Effects of taxes and safety net pensions on life-cycle labor supply, savings and human capital: The case of Australia

Fedor Iskhakov,
Australian National University and CEPAR

Michael Keane,
University of Oxford and CEPAR

International Pension Workshop
January 19, 2017
Research objectives

Main research question:
- Labor supply responses to Age Pension and taxes
- Over the whole life cycle (long run effects)
- With anticipated and unanticipated policy changes

Structural approach:
- Stochastic lifecycle model in discrete time
- Estimated with the method of simulated moments using Australia-wide longitudinal household survey (HILDA)
- Simulate counterfactual scenarios of alternative policy settings
- Simulate anticipated and unanticipated changes in policy
Stochastic life cycle model

Main features of the model:

1. Discrete time = age from 19 to 100
2. Annual decisions on
   - How much to consume of accumulated wealth (continuous choice)
   - How much to work from [0, 24, 40, 45, 50, 60] hours per week (discrete choice)
3. Stochastic elements in the model
   - Survival process (longevity risk): survival probability amplifies discounting of future utility
   - Multiplicative idiosyncratic log-normal wage shock: unforeseen circumstances of employment
4. Random utility framework and risk aversion
   - Rational forward-looking decision makers
   - Solution to the model are time-consistent decision rules
   - Constant relative risk aversion (CRRA) specification for the instantaneous utility
Stochastic life cycle model

- **Human capital accumulation**
  - Learning-by-doing → Accumulating work experience is human capital
  - Human capital increases future wage → Wage at early ages is only part of compensation

- **Wealth accumulation and decumulation**
  - Endogenous, dependent of wage income and consumption decisions
  - Credit constraint and bequest motive

- **Observed and unobserved heterogeneity in the population**
  - Education → Initial endowment and human capital technology
  - Unobserved types → Preference for leisure

- **Australian institutional settings**
  - Age Pension → Accurate representation of means testing
  - Superannuation → Lump sum at age 65 based on accumulated human capital
  - Tax rules → Simplified representation with 2 tax brackets
Preliminary results

- The model replicates available historical data very well
- Direction of the effects for all simulated policy changes are as anticipated

**Heterogeneity in labor supply effects**
- Increase along the life cycle for all education groups
- Smaller elasticity in the beginning of life cycle for higher educated
- Larger elasticity in the end of life cycle for higher educated
- Negative elasticity in mid-life for college graduates

**Sizable effects of changes of social security policy**
- Effects appear early in the life cycle
- Stronger effect on the extensive margin
- In the absence of safety net pension, labor supply before 60 would be about 20% higher, and after 65 up to 60% higher
Time and choices

- Discrete time, finite horizon
  \( t_0 = \) right after school,
  \( T = 100 \) time of certain death
  Time periods are calendar years, data is annual

- Choices
  1. consumption/savings (continuous) subject to credit constraint
     \[ c_t \leq M_t \]
     \( M_t \) – consumable wealth in the beginning of the period \( t \)
  2. hours of labor supply (discrete) subject to market frictions
     \[ h_t \in H \) (discrete, 6 levels)\]
### K-medians cluster analysis

<table>
<thead>
<tr>
<th>$h_t$</th>
<th>Nobs</th>
<th>annual</th>
<th>week</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>18,168</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>500</td>
</tr>
<tr>
<td>1</td>
<td>4,484</td>
<td>1200</td>
<td>24</td>
<td>500</td>
<td>1600</td>
</tr>
<tr>
<td>2</td>
<td>15,930</td>
<td>2000</td>
<td>40</td>
<td>1600</td>
<td>2125</td>
</tr>
<tr>
<td>3</td>
<td>5,466</td>
<td>2250</td>
<td>45</td>
<td>2133</td>
<td>2368</td>
</tr>
<tr>
<td>4</td>
<td>8,735</td>
<td>2500</td>
<td>50</td>
<td>2375</td>
<td>2750</td>
</tr>
<tr>
<td>5</td>
<td>6,259</td>
<td>3000</td>
<td>60</td>
<td>2750</td>
<td>4200</td>
</tr>
</tbody>
</table>

