Age-dependent Taxation in Australia

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Research Questions

- What is the optimal set of age-dependent income tax rates in Australia?
- How large are potential welfare gains from shifting to age-dependent taxation in Australia?
- How do existing features of Australia’s economy and tax and transfer system impact these gains? (small open economy, progressive income taxation, age pension and other transfers, superannuation)
Related Literature

- Welfare gains from shifting to age-dependent taxation are large in *most* US models $\approx 1\%$ in CEV terms in Karabarbounis (2016) and Weinzerl (2011); $\approx 0\%$ in Heathcote, Storesletten and Violante (2017).

- Key mechanisms: insurance and redistribution across ages (Weinzerl 2011), efficiency / matching differences in labour supply elasticity (Karabarbounis 2016, Gervais 2012).

- Conesa, Kitao and Krueger (2009) suggest taxing capital may be a substitute for age-dependence. Progressivity has also been shown to affect the gains from age-dependence (da Costa and Santos 2018).
Methodology

▶ Build an OLG model that closely matches Australia’s economy and tax and transfer system.
  ▶ Model individuals (tax) and households (transfers).
  ▶ Progressive taxation of income (labour + capital + transfers).
    Concessions for some types of capital income.
▶ Search for optimal differences in income taxation across ages.
Results

- Large welfare gains.
- Tax rates that increase sharply and monotonically with age are optimal in Australia. Ages 20-34: negative average tax rates vs. 10-30% ages 35-60 vs. above 40% for 65+.
- Largely driven by much higher asset accumulation in baseline small open economy.
- Capital accumulation and lifecycle redistribution important in closed economy.
Outline

- Model & calibration
- Baseline results
- Tax experiment
- Sensitivities
Demographics

- Overlapping generations of two member households $i \in \{m, f\}$
- Household age $j \in 20 - 24, \ldots, 85 - 89$
- Demographic steady state
- Stochastic household mortality: $s_j$ probability of survival from age $j - 1$ to $j$. Based on ABS life tables.
Model

Preferences

- Choices: leisure ($l_j^m, l_j^f$), consumption ($c_j$), saving ($a_{j+1}$).
- Maximize expected utility function:

$$E_0\left[ \sum_{j=1}^{J} \beta^{j-1} s_j u(c_j, l_j^m, l_j^f) \right]$$

$$u(c_j, l_j^m, l_j^f) = (1 + dp_j) \log(c_j) + \gamma^m_j \frac{(l_j^m)^{1-\sigma}}{1 - \sigma} + \gamma^f_j \frac{(l_j^f)^{1-\sigma}}{1 - \sigma}$$

- $\sigma = 4$, $dp_j =$ half of average dependents from HILDA, $\gamma^i_j$ calibrated to match HILDA working hours.
Labour productivity

- Three skill types $n \in \{\text{low, medium, high}\}$ - fixed at birth and same for both household members.

- Three labour productivity shock states $z \in \{\text{low, medium, high}\}$. Productivity shock follows a Markov process that differs for each skill type, but not by sex. While household members face same transition probabilities, they can be in different shock states.

- Given household skill type $n$ and individual shock type $z$, household member $i$ of age $j$ has productivity $e^i_{j}(n, z)$.

- Leisure is a discrete choice across six different levels that are equivalent to hours choices of 50, 40, 30, 20, 10 or 0 hours.

- Market wage $w$. Gives labour income $= w(1 - l^i_{j})e^i_{j}$
Notes: This graph shows labour productivity estimates from HILDA, by skill, shock, sex and age. These estimates are based on HILDA hourly wages data.
Model

Assets, savings and superannuation

- Only asset is riskless one period bonds that pay world interest rate $r$. No borrowing.
- Superannuation incorporated as an endogenous saving constraint. Require households below the superannuation access age to save a strictly positive share of labour earnings ($superContributionRate = 7\%$) plus the share of current assets that are superannuation ($superShare$). The variable $superShare$ differs across asset, age and labour productivity levels. It is endogenous and approximate.
Model

Transfers

- Assessed and paid at household level. Intended to represent all transfers in Australia (unemployment benefits, disability and age pensions, family payments).
- Eligibility for transfers is a decreasing function of household income from private sources \( (P) \). Transfers zero beyond a ceiling income level \( \kappa \).

\[
Transfers(P, j) = \begin{cases} 
\text{trans}(P, j) & \text{if } P \leq \kappa \\
0 & \text{if } P > \kappa 
\end{cases} 
\]

\[
P(x_j) = w(1 - l_j^m)e_j^m(z^m, n) + w(1 - l_j^f)e_j^f(z^f, n) + ra_j
\]
Notes: Median and interquartile range of household transfers with each $5,000 bucket of private household income. Source: HILDA
Calibration

