Does it pay to medicate half of Britain?

Assessing the Value of Primary Prevention of Cardiovascular Diseases in England

Paul Rodriguez Lesmes

Department of Economics
University College London

International Pension Workshop
Netspar
2016

This project

The main goal of this project is to quantify the benefit derived from adoption of a health care technology

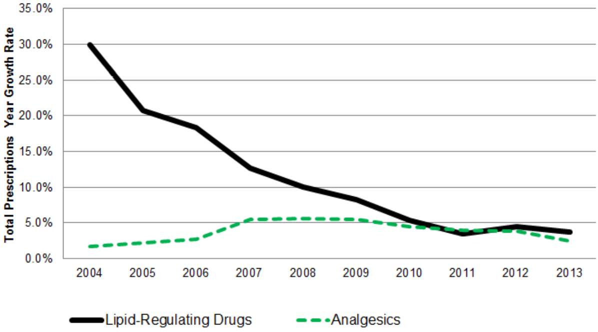
Debate around Statins for Primary Prevention

- Cardiovascular diseases (CVD) are heavy burden for health care systems
  - Development of therapies as lipid-lowering medication
- Debate on adoption of technologies for primary prevention (avoid CVDs for the first time)

Prescribing statins to millions more healthy people would make only a minimal difference to their average lifespan but risk exposing thousands to harmful side effects, a leading doctor has claimed. (Telegraph)

Some experts have claimed that all over-50s should take the drugs routinely to lower their levels of "bad" LDL cholesterol and protect against heart attacks and strokes. (Telegraph)

Statins prescriptions in England



Data Source: Prescriptions Dispensed in the Community, Statistics for England

▸ More

Pay for performance and primary prevention

- Family doctors (GPs) are free to diagnose and prescribe according to their criteria
- NICE 2006: statins should be used for primary prevention in the UK
- Quality and Outcome Frameworks: pay GPs in order to homogenize certain procedures
- Since 2009, for assessing risk of developing CVDs using standard risk calculators
    - **Preliminary results:** An incentive of 100£ increased 2-year prescription rate of Statins by 3pp., among those without a diagnosed CVD-disease

This Project

The main goal of this project is to quantify the benefit derived from adoption of a health care technology

- Estimate the willingness-to-pay for the adoption technology (financial incentives)
- This requires to estimate
  - .. .the effect of CVDs on utility via consumption and leisure
  - ... the effect of CVDs on the leisure-cost of working, labour productivity and on non-labour income
  - ... the reduction on CVD-risk due to the policy
- This is done by structurally estimating a model that involves all these components

Context

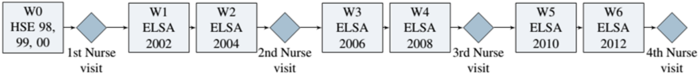
- Papageorge (2015): estimate the value of the introduction of anti-retroviral therapy for men HIV+
- Health, health expenditures, bequest motive, wealth and labour market (De Nardi, 2004; French and Jones, 2009)
- Cost-benefit analysis (Ward et al., 2007)
- Modelling health investments for ‘prevention’ and in ‘treatment’ of diseases (Ozcan, 2014)
- *This a work in progress, therefore any suggestions are more than welcome!*

Outline

1. Introduction
2. Data
3. Life-cycle model with CVD-progression
4. QOF and primary prevention of CVDs
5. Willingness-to-pay calculations
6. Summary

Data

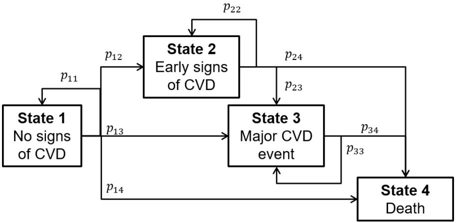
- Use the *English Longitudinal Study of Ageing*



- Representative sample of England's population aged 50+
- Rich data on health and financial circumstances
- Data for males. Cohort-Health and family size effects are removed for non-housing assets, part/full-time labour, earnings per hour and non-labour income