### Correspondence to HILDA

<table>
<thead>
<tr>
<th></th>
<th>Empl FT</th>
<th>Empl PT</th>
<th>Unemp</th>
<th>OLF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>251</td>
<td>1,260</td>
<td>1,269</td>
<td>13,329</td>
</tr>
<tr>
<td>1</td>
<td>880</td>
<td>3,604</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>15,814</td>
<td>116</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>5,466</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>8,735</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>6,259</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
State variables

- **Human capital**, learning-by-doing
  - \( E_t \) is fraction of total working time in total time budget
  - Bounded to \([0, 1]\)
  - Everybody starts with \( E_0 = 0 \)
  - Simple recursive formula for \( E_{t+1} \)

- **Heterogeneity**
  - Education \( \rightarrow \) Endowment + human capital production technology
  - Unobserved \( \rightarrow \) Preference for leisure

- **State variables**
  1. Consumable wealth \( M_t \) (continuous, endogenous grid)
  2. Work experience \( E_t \) (continuous, discretized)
  3. Education (discrete, constant over time)
  4. Unobserved heterogeneity types (discrete, constant over time)

\[
X_t = (M_t, E_t, \text{education, type})
\]
Wage

- Employment → Human capital (work experience) → Higher wage
- Human capital accumulation
  \[ K_t = f(\mathcal{E}_t, \mathcal{E}^2_t, \text{age, age}^2, \text{education, type}) \]
- Wage
  \[ \text{wage}_t = K_{t-1} \cdot R_t \cdot \epsilon^{\text{wage}}_t \]
  \[ R_t = 1 \] is uniform rental rate of human capital
- Two sources of uncertainty in the model:
  1. Survival process (longevity risk)
  2. Wage shocks \( \epsilon^{\text{wage}}_t \sim \ln N(0, \sigma^{\text{wage}}_t) \)
Intertemporal budget

\[ M_{t+1} = (M_t - c_t) (1 + r) + \text{AfterTax}(h_t \cdot \text{wage}_{t+1}) \]

\[ + \ tr_{t+1} \cdot 1\{t + 1 \leq 22\} \]

\[ + \ pens_{t+1} \cdot 1\{t + 1 \geq 65\} \]

\[ + \ super_{t+1} \cdot 1\{t + 1 = 65\} \]

- \( tr_{t+1} \) transfers from parents at young ages
- \( pens_{t+1} \) means tested old age pension
  - Simplified equation estimated outside of the model
- \( super_{t+1} \) accumulated DC pension (super) can be spent from age 65
Preferences

- CRRA utility of consumption
  \[ u(c_t) = \frac{c_t^{1-\zeta} - 1}{1 - \zeta} \]

- Additively separable disutility of work
  \[ \nu_t(h_t) = \mathbb{1}\{h_t > 0\} \cdot \kappa_{\text{type}}(\tau_{uh}) \cdot \kappa_{\text{age}}(t) \cdot \gamma(h_t) \]
  \[ \gamma(h_t) = (\gamma^{(1)}, \ldots, \gamma^{(5)}) \] associated with the discrete levels of hours

- Bequest utility
  \[ w(B_t) = b_{scale} \cdot \frac{(B_t + a_0)^{1-\xi} - a_0^{1-\xi}}{1 - \xi} \]
Bellman equation

\[ V_t(M_t, \mathcal{E}_t, \tau_{edu}, \tau_{uh}) = \max_{0 \leq c_t \leq M_t + a_0, h_t \in H_t} \left\{ u(c_t) - v_t(h_t, \tau_{uh}) \right\} \]

\[ + \delta_t \cdot \beta(\tau_{edu}) E \left[ V_{t+1}(M_{t+1}, \mathcal{E}_{t+1}, \tau_{edu}, \tau_{uh}) | X_t, c_t, h_t \right] \]

\[ + (1 - \delta_t)w(M_t - c_t) \right\}, \]