Transfers by Household Private Income

Notes: Estimated transfer functions for each age range. Source: Author’s calculations
Model

Taxes

- Two-parameter income tax function (as in Karabarbounis 2016, HSV2017, Persson 1983):

\[ \text{Tax} = \text{Income} - h \times \tau_0^j \text{Income}^{\tau_1^j} \] (5)

- \( \tau_0 \) mainly controls average tax rate. Progressive if \( \tau_1 < 1 \)
- Scaling factor \( h \) to balance government budget constraint.
- Levied on each household member individually. Asset and transfer income split equally for tax.
- Taxable income is labour income plus asset income plus transfers, less:
  - A share of asset income, \( \mu_j < 1 \), is untaxed. Capital gains concessions. \( \mu_j \) based on ATO data. Ranges from 4% to 15%.
  - Earnings on superannuation assets. These are taxed at a flat rate, \( \tau_s = 15\% \).
  - Superannuation contributions. Also taxed at \( \tau_s \).
Notes: The distribution of disposable income, within each $5,000 bucket of individual taxable income. Source: HILDA and author’s calculations.
Calibration

\[
\text{Tax} = \text{Income} - \tau^0 \text{Income}^{\tau^1}
\]  

\[
\Rightarrow \text{DisposableIncome} = \tau^0 \text{Income}^{\tau^1}
\]  

\[
\ln(\text{DisposableIncome}) = \ln(\tau^0) + \tau^1 \ln(\text{Income})
\]
## Calibration

Estimated Tax Functions

<table>
<thead>
<tr>
<th></th>
<th>All ages</th>
<th>25 to 34</th>
<th>35 to 49</th>
<th>50 to 54</th>
<th>65 plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_0$</td>
<td>1.824***</td>
<td>1.966***</td>
<td>1.975***</td>
<td>1.635***</td>
<td>1.789***</td>
</tr>
<tr>
<td>$\tau_1$</td>
<td>0.924***</td>
<td>0.917***</td>
<td>0.916***</td>
<td>0.934***</td>
<td>0.933***</td>
</tr>
<tr>
<td>Observations</td>
<td>139886</td>
<td>30841</td>
<td>43373</td>
<td>34725</td>
<td>23269</td>
</tr>
<tr>
<td>Rsquared</td>
<td>0.993</td>
<td>0.995</td>
<td>0.994</td>
<td>0.994</td>
<td>0.986</td>
</tr>
</tbody>
</table>

*** indicates a p-value < 0.01
Model

Everything else

- Production sector a single perfectly competitive firm that produces using capital and labour in a CRS production function.
- Small open economy with interest rate equal to world rate, $r = 4\%$.
- Government sector consumes $G$, fixed to 18% of $Y$. Also taxes consumption at $\tau_c = 10\%$. Balances budget each period.
- Normal conditions for steady-state competitive equilibrium.
### Summary of Model Parameters and Sources

<table>
<thead>
<tr>
<th>Description</th>
<th>Symbol</th>
<th>Value</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household Parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life periods</td>
<td>$J$</td>
<td>14</td>
<td>Chosen (model design)</td>
</tr>
<tr>
<td>Annual population growth rate</td>
<td>$n$</td>
<td>1.5%</td>
<td>Chosen (ABS data)</td>
</tr>
<tr>
<td>Survival probabilities</td>
<td>$s_j$</td>
<td>Multiple</td>
<td>Chosen (ABS data)</td>
</tr>
<tr>
<td>Dependency ratios</td>
<td>$dp_j$</td>
<td>Multiple</td>
<td>Chosen (HILDA data)</td>
</tr>
<tr>
<td>Annual time preference parameter</td>
<td>$\beta$</td>
<td>0.979</td>
<td>Calibrated (targeting C/Y)</td>
</tr>
<tr>
<td>Leisure - discrete levels</td>
<td>$l_1, l_2, l_3, l_4, l_5, l_6$</td>
<td>Multiple</td>
<td>Chosen (model design)</td>
</tr>
<tr>
<td>Leisure weights in Utility</td>
<td>$\gamma_j^m, \gamma_j^f$</td>
<td>Multiple</td>
<td>Calibrated (targeting HILDA hours)</td>
</tr>
<tr>
<td>Coefficient of relative risk aversion</td>
<td>$\sigma$</td>
<td>4</td>
<td>Chosen (literature)</td>
</tr>
<tr>
<td>Labour productivity parameters</td>
<td>$e_j^i(n, z)$</td>
<td>Multiple</td>
<td>Chosen (HILDA data)</td>
</tr>
<tr>
<td>Shock transition probabilities</td>
<td></td>
<td>Multiple</td>
<td>Chosen (HILDA data)</td>
</tr>
<tr>
<td><strong>Fiscal Parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private income limit for Transfers</td>
<td>$\kappa$</td>
<td>$130,000$</td>
<td>Chosen (Data)</td>
</tr>
<tr>
<td>Consumption tax rate</td>
<td>$\tau_c$</td>
<td>10%</td>
<td>Chosen (ATO data)</td>
</tr>
<tr>
<td>Government consumption</td>
<td>$G$</td>
<td>18% of $Y$</td>
<td>Chosen (ABS data)</td>
</tr>
<tr>
<td>Super tax rate</td>
<td>$\tau_s$</td>
<td>15%</td>
<td>Chosen (ATO data)</td>
</tr>
<tr>
<td>Super contribution rate</td>
<td>superContribRate</td>
<td>7%</td>
<td>Chosen (ATO data)</td>
</tr>
<tr>
<td>Super access age</td>
<td>$j_{preservation}$</td>
<td>9 (age 60-64)</td>
<td>Chosen (ATO data)</td>
</tr>
<tr>
<td><strong>Production Parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital intensity of production</td>
<td>$\alpha$</td>
<td>0.330</td>
<td>Calibrated (to match K/Y)</td>
</tr>
<tr>
<td>Annual depreciation rate</td>
<td>$\delta$</td>
<td>0.068</td>
<td>Calibrated (to match I/Y)</td>
</tr>
</tbody>
</table>
## Baseline Results