Model sketch I

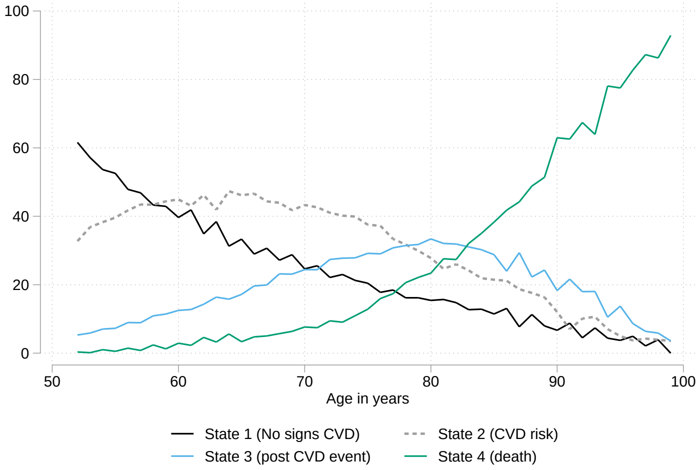
- Finite-Horizon Life-cycle model
- Health Status (S): no signs of CVD, in risk of a CVD event, major CVD event, death
  - Risk: hypertension, diabetes type 2, high cholesterol
  - CVD: Stroke, Congestive Heart Failure, M Infarction, Angina
  - Markov-model
- Production of CVD-risk index (H): risk of developing CVD affects p_{ij}



$$P_{t,t+1} = \begin{pmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ 0 & p_{22} & p_{23} & p_{24} \\ 0 & 0 & p_{33} & p_{34} \\ 0 & 0 & 0 & p_{44} \end{pmatrix}$$

More

Model sketch II



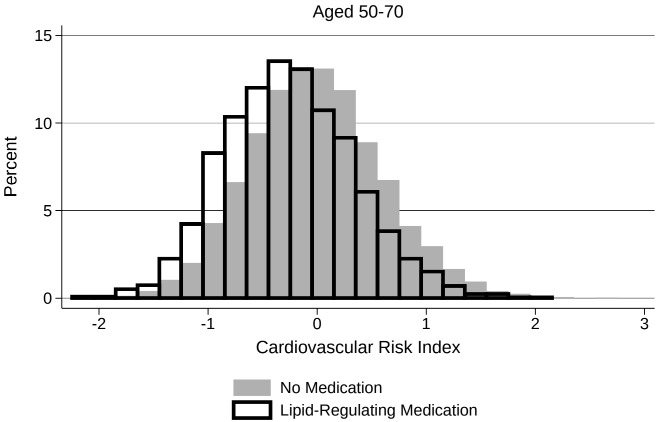
ELSA data profiles for individuals aged 50 to 100.

CVD-risk index I

- Summarize biomarkers that are related to CVDs into a single index
- A continuous index is constructed using factor analysis
- Variables included:
  - Systolic BP
  - Diastolic BP
  - Total Cholesterol
  - Non-HDL Cholesterol ← *Statins reduce this*

CVD-risk index II

Statins reduce in 1mmol/L LDL cholesterol (CTT,2012), an element that is reflected in the index using ELSA data



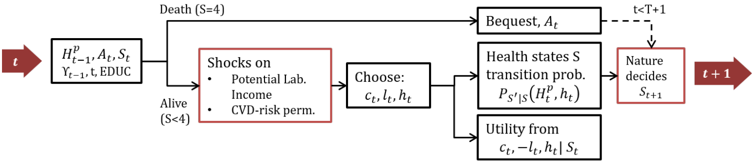
CVD-risk index III

- The index is modelled as composed by a transitory and a permanent component.
- The effect of medication is transitory
- Lifetime investments (diet, smoking, etc.) are reflected on initial heterogeneity on the permanent component

More

Choices

- Consumption c_{it}, labour supply l_{it} (0,PT,FT), medication $h_{it} \in \{0, 1\}$.
- Medication has a cost, associated with local primary care
- Bequest motive $b(A_{it})$ which depends on assets



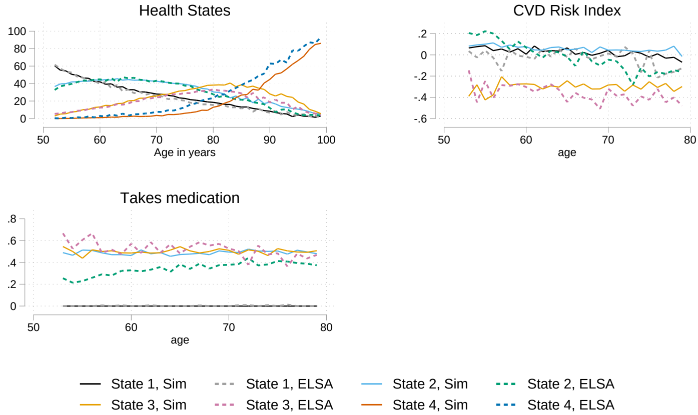
- CVD has 3 main effects:
  - Increase the marginal disutility of working
  - Wage per hour (productivity)
  - Modify non-labour income of the household (external transfers)