\( \tau_{edu} \) education (observed heterogeneity)

\( \tau_{uh} \) unobserved heterogeneity

\( a_0 \) credit constraint (maximum amount of borrowing)

\( \beta(\tau_{edu}) \) discount factor dependent on education

\( \delta_t \) survival probability
HILDA data

*Household, Income and Labor Dynamics in Australia* survey

- The primary source of data is Wave 12 of the Household, Income and Labor Dynamics in Australia Survey (HILDA).
- Broad social and economic longitudinal survey
- Annual waves 2001-2012
- Family dynamics, income and labor supply (each year)
- Modules on wealth, health and health insurance, retirement, fertility, literacy and numeracy (particular years, reoccurring)
- Australian national representative sample
- First wave administered to 19,914 people in total
- In 2011 (wave 11) 2,153 new households were added to replenish the sample.
## Education levels

<table>
<thead>
<tr>
<th>Original HILDA classification</th>
<th></th>
<th>Coarsened 3 level classification</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N obs</td>
<td>%</td>
<td>N obs</td>
</tr>
<tr>
<td>Postgrad (Master or PhD)</td>
<td>452</td>
<td>5.12</td>
<td>College</td>
</tr>
<tr>
<td>Grad diploma</td>
<td>436</td>
<td>4.93</td>
<td></td>
</tr>
<tr>
<td>Bachelor or honours</td>
<td>1,135</td>
<td>12.85</td>
<td></td>
</tr>
<tr>
<td>Diploma</td>
<td>793</td>
<td>8.97</td>
<td>High school</td>
</tr>
<tr>
<td>Certificate III or IV</td>
<td>2,697</td>
<td>30.52</td>
<td></td>
</tr>
<tr>
<td>Certificate I or II</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Year 12</td>
<td>1,007</td>
<td>11.40</td>
<td></td>
</tr>
<tr>
<td>Year 11 and below</td>
<td>2,316</td>
<td>26.21</td>
<td>Dropouts</td>
</tr>
<tr>
<td>Undetermined</td>
<td>0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
Age Pension equation

\[
\text{benefit}_{\text{max}} = 10,826.40 + 1249.67(\text{when year } \geq 2010)
\]
\[
\text{pension} = \max \left\{ \text{benefit}_{\text{max}} - \max \left[ \max \left\{ 0.26906 \, \text{income}, \ 0.00402(\text{wealth} - 140,326.90) \right\}, \ 0 \right], \ 0 \right\}
\]
Income tax function

\[
\text{tax} = \begin{cases} 
0 & \text{if income} < \text{thld}_1 = 13.92775, \\
0.22149 \cdot (\text{income} - \text{thld}_1) & \text{if } \text{thld}_1 \leq \text{income} < \text{thld}_2, \\
0.31183 \cdot (\text{income} - \text{thld}_2) + 0.22149 \cdot \text{thld}_1 & \text{if } \text{income} \geq \text{thld}_2 = 33.28298, 
\end{cases}
\]
Model solution, estimation and simulation

Solution: Dynamic programming
- For given value of all preference parameters and policy parameters
- Compute optimal decision rules from terminal period backwards through time
- Fast DC-EGM method for solving discrete-continuous choice model

Estimation: Method of simulated moments
- Minimize the distance between simulated and observed data
- Search for best parameters values using numerical optimization

Simulation
- Fix a large array of pseudo random numbers
- Endow a large number of simulated individuals with initial wealth and human capital
- Simulate choices and transitions of states from initial period forward
# Choice of moments to match in estimation

