The Introduction of a Private Wealth Module in CAPP_DYN

Carlo Mazzaferro
University of Bologna (Italy) and CAPP

Marcello Morciano
University of East Anglia (UK), ISER and CAPP

Simone Tedeschi
University of Modena and Reggio Emilia (Italy)

European Workshop on Dynamic Micro Simulation modelling
Brussels, March 4-5th 2010
The main modules of CAPP_DYN

Demography
- Mortality
- Fertility
- Net Migration
- Children leaving parental house
- (re)Marriage
- Separation/Divorce

Education and labour
- Education (three levels)
- Transition to the labour market
- Occupational status (employed PT/employed FT/ unemployed/Inactive)
- Sector of employment (dependent / self employed)
- Income generation (earnings)

Social Security
- Retirement decision
- Old age pension
- Survival pension
- Disability
- Social Assistance Pension

Modelling Population at time $t$

Next year ($t = t+1$)

Modelling Population at time ($t+1$)
Private wealth module in a DMSM: advantages & drawbacks

In the micro simulation literature only *few models* developed a module that analyses and projects the evolution of private wealth through time (PENSIM2 in Great Britain, MINT3 in the United States, SESIM III...)

- **Advantages**
  - *allows to build more complete description of the evolution of households disposable income*
  - analyses the likely *long term redistributive effects of reforms in the public and in the private pension pillar*

- **Drawbacks**
  - increases the complexity of the model
  - put explicitly the question of the *choice between a probabilistic and a behavioural approach*
Our approach

We approximate a structural form for modelling consumption/saving behaviour, while relying on the traditional reduced form-probabilistic approach when dealing with asset allocation (i.e. investment decisions):

Combine a basic micro foundation of household behaviour and a DMSM with a high degree of institutional details:

1. real social security system
2. personal income taxation (IRPEF) sub-module accounting for progressivity.
3. modeling the role of TFR to relax liquidity constraint for 1° house purchasing

Stochastic processes accounting for individual risk in private accumulation.

Probabilistic sub-module for modelling intergenerational transfers (inter-vivos&bequests)
Here we try to highlight two focal points:
1. household savings/consumption behaviour
2. intergenerational transmission of wealth

\[
\begin{align*}
\text{Max} & \quad E_i \sum_{i=0}^{\infty} \phi^i \left[ U^{t+i}_a(C^{t+i}_a, C^{t+i-1}_a; H^t) \right] \\
\text{s.t.} & \quad A^t_a = (1 + r^t_a) \left[ \frac{A^{t-1}_{a-1}}{1 - \pi} + y^t_a - C^t_a \right]
\end{align*}
\]

Where:
- \(a\) = age of household head
- \(C^t_a\) = current consumption
- \(C^{t-1}_a\) = last period consumption for the same household (internal habit)
- \(A^t_a\) = non-human household wealth in year \(t\) when the age of household head is \(a\)
- \(y^t_a\) = current household disposable income (earnings and pensions) in year \(t\) when the age of household head is \(a\)
- \(\pi\) = period constant probability of household extinction\(^1\)
- \(H\) = household characteristics and type
- \(r\) = real interest rate
The solution

Following Willman (2003) we can derive an algebraic expression for current consumption which in its implicit form is given by:

$$C^t_d(H) = f \left( C^{t-1}_d; a, \pi, H, A^{t-1}_d, y^t_d, HR^t(r, H, a) \right)$$

where $HR$ represents the (expected) life-time human resources (or human wealth) given by the discounted future labour and pension income stream.

$$HR^t(i, H, a) = \left\{ \begin{array}{l} \sum_{k=1}^{2} \left\{ \sum_{i=1}^{p_k-a_k} E_i \left[ \frac{w L^t_{k, a_k+i}}{(1+r)^i} \right] + \sum_{i=1}^{T_k-a_k-p_k} E_i \left[ \frac{P^t_{k, a+i}}{(1+r)^i} \right] I_k \right\} \\
= 0 \text{ if } p_k \leq a_k \\
\text{Spouses' human resources} \\
\right\} + \left\{ \sum_{j=1}^{30-a_j} \left[ \sum_{i=1}^{w L^t_{j, a_j+i}} \right] \right\} \text{active children's projected resources up to 30}$$