### Key Macroeconomic Aggregates

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption share of output</td>
<td>53.7%</td>
<td>57.0%</td>
</tr>
<tr>
<td>Investment share of output</td>
<td>25.0%</td>
<td>26.0%</td>
</tr>
<tr>
<td>Gov Consumption share of output</td>
<td>18.0%</td>
<td>18.0%</td>
</tr>
<tr>
<td>Net exports share of output</td>
<td>3.4%</td>
<td>-1.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.0%</td>
<td></td>
</tr>
<tr>
<td>Capital-to-output ratio</td>
<td>320.0%</td>
<td>315.0%</td>
</tr>
<tr>
<td>Foreign ownership of capital stock</td>
<td>10.2%</td>
<td>15.8%</td>
</tr>
</tbody>
</table>
Baseline Results

Male Labour Supply by Skill Type

Notes: This graph compares labour supply from the baseline results to that in HILDA.
Baseline Results

Female Labour Supply by Skill Type

Notes: This graph compares labour supply from the baseline results to that in HILDA.
Baseline Results

**Assets by Skill Type**

Notes: This graph compares household assets from the baseline results to those in HILDA.
Baseline Results

- $h = 0.95$ balances government budget constraint

Taxes by Household Age

Notes: This graph compares tax payable by household from the baseline results to those in HILDA.
Baseline Results

Transfers by Household Age

Notes: This graph compares tax payable by household from the baseline results to those in HILDA.
I search for the $\tau^j_0$'s that maximize the expected utility of an unborn household.

To make computationally feasible, I search within the set of $\tau^j_0$ described by:

$$\tau^j_0 = \beta_0 + \beta_1 \times j + \beta_2 \times j^2$$

(9)

where $\beta_0 = 2$, $\text{abs}(\beta_1) \leq \frac{1}{14}$, $\text{abs}(\beta_2) \leq \frac{1}{14^2}$

(10)

These $\beta$ constraints limit relative differences in average tax rates between ages.
Tax Experiment

- Optimal values are $\beta_1 = -\frac{1}{14}$ and $\beta_2 = -\frac{1}{14^2}$, the lower bounds on these parameters.
- Increase in utility of 8.3% in consumption-equivalent variation terms.

Tax Parameters: Optimal Age-dependent vs Baseline
Tax Experiment

- Younger households have negative average tax rates, so receive large transfers through the tax system for working.
- Older households face very high average tax rates.

Tax Paid: Optimal Age-dependent vs Baseline
## Tax Experiment

Baseline versus Optimal Results (unscaled per capita aggregates)

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>1.98</td>
<td>1.93</td>
</tr>
<tr>
<td>Labour</td>
<td>2.06</td>
<td>2.00</td>
</tr>
<tr>
<td>Output</td>
<td>3.07</td>
<td>2.99</td>
</tr>
<tr>
<td>Consumption</td>
<td>1.62</td>
<td>1.75</td>
</tr>
<tr>
<td>Investment</td>
<td>0.85</td>
<td>0.83</td>
</tr>
<tr>
<td>Net Exports</td>
<td>0.05</td>
<td>-0.15</td>
</tr>
<tr>
<td>Labour earnings</td>
<td>2.06</td>
<td>2.00</td>
</tr>
<tr>
<td>Households assets</td>
<td>1.44</td>
<td>3.79</td>
</tr>
<tr>
<td>Foreign assets</td>
<td>0.55</td>
<td>-1.86</td>
</tr>
<tr>
<td>Investment earnings</td>
<td>0.30</td>
<td>0.82</td>
</tr>
<tr>
<td>Transfers</td>
<td>0.18</td>
<td>0.12</td>
</tr>
<tr>
<td>Taxes</td>
<td>0.58</td>
<td>0.49</td>
</tr>
</tbody>
</table>
Labour supply of younger households rises significantly in response to much lower tax rates. (Non-tax) Transfers to these households fall.

