td>0.027</td>
<td>0.005</td>
</tr>
<tr>
<td>3</td>
<td>0.039</td>
<td>0.124</td>
<td>0.619</td>
<td>0.207</td>
<td>0.010</td>
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<tr>
<td>4</td>
<td>0.015</td>
<td>0.029</td>
<td>0.152</td>
<td>0.637</td>
<td>0.166</td>
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<tr>
<td>Quintile 5</td>
<td>0.002</td>
<td>0.012</td>
<td>0.015</td>
<td>0.132</td>
<td>0.840</td>
</tr>
</tbody>
</table>
Definitions: income, average tax rate (ATR) and progressivity

- Gross earnings is earnings from employment
- Equivalised using modified OECD equivalence scale
- Average tax rate:
  \[ ATR = \frac{N}{E} = \frac{T - B}{E} \]
  \( E \) = equivalised d gross family earnings
  \( N \) = equivalised d taxes net of benefits
  \( T \) = equivalised d family tax liability
  \( B \) = equivalised d family benefit entitlements

- Progressivity = ATR increases with equivalised gross family earnings
- Cross-section dataset: randomly selected one age for each family
Q1: How progressive is the UK tax and benefit system from annual and lifecycle perspectives?
Median net tax and ATR by gross income decile
2006 tax system

2006: Median net tax and ATR by decile of gross family income
Equivalised; no childcare costs

Net tax
ATR

Equivalised gross family income decile

Annual income
Annualised lifecycle income
Median cross-sectional ATR by age and quintile
2006 tax system

2006: Median cross-sectional ATR for all females
No childcare costs

By cross-sectional income quintile

By lifecycle income quintile

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Income shares by decile
2006 tax system

Income shares by decile in 2006 (equiv income)

Decile of income distribution

- annual gross income
- annual net income
- LC gross income
- LC net income
Q2: How has progressivity changes over time?
Change in median ATR by income quintile, 1990–2006

1990-2006: Median ATR across all families
By gross family income quintile; no childcare costs

Median ATR
Year
Annual

Lifecycle
<table>
<thead>
<tr>
<th></th>
<th>Annual gross</th>
<th>Annual net</th>
<th>Lifecycle gross</th>
<th>Lifecycle net</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintile 1</td>
<td>+0.2%</td>
<td>+1.4%</td>
<td>-0.0%</td>
<td>+0.6%</td>
</tr>
<tr>
<td>2</td>
<td>-0.9%</td>
<td>-0.3%</td>
<td>-0.2%</td>
<td>+0.1%</td>
</tr>
<tr>
<td>3</td>
<td>+0.0%</td>
<td>-0.3%</td>
<td>-0.1%</td>
<td>-0.0%</td>
</tr>
<tr>
<td>4</td>
<td>+0.2%</td>
<td>-0.2%</td>
<td>+0.0%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Quintile 5</td>
<td>+0.5%</td>
<td>-0.6%</td>
<td>+0.3%</td>
<td>-0.5%</td>
</tr>
</tbody>
</table>
Q3: What are the implications for inequality and its sources?
### Variance decomposition for annual income: within vs between groups

<table>
<thead>
<tr>
<th></th>
<th>Within</th>
<th>Between</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female earnings</td>
<td>0.445</td>
<td>0.555</td>
<td>1</td>
</tr>
<tr>
<td>Equivalised gross family income</td>
<td>0.563</td>
<td>0.437</td>
<td>1</td>
</tr>
<tr>
<td>Equivalised net family income</td>
<td>0.577</td>
<td>0.423</td>
<td>1</td>
</tr>
<tr>
<td>% reduction in variance</td>
<td>60.1</td>
<td>62.3</td>
<td>61.1</td>
</tr>
</tbody>
</table>

**Within** = variation in annual income (i.e. transitory)

**Between** = variation in lifecycle income (i.e. permanent)
Change in annual income variance: 1991–2006

<table>
<thead>
<tr>
<th></th>
<th>Within</th>
<th>Between</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalised gross family income</td>
<td>-0.9%</td>
<td>+0.3%</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Equivalised net family income</td>
<td>-8.0%</td>
<td>-6.5%</td>
<td>-6.7%</td>
</tr>
</tbody>
</table>
## Variance decomposition for lifecycle income

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>Initial conditions</th>
<th>Education</th>
<th>Family</th>
<th>Residual</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female earnings</td>
<td>0.314</td>
<td>0.244</td>
<td>0.020</td>
<td>0.419</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Equivalised gross family income</td>
<td>0.169</td>
<td>0.234</td>
<td>0.055</td>
<td>0.538</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Equivalised net family income</td>
<td>0.174</td>
<td>0.216</td>
<td>0.035</td>
<td>0.571</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>% reduction in variance</td>
<td>62.1</td>
<td>65.9</td>
<td>76.0</td>
<td>60.8</td>
<td>63.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th></th>
<th>Family</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalised gross family income</td>
<td></td>
<td>0.051</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equivalised net family income</td>
<td></td>
<td>0.047</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>% reduction in variance</td>
<td></td>
<td>63.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Tax and benefit system broadly progressive, but not clearly more so from cross-sectional rather than lifecycle perspective
• We are less pessimistic than other papers about ability of tax and benefit system to affect lifecycle outcomes
• Reforms since 1990 have:
  – Favoured bottom of distribution
  – Affected within (annual) and between (lifecycle) inequality fairly evenly
• Sources of lifecycle inequality:
  – Initial conditions and education account for over half of variability in lifecycle earnings
  – Education important: selection in partnering and odds of separation