<table>
<thead>
<tr>
<th>Moments</th>
<th>Ages</th>
<th>N</th>
<th>Ages</th>
<th>N</th>
<th>Ages</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fraction of working</td>
<td>19 - 85</td>
<td>67</td>
<td>19 - 85</td>
<td>67</td>
<td>23 - 85</td>
<td>63</td>
</tr>
<tr>
<td>Hours conditional on working</td>
<td>19 - 75</td>
<td>57</td>
<td>19 - 78</td>
<td>60</td>
<td>23 - 71</td>
<td>49</td>
</tr>
<tr>
<td>Wage (conditional on working)</td>
<td>19 - 73</td>
<td>55</td>
<td>19 - 69</td>
<td>51</td>
<td>23 - 69</td>
<td>47</td>
</tr>
<tr>
<td>Variance of wage</td>
<td>19 - 73</td>
<td>55</td>
<td>19 - 69</td>
<td>51</td>
<td>23 - 69</td>
<td>47</td>
</tr>
<tr>
<td>Fraction of working 20h per week</td>
<td>19 - 85</td>
<td>67</td>
<td>19 - 85</td>
<td>67</td>
<td>23 - 85</td>
<td>63</td>
</tr>
<tr>
<td>Fraction of working 40h per week</td>
<td>19 - 85</td>
<td>67</td>
<td>19 - 85</td>
<td>67</td>
<td>23 - 85</td>
<td>63</td>
</tr>
<tr>
<td>Fraction of working 45h per week</td>
<td>19 - 85</td>
<td>67</td>
<td>19 - 85</td>
<td>67</td>
<td>23 - 85</td>
<td>63</td>
</tr>
<tr>
<td>Fraction of working 50h per week</td>
<td>19 - 85</td>
<td>67</td>
<td>19 - 85</td>
<td>67</td>
<td>23 - 85</td>
<td>63</td>
</tr>
<tr>
<td>Wealth</td>
<td>19 - 85</td>
<td>55</td>
<td>19 - 85</td>
<td>55</td>
<td>23 - 85</td>
<td>49</td>
</tr>
<tr>
<td>Transition from work work</td>
<td>19 - 74</td>
<td>56</td>
<td>19 - 77</td>
<td>59</td>
<td>23 - 70</td>
<td>48</td>
</tr>
<tr>
<td>Transition from no work to no work</td>
<td>19 - 85</td>
<td>67</td>
<td>19 - 85</td>
<td>67</td>
<td>25 - 85</td>
<td>61</td>
</tr>
<tr>
<td>Total</td>
<td>681</td>
<td>679</td>
<td></td>
<td>617</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Goodness of fit: fraction working high school graduates
Goodness of fit: fraction working for all education groups
Goodness of fit: fraction working and hours

working college

working highschool

working dropout

hours college

hours highschool

hours dropout

hours | working college

hours | working highschool

hours | working dropout
Goodness of fit: discrete levels of hours

- Hours 20pw college
- Hours 20pw highschool
- Hours 20pw dropout
- Hours 40pw college
- Hours 40pw highschool
- Hours 40pw dropout
- Hours 45pw college
- Hours 45pw highschool
- Hours 45pw dropout
- Hours 50pw college
- Hours 50pw highschool
- Hours 50pw dropout
Goodness of fit: wage and wealth
Policy simulation algorithm

- Solve the model separately under both baseline and alternative policy regimes
- Simulate the behavior implied by the estimated parameters

**Baseline:** whole life cycle under status quo policy (regime 1)
- Policy parameters are constant and known to the decision maker

**Anticipated:** Fully anticipated shift to alternative policy (regime 2)
- Parameters of both policies are known over the whole life cycle
- The time when alternative policy is introduced is also known

**Unanticipated:** Surprise shift from regime 1 to regime 2
- At early ages parameters of baseline policy are believed to hold over the whole life cycle
- Alternative policy is introduced at a given age without warning
- Technically: exogenous shift from one model solution to the alternative
Permanent 10% wage decrease $\mapsto$ hours

Highschool, anticipated

Highschool, unanticipated
Permanent 10% wage decrease $\sim$ hours

**Highschool, anticipated**

**Highschool, unanticipated**
Permanente 10% wage decrease $\Rightarrow$ hours

**Highschool, anticipated**

**Highschool, unanticipated**
Permanent 10% wage decrease \(\rightarrow\) hours

![Graphs showing the effects of a permanent 10% wage decrease on hours worked by age for high school students, anticipated and unanticipated cases.](image)
Permanent 10% wage decrease $\sim$ hours (high school)
Permanent 10% wage decrease \(\sim\) hours (dropouts)
Permanent 10% wage decrease $\rightarrow$ hours (college)
Summary of the effects on labor supply

- Labor supply elasticities change over life cycle and are heterogeneous in population.
- Larger decline in hours if policy is anticipated, labor supply shifts forward.
- Effect is very different at different points of the life cycle.
- Sizable increase in hours following a wage decrease in young age, especially for college graduates (even negative labor supply elasticity).