Obtained, each period, as the projection -throw econometric models- of:

1. **individual earnings stream up to (planned) retirement and**
2. **expected pension incomes from retirement to death**

⇒ relevance of expectations about replacement rate and retirement age.
Crucial role in HR of pension outcome expectations: info available in SHIW ➞ *three-stage least square estimation* for systems of simultaneous equations & calibration

<table>
<thead>
<tr>
<th>Planned Age of Retirement</th>
<th>B</th>
<th>Std. Err.</th>
<th>T</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>acontrib</td>
<td>-0.2105***</td>
<td>0.0039</td>
<td>-54.2148</td>
<td>-0.2181, -0.2028</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>0.1676***</td>
<td>0.0038</td>
<td>43.6939</td>
<td>0.1601, 0.1751</td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>-2.1934***</td>
<td>0.0473</td>
<td>-46.3329</td>
<td>-2.862, -2.1006</td>
<td></td>
</tr>
<tr>
<td>NDC</td>
<td>0.7855</td>
<td>0.4597</td>
<td>1.7086</td>
<td>-0.1151, 1.6864</td>
<td></td>
</tr>
<tr>
<td>upper_secondary</td>
<td>0.4658***</td>
<td>0.0501</td>
<td>9.2942</td>
<td>0.3675, 0.5640</td>
<td></td>
</tr>
<tr>
<td>degree_or_more</td>
<td>1.1723***</td>
<td>0.0760</td>
<td>15.432</td>
<td>0.2337, 1.3211</td>
<td></td>
</tr>
<tr>
<td>self_empl</td>
<td>1.2500***</td>
<td>0.0582</td>
<td>21.467</td>
<td>1.1358, 1.3641</td>
<td></td>
</tr>
<tr>
<td>public</td>
<td>-0.3074***</td>
<td>0.0574</td>
<td>-5.353</td>
<td>-0.4199, -0.1948</td>
<td></td>
</tr>
<tr>
<td>home_owner</td>
<td>-0.1268*</td>
<td>0.0503</td>
<td>-2.523</td>
<td>-0.2253, -0.0283</td>
<td></td>
</tr>
<tr>
<td>south</td>
<td>0.5597***</td>
<td>0.0526</td>
<td>10.637</td>
<td>0.4565, 0.6628</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>0.7350***</td>
<td>0.0900</td>
<td>8.162</td>
<td>0.5585, 0.9114</td>
<td></td>
</tr>
<tr>
<td>tau2004</td>
<td>0.4969***</td>
<td>0.0540</td>
<td>9.198</td>
<td>0.3910, 0.6027</td>
<td></td>
</tr>
<tr>
<td>tau2006</td>
<td>0.4653***</td>
<td>0.0545</td>
<td>8.532</td>
<td>0.3583, 0.5721</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>58.7778***</td>
<td>0.1175</td>
<td>500.310</td>
<td>58.54, 59.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected Replacement Rate</th>
<th>B</th>
<th>Std. Err.</th>
<th>T</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>ret_age</td>
<td>0.0033**</td>