More

Estimation of model's parameters

1. Adjusted profiles are obtained in order to derive moments
2. Initial conditions for the simulations (assets, CVD-risk index, initial health states, potential earnings and non-labour income)
3. Use SMM for comparing the estimated data profiles and the ones calculated over the simulated dataset using the model
    - Calibrate some parameters from literature and get initial values from reduce form estimates of earnings and non-labour income
    - Given a set of parameters, simulate the profiles and compare against the real ones

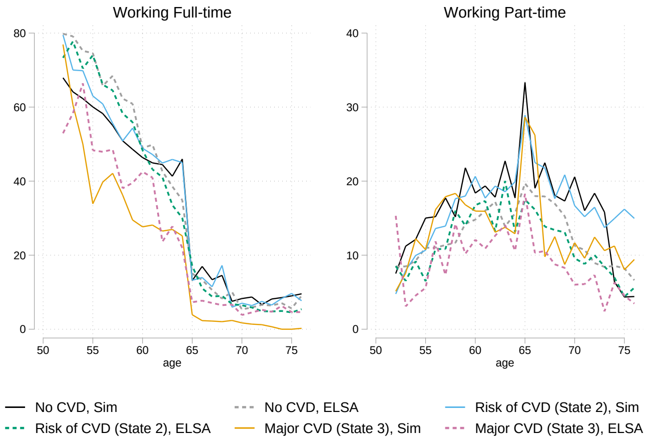
Some simulations: health evolution



State 2: high risk of CVD, State 3: CVD, State 4: death
Cohort, unemployment and family size effects were removed from ELSA profiles (age>52).

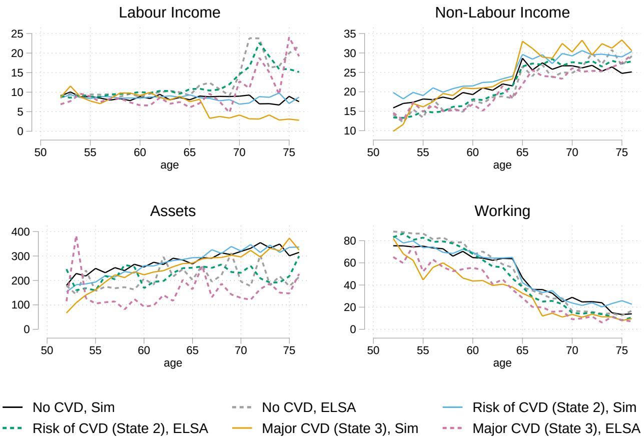
Some simulations: labour supply

Burden of CVD illness for FT work: 23 hours. For PT: 13 hours. More



Cohort, unemployment and family size effects were removed from ELSA profiles.

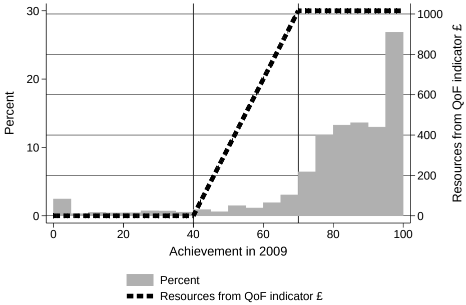
Some simulations: households' finances



Cohort, unemployment and family size effects were removed from ELSA profiles.