Implied labor supply elasticities:
- High school: < 0.1 at young age to > 1 at retirement age.
- Dropouts: slightly higher, similar range.
- College: 0 and negative at young age, > 1 at retirement age.
Intensive vs. extensive margin of labor supply

- How is change in total hours decomposed into:
  - Reduction in hours of those who work (intensive margin), and
  - Decision not to work at all (extensive margin)?

- Permanent unanticipated 10% wage decrease $\rightarrow$ probability of working
- Permanent unanticipated 10% wage decrease $\rightarrow$ hours conditional on working
- Relative changes (%) to be able to compare effects

- Evidence of significantly higher elasticity on the extensive margin for all education groups
Intensive vs. extensive margin (high school, %)
Income tax rates +10% \(\sim\) hours

- **Dropout, unanticipated**
- **Highschool, unanticipated**
- **College, unanticipated**

![Graphs showing the impact of income tax rates on hours worked for different educational levels.](image-url)
Introduction

The Model

Data and Estimation

Simulations

Effects of Age Pension on labor supply

- Increase in full pension benefit (+25%)
- Decrease in income taper rate (-10%)
- Decrease in taper rate in asset test (-10%)

Complete removal of Age Pension program

- Regime 2 is the world without Age Pension
- The effects on labor supply are seen from the comparing this “alternative” policy to the baseline
Elimination of age pension $\rightarrow$ hours (annual and %)

**Highschool, Absolute differences**

**Highschool, Relative differences, %**
Elimination of age pension, intensive vs. extensive margins

### Hours conditional on working (%)

- **Hours conditional on working (%)**
- **Highschool, Relative differences, %**

### Fraction of working (%)

- **Fraction of working (%)**
- **Highschool, Relative differences, %**
Maximum age pension $+25\% \rightarrow$ hours (annual and %)

**Highschool, Absolute differences**

**Highschool, Relative differences, %**
Maximum age pension +25% \rightarrow wealth ($1000 and %)

Highschool, Absolute differences

Highschool, Relative differences, %
Maximum age pension +25% \(\rightarrow\) consumption

Highschool, Absolute differences

Highschool, Relative differences, %
Effects of Age Pension

- **Increase in full pension benefit (+25%)**
  ⇒ Up to 7% decrease in hours before age 65
  ⇒ About 7% decrease in wealth before 65
  ⇒ Uniform increase in consumption with up to 5% in old ages

- **Decrease in income taper rate (-10%)**
  ⇒ About 2.5% increase in hours after 65
  ⇒ Up to 0.3% decrease in wealth before 65, similar magnitude increase thereafter
  ⇒ Small uniform increase in wealth over the life cycle

- **Decrease in taper rate in asset test (-10%)**
  ⇒ Small (up to 0.2%) increase in hours before 65, up to 1% decrease thereafter
  ⇒ Uniform increase in wealth over the life cycle, up to 3% in old ages
  ⇒ Up to 0.4% decrease in consumption before 65 and up to 0.6% increase in old ages
Preliminary results

- The model is sufficiently flexible to replicate the observed data well
- Policy experiments produce reasonable behavioral responses
- Large variations of labor supply responses over the life cycle and among education levels
  - Labor supply elasticity increases with age
  - Smaller for the higher education groups in the beginning of life cycle
- Strong influence of age pension system on the labor supply
- Effects seen throughout the life cycle
- Different magnitudes for anticipated and unanticipated changes
- Stronger effects on the extensive margin for all education levels