<td>0.0010</td>
<td>3.208</td>
<td>0.0013, 0.0053</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>-0.0100***</td>
<td>0.0005</td>
<td>-21.229</td>
<td>-0.0109, -0.0091</td>
<td></td>
</tr>
<tr>
<td>acontrib</td>
<td>0.0056***</td>
<td>0.0003</td>
<td>22.179</td>
<td>0.0050, 0.0060</td>
<td></td>
</tr>
<tr>
<td>NDC</td>
<td>-0.0671**</td>
<td>0.0207</td>
<td>-3.233</td>
<td>-0.1076, -0.0264</td>
<td></td>
</tr>
<tr>
<td>single</td>
<td>0.0096*</td>
<td>0.0041</td>
<td>2.359</td>
<td>0.0016, 0.0176</td>
<td></td>
</tr>
<tr>
<td>upper_secondary</td>
<td>0.0133***</td>
<td>0.0023</td>
<td>5.864</td>
<td>0.0088, 0.0177</td>
<td></td>
</tr>
<tr>
<td>degree_or_more</td>
<td>0.0160***</td>
<td>0.0036</td>
<td>4.472</td>
<td>0.0089, 0.0230</td>
<td></td>
</tr>
<tr>
<td>self_empl</td>
<td>-0.1161***</td>
<td>0.0029</td>
<td>-39.842</td>
<td>-0.1218, -0.1104</td>
<td></td>
</tr>
<tr>
<td>public</td>
<td>0.0417***</td>
<td>0.0027</td>
<td>15.730</td>
<td>0.0365, 0.0468</td>
<td></td>
</tr>
<tr>
<td>partime</td>
<td>-0.0383***</td>
<td>0.0042</td>
<td>-9.034</td>
<td>-0.0466, -0.0300</td>
<td></td>
</tr>
<tr>
<td>center</td>
<td>0.0345***</td>
<td>0.0026</td>
<td>13.462</td>
<td>0.0294, 0.0395</td>
<td></td>
</tr>
<tr>
<td>south</td>
<td>0.0425***</td>
<td>0.0027</td>
<td>15.981</td>
<td>0.0372, 0.04765</td>
<td></td>
</tr>
<tr>
<td>coor_2</td>
<td>-0.0831***</td>
<td>0.0130</td>
<td>-6.374</td>
<td>-0.1086, -0.0575</td>
<td></td>
</tr>
<tr>
<td>coor_3</td>
<td>-0.1249***</td>
<td>0.0132</td>
<td>-9.449</td>
<td>-0.1507, -0.0989</td>
<td></td>
</tr>
<tr>
<td>coor_4</td>
<td>-0.1530***</td>
<td>0.0138</td>
<td>-11.115</td>
<td>-0.1799, -0.1259</td>
<td></td>
</tr>
<tr>
<td>coor_5</td>
<td>-0.1921***</td>
<td>0.0142</td>
<td>-13.513</td>
<td>-0.2199, -0.1642</td>
<td></td>
</tr>
<tr>
<td>coor_6</td>
<td>-0.2248***</td>
<td>0.0150</td>
<td>-14.983</td>
<td>-0.2542, -0.1954</td>
<td></td>
</tr>
<tr>
<td>coor_7</td>
<td>-0.2599***</td>
<td>0.0161</td>
<td>-16.122</td>
<td>-0.2914, -0.2282</td>
<td></td>
</tr>
<tr>
<td>coor_8</td>
<td>-0.2944***</td>
<td>0.0174</td>
<td>-16.957</td>
<td>-0.3295, -0.2612</td>
<td></td>
</tr>
<tr>
<td>coor_9</td>
<td>-0.3280***</td>
<td>0.0189</td>
<td>-17.392</td>
<td>-0.3649, -0.2910</td>
<td></td>
</tr>
<tr>
<td>coor_10</td>
<td>0.2550***</td>
<td>0.0204</td>
<td>18.353</td>
<td>0.1459, 0.3649</td>
<td></td>
</tr>
</tbody>
</table>