Outline

Policy: QOF and primary prevention of CVDs

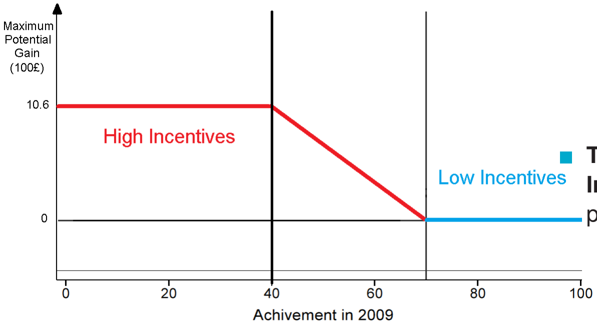


- Payment according to achievement in the indicator:

$$P = \frac{\text{Formal CVD risk assesment}}{\text{Patients newly diagnosed with HBP}}$$

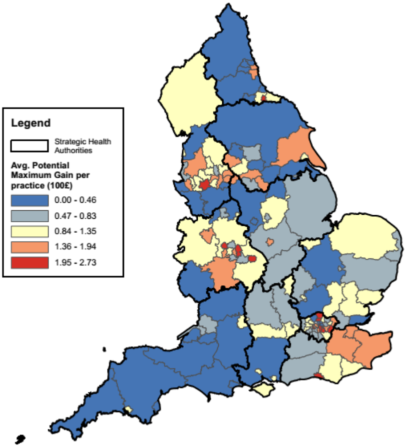
- 15%(6%) of the 8213 practices with at least 1 new case of hypertension obtained an achievement below 70%(40%) in 2009

Treatment Intensity



- **Treatment Intensity:** maximum potential gain (100£)

Potential gains: PCT level



Source: Own calculations from *Quality Management and Analysis System* data on the *Quality and Outcomes Framework* at GP practice level for 2009/10. Data was aggregated according to 2012 PCT boundaries (ONS).

- Potential Gains from QOF indicate the incentives for modifying primary prevention procedures in a region
- Estimate the effect of the program on primary prevention prescriptions by comparing low and high performance areas
- ELSA data was linked by postcode to the QOF data at PCT level

Intervention II

- Compare the odds to be under statins for people living in areas (r) where GPs have high incentives for improving health care (high PG_r), with those in areas with low incentives
- Outcome $Y_{ir,t} - Y_{ir,t-2}$: 2 years variation on the usage of statins, for those not diagnosed with CVDs at t
- Control for regional trends prior to the introduction of the policy, and for time effects
- Impact captured by α_2

$$Y_{ir,t} - Y_{ir,t-2} = \alpha_1 PG_r + \alpha_2 PG_r \cdot \mathbb{1}\{t = 10\} + \alpha X_{ir,t-2} + d_{t=10} + u_{irt}$$
$$t \in [08, 10]$$

- **Results:** A potential gain of 100£ increased primary prevention usage of statins by 2pp.

More

Outline

Welfare Analysis

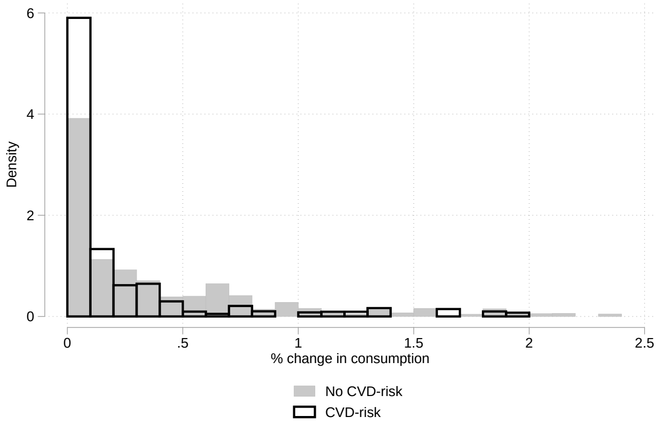
- For each simulated individual, calculate the willingness to pay in order to be indifferent between the worlds with the policy and without the policy ($G = 1$, $G = 0$).
- The policy is assumed to modify the cost of taking medication h

$$\pi_i \in \operatorname{argmin} \left| E_0 \sum_{t=\tau_i}^{T} \beta^t U(l_{it}, c_{it} | S_{it}, G_{it}) - E_0 \sum_{t=\tau_i}^{T} \beta^t U(l_{it}, (1 - \pi_i) c_{it} | S_{it}, 0) \right| \quad (1)$$

- The benefit of the policy on individuals' welfare is $\sum_i \pi_{ij}$

Current version willingness to pay

Very preliminar!



Estimated values for each individual in a simulated dataset of 10.000 individuals of age 50.
CVD-risk: diagnosed with high blood pressure, diabetes or high cholesterol.