Transfers fall at older ages due to higher asset income.
Tax Experiment - Closed Economy

- \( r^{closed} = 4.4\% \)
- Optimal values for \( \beta \) and \( \tau_0 \) are the same.
- Increase in utility of 1.5\% in consumption-equivalent variation terms.

Labour Supply and Consumption: Optimal Age-dependent vs Baseline
### Baseline versus Optimal Results (unscaled per capita aggregates)

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>1.82</td>
<td>2.36</td>
</tr>
<tr>
<td>Labour</td>
<td>2.05</td>
<td>2.04</td>
</tr>
<tr>
<td>( r )</td>
<td>4.4%</td>
<td>3.0%</td>
</tr>
<tr>
<td>( w )</td>
<td>0.97</td>
<td>1.06</td>
</tr>
<tr>
<td>Output</td>
<td>2.98</td>
<td>3.24</td>
</tr>
<tr>
<td>Consumption</td>
<td>1.66</td>
<td>1.63</td>
</tr>
<tr>
<td>Investment</td>
<td>0.78</td>
<td>1.03</td>
</tr>
<tr>
<td>Labour earnings</td>
<td>2.00</td>
<td>2.17</td>
</tr>
<tr>
<td>Households assets</td>
<td>1.82</td>
<td>2.36</td>
</tr>
<tr>
<td>Investment earnings</td>
<td>0.42</td>
<td>0.36</td>
</tr>
<tr>
<td>Transfers</td>
<td>0.16</td>
<td>0.19</td>
</tr>
<tr>
<td>Taxes</td>
<td>0.52</td>
<td>0.61</td>
</tr>
</tbody>
</table>
## Tax Experiment - Closed Economy

<table>
<thead>
<tr>
<th></th>
<th>Consumption Equivalent Variation: Optimal vs Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>Open Economy</td>
<td>8.3%</td>
</tr>
<tr>
<td>Closed Economy</td>
<td>1.5%</td>
</tr>
</tbody>
</table>
Next Steps

- Deconstruct these results, by re-running tax experiment and removing model elements:
  - Flatten capital tax
  - Set transfers to zero
  - Set superannuation to zero

- Consider a wider range of tax experiments: cubic of age, non-parametric (with fewer age ranges)
Spares - Model

State space

- For households of age \( j \), the state space is \( \Omega_j = A \times Z \times Z \times N \), \( A = [0, \bar{a}] \), \( Z = N = \{1, 2, 3\} \).

- Convenient shorthand: let \( x_j \in \Omega_j \) denote the vector of state variables of a particular household at age \( j \).
Spares - Model

Household Problem:

\[ V^j(x_j) = \max_{c_j, l^m_j, l^f_j, a_{j+1}} \{ u(c_j, l^m_j, l^f_j) + \beta \frac{S_j - 1 - s_j}{S_{j-1}} E[V^{j+1}(x_{j+1}|x_j)] \} \]

for \( j \in \{1, \ldots, J\} \) and subject to:

\[
\begin{align*}
    a_{j+1} &= [a_j + e^m_j(1 - l^m_j)w + e^f_j(1 - l^f_j)w + ra_j + B + \\
    &\quad Trans(x_j, j) - Tax(W^m_j, j) - Tax(W^f_j, j) - (1 + \tau_c)c_j]
\end{align*}
\]

\[ a_{j+1} \geq a_j(1 + r(1 - \tau_s)) \ast \text{superShare}(x_j) + (e^m_j(1 - l^m_j)w + e^f_j(1 - l^f_j)w) \ast \text{superContribRate} \]

\[ a_1 = 0 \]

\[ a_J = 0 \]

\[ l^i_j \in [l_1, l_2, l_3, l_4, l_5, l_6] \]
Exact tax functions:

\[ Tax(W^i, j) = W^i - h \times \tau^i_0(\tau^i_0) \]
\[ + \tau_s(r \times \frac{a_j}{2}) \times \text{superShare}_{j,n} \]
\[ + w(1 - l_j^i)e_j^i(z^i, n) \times \text{superContribRate} \]

\[ W^i = w(1 - l_j^i)e_j^i(z^i, n)(1 - \text{superContribRate}) \]
\[ + r \times a_j \times (1 - \mu_j - \text{superShare}_{j,n}) \]
\[ + \frac{\text{Transfers}(P, j)}{2} \]