**Endogenous variables:**

1. Planned retirement age
2. Expected replacement rate

Workers falling under NDC system expect a replacement rate 7% lower than DB or mixed workers, despite they plan to retire later.

**Significant cohort effects on expected replacement rate**
From the theory …to the econometrics …to the simulation

For the estimation we chose an (empirical) specification which better fits our data and nicely describe the consumption/saving behavior of Italian household in our sample.

\[
\frac{C'_t}{HR'^{t+1}} = \rho \frac{C'^{t-1}}{HR'^t} + f(a) + \beta_1 A'_t + \beta_2 y'_t + \sum_k \beta_k D'_k(H)
\]

In the dynamic simulation program we obtain from this equation a predicted value for the current level of consumption \( \hat{C}'_t \) and, in order to account for the role of liquidity constraints, we compute current simulated consumption as:

\[
C'_t = \min\left\{ \hat{C}'_t, y'_t + (1 - \phi'_t)A'_t - R'_t \right\}
\]

That is current household consumption can never exceed the sum of current disposable income plus the liquid share of enlarged financial wealth, net of the mortgage instalment (if any).

Each year of simulation the model re-program HR, update all the covariates and evaluate household consumption and, as a residual, savings
Why this empirical specification?

A dynamic specification in ratio (as in Ando & Nicoletti, 2004) instead of in level:

1. Fit much more closely our panel dataset all over the distribution (very important for a micro simulation distributional model!!)

2. We get rid of the necessity to make arbitrary assumption due to the nonstationarity of consumption

Source: Author’s computations on SHIW 1991-2006
Age profile of Consumption over Human Resources ratio, by income quintile (SHIW)

Source: Author’s computations on SHIW 1991-2006, cubic fit.
Age profile of Consumption over Human Resources ratio, by household type (SHIW)

Source: Author’s computations on SHIW 1991-2006, cubic fit.
Dynamic panel-data estimation of the consumption rule, Two-step system GMM

$$\ln \left( \frac{C_t}{HR^{t+1}} \right) = 0.1208 \ln \left( \frac{C_{t-1}}{HR^t} \right)$$

$$+ 0.0128(a_f^t) - 0.1129(q1_{-}y^t) - 0.1527(q2_{-}y^t) - 0.2128(q3_{-}y^t) - 0.2616(q4_{-}y^t)$$

$$+ 0.2147 \text{age} - 0.0068 \text{age}^2 + 0.0001 \text{age}^3 + 0.00002 \text{age}^4$$

$$+ 0.0211 \text{single} + 0.1134 \text{nusihehh} + 0.4021 \text{non}_{-} \text{nusihehh} + 0.1763 \text{non}_{-} \text{nuclfam}$$

$$+ \sum_{k} \beta_k D_k^t(H) + \nu_i + \epsilon_{it}$$

Number of obs = 21776
Number of groups = 10138
Number of instruments = 43
Wald chi2(27) = 19117.40
Prob > chi2 = 0.000
Intergenerational Transfers

sub-module structure

Wealth transfers

Read dataset year t

household extinguished?

Yes

No

estimate probability of being donor

Prob>=r

No

Yes

Heirs Identification

Allocation of bequest

Distribution of Residual

Estimate amount transferred

Wealth spend down

estimate probability of being recipient (and calibration)

prob>=r

No

Yes

Estimate amount received (plus calibration)

Accumulation of wealth

Save dataset year

End
MSMs & Intergenerational Transfers

- precedent of the use of micro simulation is the WTMM developed by the Center on Wealth and Philanthropy of the Boston College which is focused and dedicated on the wealth transmission phenomenon
- the introduction of such processes in a “multitasking” dynamic population model is still limited
- dynamic micro simulation represents a powerful tool compared with other kind of methods since it provides a complete account of predicted transfers given and received each year which can be compared with actual data, incorporating any demographic transition and generating the future path of characteristics that determine choices. (Christelis, 2008).
SHARE data

- Collects information on representative sample of a cross country of populations for individuals aged over 50 with detailed info on their children—precious source to study intergenerational exchange relationships.
- We use the 1st wave (2004), containing 32,000 individuals of which 3,100 Italians, to estimate inter-vivos monetary transfers toward children & grandchildren living outside the family of origin.
- We reconstruct a correspondence between parents and children characteristics, providing a matching between donors and recipients.
- We estimate the two sides of the exchange separately, using mutual characteristics.
- For estimating recipients we invert the dataset.
### Donor side

| log(ratio)     | beta    | Std. Err. | z      | P>|z| |
|----------------|---------|-----------|--------|-----|
| age            | -0.7666357 | 0.2406    | -3.19  | 0.001 |
| age2           | 0.0108139 | 0.0036    | 3.03   | 0.002 |
| age3           | -0.00000506 | 2E-05    | -2.9   | 0.004 |
| inwork         | -0.3168297 | 0.0679    | -4.66  | 0    |
| married        | -0.149661 | 0.0599    | -2.5   | 0.012 |
| upper_secondary| -0.3324848 | 0.0632    | -5.26  | 0    |
| degree         | -0.3815539 | 0.0669    | -5.7   | 0    |
| Q3_wealth      | -0.5916644 | 0.0752    | -7.87  | 0    |
| Q4_wealth      | -0.9548991 | 0.0734    | -13.01 | 0    |
| Q5_wealth      | -1.465867  | 0.0746    | -19.66 | 0    |
| ita            | **0.6548956** | 0.0965    | 6.78   | 0 |
| Intercept      | 16.38053  | 5.339     | 3.07   | 0.002 |