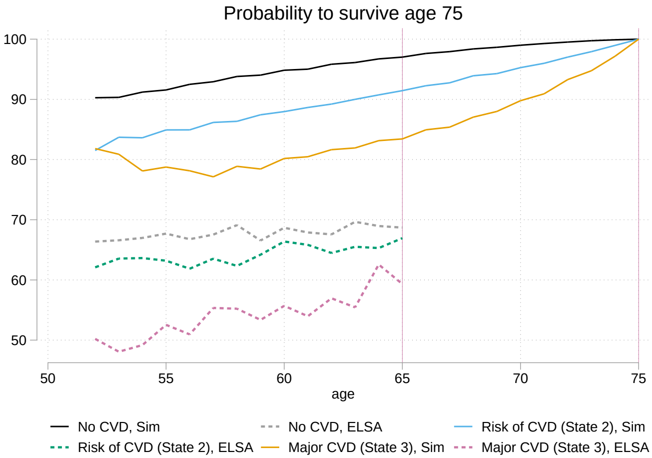
Summary

- This project
  - Estimates the effect of CVDs on consumption, labour supply and asset accumulation in England
  - Estimates the impact of financial incentives on adoption of statins for primary prevention of CVDs
  - Estimates the willingness-to-pay for such policy

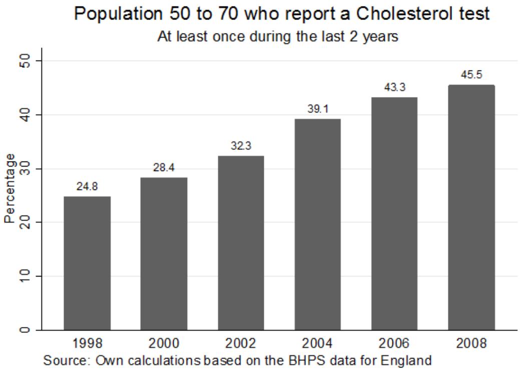
Thank you very much!

Subjective Survival Probabilities

Which is the right assumption for the mortality process?



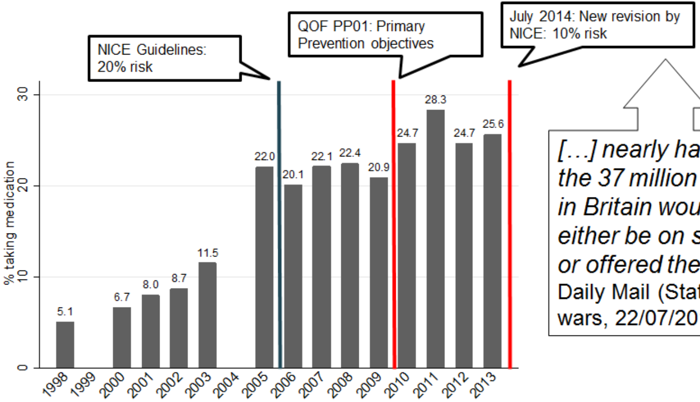
Cholesterol tests



Back

Statins adoption

% of individuals aged 50-70 under lipid-lowering medication

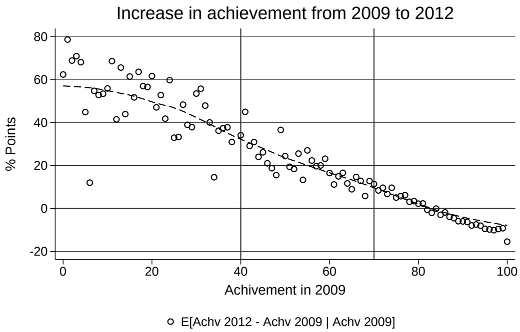


Source: Own calculations based on Health Survey England. Unweighted figures

[...] nearly half of the 37 million adults in Britain would either be on statins or offered them
Daily Mail (Statin wars, 22/07/2014)

NICE: National Institute for Health and Care Excellence

Intervention II



- **Treatment Intensity:** maximum potential gain (100£)
- On average, those practices gained the points that they needed to obtain full payment

Results

Table 4: Potential gains from QOF PP01, according to 2009 achievement and Medication and CVD status

Includes individuals aged 50 to 70 interviewed in 2008/09 without history of CVD by 2006/07, or for those interviewed in 2010/11 without history of CVD by 2009/10

	Dependent: two years variation on				
	lipidpill	**bppill**	**healthS2**	**healthS3**	**healthS4**
Panel A: Main Results					
Pot. Gains	−0.010	−0.007	−0.001	−0.010**	0.003*
	(0.011)	(0.009)	(0.009)	(0.004)	(0.002)
Pot. Gains 2010	0.033**	0.024**	0.018	0.012**	−0.002*
	(0.014)	(0.012)	(0.013)	(0.006)	(0.001)
Observations	4861	4863	4862	4862	4862
Individuals	3726	3728	3727	3727	3727
R squared	0.034	0.037	0.027	0.009	0.005

Own calculations using data for males from ELSA waves 3 to 5 and QoF data at PCT level. Clustered at individual level SE in parenthesis. Significance Level: 1% ***; 5% **; 10% *.

Utility

c: consumption
ℓ: leisure
l: labour supply in hours (FT=40, PT=20)
A: assets
S: health states

$$U = u(l_{it}, c_{it}, h_{it}|S_{it}) = \frac{(c_{it}^{\eta} \ell_{it}^{1-\eta})^{1-\gamma}}{1-\gamma} + \phi_3 hi_{i,t} \quad \text{if } S_{it} < 4 \tag{2}$$

$$\ell_{it} = \Psi - l_{it} - \theta_P * FT - (\phi_1 + \phi_2 * FT) * (S_{it} = 3) * (l_{it} > 0)$$

$$U = b(A_{it}) = \theta_B \frac{(A_{it} + \theta_K)^{(1-\gamma)\eta}}{1-\gamma} \quad \text{if } S_{it} = 4 \tag{3}$$

Back

Asset Accumulation and Income I

- Assets evolution

$$\frac{A_{i,t+1}}{1+r} = A_{i,t} + y^L_{i,t} * \kappa * l_{i,t} + y^{NL}_{i,t}(\text{age}_{i,t}, l_{i,t}, S_{i,t}, \text{EDUC}_i) - c_{i,t} \quad (4)$$

$$A_{i,t} \geqslant BC_t \text{ where } \sum_{t=1}^{T} BC_i = \frac{BC_{t+1}}{1+r} - y_{min} + c_{min} \quad (5)$$

- Labour Income. For a given $Y_{ij,0}$

$$ln(y^L_{i,t}) = \iota^L_1 + \iota^L_2 * \text{EDUC}_i + \iota^L_3 * (S_{it} = 3) + \Upsilon_{i,t} \quad (6)$$

$$\Upsilon_{i,t} = \rho\Upsilon_{i,t-1} + u_{i,t}$$

$$u_{i,t} \sim N(0, \sigma_u) \quad (7)$$

Back

Asset Accumulation and Income II

- Non-Labour Income

$$
\begin{aligned}
In(y_{i,t}^{L}) =& \iota_1^L + \iota_2^L * \text{EDUC}_i + \iota_3^L * (S_{it} = 3) + \Upsilon_{i,t} \\
\Upsilon_{i,t} =& \rho \Upsilon_{i,t-1} + u_{i,t} \\
& u_{i,t} \sim N(0, \sigma_u)
\end{aligned} \tag{8}
$$

$$
\begin{aligned}
In(y_{it}^{NL}) =& \iota_1 + \iota_2 * \text{EDUC}_i + (\iota_3 + \iota_4 * \text{EDUC}_i) * [\text{age} \geqslant 65] \\
& + \iota_5 * (\text{age} - 50) * (\text{age} < 65) + [\iota_6(\text{age}_{it} - 65) + \iota_7(\text{age}_{it} - 65)^2] * [\text{age} \geqslant \\
& + [\iota_8 + \iota_9 * \text{EDUC}_i + \iota_{10} * (\text{age} \geqslant 65)] * I_{it} \\
& + [(\iota_{11} * (I_{it} = 1) + \iota_{12} * (I_{it} = 2))\text{ln}(y_{it}^{L})] * [\text{age} \geqslant 65] \\
& + [\iota_{13} + (\iota_{14} + \iota_{15} * (\text{age} \geqslant 65)) * (I_{it} = 1)] * [S_{it} = 3]
\end{aligned} \tag{9}
$$