### Recipient side

| log(amount) | beta    | Std. Err. | z      | P>|z| |
|-------------|---------|-----------|--------|-----|
| log(af parents) | **0.1053938** | 0.0142  | 7.45   | 0 |
| age         | -0.0051044 | 0.0018   | -2.83  | 0.01 |
| grandchildren | -0.1938117 | 0.0516  | -3.75  | 0 |
| married     | 0.035819   | 0.0134   | 0.66   | 0.01 |
| divor       | 0.1222913  | 0.0846   | 1.45   | 0.148 |
| Intercept   | 6.25393    | 0.2939   | 21.28  | 0 |

### Recipient

| log (af parents) | beta    | Std. Err. | z      | P>|z| |
|------------------|---------|-----------|--------|-----|
| age              | -0.0518585 | 0.0059   | -8.86  | 0 |
| age2             | 0.000397  | 7E-05    | 5.58   | 0 |
| married          | 0.1442751 | 0.0586   | 2.46   | 0.014 |
| single           | 0.3446326 | 0.0597   | 5.77   | 0 |
| divor            | 0.3363424 | 0.0683   | 4.92   | 0 |
| inwork           | -0.1407145 | 0.0227 | -6.2   | 0 |
| degree           | 0.1956938 | 0.0237   | 8.26   | 0 |
| grandchildren   | 0.1651595 | 0.0246   | 6.71   | 0 |
| ita              | 0.1069721 | 0.0382   | 2.8    | 0.005 |
| Intercept        | -0.6580214 | 0.1179 | -5.58  | 0 |

| mills lambda     | 0.0866149 | 0.1886 | 0.46   | 0.646 |
| mills rho        | 0.07045   |        |        |      |
| mills sigma      | 1.2294872 |        |        |      |
| mills lambda     | 0.08661491 | 0.1886 |       |
Some Preliminary Results...

Two simulation scenarios according to the average stochastic returns we assume on assets and liabilities:

1. Benchmark: risky AF=3%, AR=2%, PF=3%
2. Low returns: risky AF=1%, AR=1%, PF=1%
The average evolution of inter vivos transfers (2008-2050)
The evolution of the avg IV transfer and its dispersion (2008-2050, benchmark)
The average evolution of bequests (2008-2050, benchmark)
The evolution of the avg bequest and its dispersion (2008-2050, benchmark)
Equivalent propensity to consume vs HH age (2008, 2025, 2050)…

Nadaraya-Watson nonparametric regression (Kernel). OECD equivalence scale.
In the long run, changing in both current and expected social security outcomes brings about a significant modification in the consumption/saving lifetime pattern of Italian families: more saving before retirement, more dissaving after.
Mean vs Median Household saving propensity (2005-2050) and the role of permanent income (=HR/residual life)
Mean vs Median Household assets accumulation (2005-2050, benchmark simulation)

Average Household Wealth to Income Ratio (2008-2050)

Median Household Wealth to Income Ratio (2008-2050)
Avg assets accumulation
(2005-2050, low returns scenario)
Net Wealth Inequality (2008-2050)

Gini Net Worth

Year

Gini benchmark simulation
gini low returns simulation

NDC scheme fully operating plus growth in iv transfers dispersion
Next Improvements…

- Deeper sequential integration between CAPP_DYN and the Wealth Module

- Modelling the role of complementary private pension pillar, accounting for systemic risk

- For interested people, details about the work will be soon available as a working paper by CAPP
  www.capp.unimore.it

...Thanks