Back

Health States Transition I

- The transition matrix is governed by a logistic processes

$$\text{xb2}(t, H_t) = \tau_{21} * \text{age}_{it} + \tau_{22} * \text{age}_{it}^2 + \tau_{23} * \ln(H_{it}) + \tau_{24} * SES_i + \tau_{25} \tag{10}$$

$$\text{xb3}(t, H_t, s) = \tau_{3,s,1} * \text{age}_{it} + \tau_{3,s,2} * \text{age}_{it}^2 + \tau_{3,s,3} * \ln(H_{it}) + \tau_{3,s,4} * SES_i + \tau_{3,s,5}$$

$$\text{xb4}(t, H_t, s) = \tau_{4,s,1} * \text{age}_{it} + \tau_{4,s,2} * \text{age}_{it}^2 + \tau_{4,s,3} * \ln(H_{it}) + \tau_{4,s,4} * SES_i + \tau_{4,s,5}$$

- In states 1 to 2, transitions can be represented as a multinomial logistic process. In 3, it simplifies to a logit process. Example:

$$Pr(S_{t+1} = 3 | t, H_t, S_t = 1) = \frac{\exp(\text{xb3}(t, H_t, S_t = 1))}{1 + \exp(\text{xb2}(t, H_t)) + \exp(\text{xb3}(t, H_t, S_t = 1)) + \exp(\text{xb4}(t, H_t, S_t = 1))} \tag{11}$$

Back

Health States Transition III

- The index H is modelled as composed by a transitory H^{tra} and a permanent H^{per} component.
- The effect of medication h_{it} is transitory
- Lifetime investments (diet, smoking, etc.) are reflected on initial heterogeneity on the permanent component

$$H_{i,t} = H_{i,t}^{per} + H_{i,t}^{tra} \tag{12}$$

$$H_{i,t}^{per} = \omega_1 H_{i,t-1}^{per} + \omega_2 + \omega_3 EDUC_i + e_{i,t} \tag{13}$$

$$H_{i,t}^{tra} = \omega_4 h_{it} + \omega_{5,s} \tag{14}$$

Back

Solve the problem

- The problem is solved recursively
- Assume $V_{T+1} = b(A_T)$, where $T = 48$ (age 100)
- Using the Bellman equation (if alive):

$$\begin{aligned} V(A, H, S, \Upsilon; X, \epsilon_h) &= \max\left\{V_{h=1} + \epsilon_1, V_{h=0+\epsilon_0}\right\} \\ V_h &= \underset{(c,l)}{\operatorname{argmax}}\, u(c, l, h) \\ &+ \beta E_{e', S', u', \epsilon_h'}\left[V'(A'(c, l), H'(h, e'), s, \Upsilon'(u'); X)\right] \end{aligned} \tag{15}$$

- A set of policy functions A', l, h is derived

Back

Parameters

	Parameter	Value
Utility		
β	Discount factor **(Cal)**	0.98
η	Importance of consumption in utility	0.8414
γ	Relative risk aversion **(Cal)**	1.5600
θ_p	Disutility of participation	25.3521
ϕ_1	Disutility of bad health while working	-26.2778
θ_B	Bequest importance	1.0000
θ_K	Base for not leaving bequest penalty **(Cal)**	8.0000
ϕ_2	Additional disutility of bad health while PT	-12.5872
ϕ_3	Cost of CVD-prevention investment	-0.0424
Earnings per hour		
σ_u	Variance innovations	0.8411
ρ	Persistence innovations	0.5192
ι_1^L	EDUC	0.0045
ι_2^L	To be in State 3	-0.1717
ι_3^L	Mean	1.5206

	Parameter	Value
Non-labour Income		
ι_1	Constant	2.2931
ι_2	EDUC	0.4064
ι_3	Age $\geq$ 65	0.4348
ι_4	Age $\geq$ 65 * EDUC	0.0727
ι_5	(Age<65) * (Age-50)	0.0330
ι_6	(Age $\geq$ 65) * (Age-65)	0.0066
ι_7	(Age $\geq$ 65) * $(\text{Age-65})^2$	-0.0258
ι_8	Hours of work	-0.0146
ι_9	Hours of work * EDUC	0.0136
ι_{10}	Hours of work * Age $\geq$ 65	0.0056
ι_{11}	Age $\geq$ 65 * Y^L * Not work	0.2157
ι_{12}	Age $\geq$ 65 * Y^L * Part-time	0.0900
ι_{13}	CVD	0.0000
ι_{14}	CVD * Not work	0.1014
ι_{15}	CVD * Not work * Age $\geq$ 65	-0.0973

Back