The Costs of Bad Mental and Physical Health

Workshop Presentation

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1. Updates
2. Changes in the sample
3. Income process
4. Health transition process
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Updates and current work

1. Corrected the tables using weights.
2. Changed the sample.
3. Estimation of income and health transition processes.

Current work: Writing the code to estimate the model using the income and health processes as inputs.

Changes in the sample

Data from PSID Individual and Family level for 2001-2003 and 2007-2021 waves.
Sample: Households where the head is between the ages of 25 and 90.

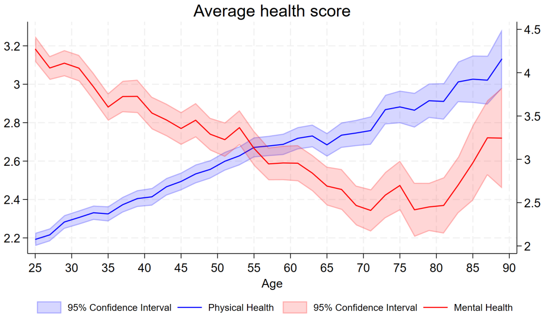
1. Income: Sum of labor, business, and farm income.
2. Wealth: Net of debt value. With and without the value of home equity.
3. Demographics: Age, sex, race, migration status of the head.
4. Physical health of the head: *Would you say your health in general is excellent, very good, good, fair, or poor?*
5. Mental health: K-6 Non-Specific Psychological Distress Scale.
    - K-6 scale is assessed at the respondent level.
    - I restrict my sample to HHs where the respondent is the head.

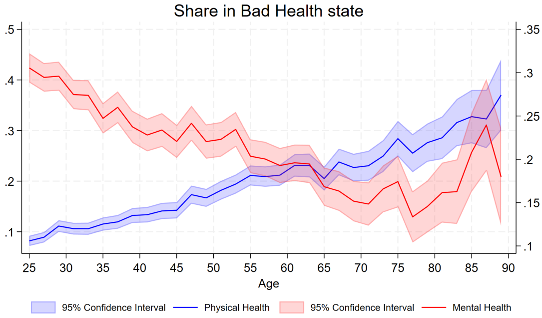
Summary Statistics

Table: Descriptive Statistics

	N(obs)	N(ind)	Mean	Std. Dev.	P5	P25	Median	P75	P95
Income	54,881	11,656	39,723.34	70,802.04	0.00	0.00	25,275.84	54,081.23	127,195.07
Wealth	54,881	11,656	346,911.98	1.49e+06	-22,000.00	3,636.28	62,048.31	282,000.00	1.40e+06
Wealth (ex. RS equity)	54,881	11,656	250,648.35	1.39e+06	-25,643.09	850.00	19,104.29	136,257.06	1.04e+06
Physical Health Score	54,768	11,644	2.58	1.05	1.00	2.00	3.00	3.00	4.00
$\mathbb{1}\{p_t = bad\}$	54,768	11,644	0.19	0.39	0.00	0.00	0.00	0.00	1.00
K6 Scale	54,517	11,622	3.35	4.05	0.00	0.00	2.00	5.00	12.00
$\mathbb{1}\{m_t = bad\}$	54,768	11,622	0.23	0.42	0.00	0.00	0.00	0.00	1.00
Age	54,881	11,656	51.59	16.69	27.00	37.00	51.00	64.00	81.00
Sex at birth	54,881	11,656	0.39	0.49	0.00	0.00	0.00	1.00	1.00
Race indicator	51,637	10,918	0.16	0.37	0.00	0.00	0.00	0.00	1.00
Migrant indicator	54,881	11,656	0.08	0.27	0.00	0.00	0.00	0.00	1.00

Health dynamics





Income process

Income process: How I estimated it

Following the approach of Storesletten, Telmer, and Yaron (2004), I model the income process as follows:

$$\log y_{i,t} = \beta_t + \kappa_i + f(X_{i,t}) + \log \varepsilon_{i,t} \quad (1)$$

$$\log \varepsilon_{i,t} = \eta_{i,t} + \epsilon_{i,t} \quad (2)$$

$$\eta_{i,t} = \rho \eta_{i,t-1} + \nu_{i,t} \quad (3)$$

where κ_i corresponds to the individual fixed effect, η is the persistent part of the income shock, while ϵ corresponds to the transitory part of the income shock

$$\kappa \sim N(0, \sigma_\kappa^2), \quad \epsilon \sim N(0, \sigma_\epsilon^2), \quad \nu \sim N(0, \sigma_\nu^2), \quad var(\eta_{i,-1}) = 0$$

and

$$\kappa_i \perp \epsilon_{i,t} \perp \nu_{i,t}, \quad i.i.d$$

Income process: How I estimated it

1. Run the following fixed effect regression and store the predicted error and the fixed effect.

$$\log y_{i,t} = \kappa_i + \beta_t + \alpha(age_{i,t}) + \theta\mathbb{1}\{m_{i,t-1} = bad\} + \gamma\mathbb{1}\{p_{i,t-1} = bad\} + \mu\mathbb{1}\{m_{i,t-1} = bad \wedge p_{i,t-1} = bad\} + \log \varepsilon_{i,t}$$

2. Using the regression's residuals, choose the vector of parameters $\theta = \{\sigma^2_\kappa, \sigma^2_\epsilon, \sigma^2_\nu, \rho\}$ and the Variance-Covariance matrix under an AR(1) process to minimize the unweighted squared errors.

Income process: How I estimated it

3. The empirical Variance-Covariance matrix is given by

$$\hat{\Sigma} = \begin{bmatrix} \hat{\sigma}^2_{25} & . & . & . & . & \cdots & . \\ . & \hat{\sigma}^2_{26} & . & . & . & \cdots & . \\ cov(r_{i,27}, r_{i,25}) & . & \hat{\sigma}^2_{27} & . & . & \cdots & . \\ . & cov(r_{i,28}, r_{i,26}) & . & \hat{\sigma}^2_{28} & . & \cdots & . \\ cov(r_{i,29}, r_{i,25}) & . & cov(r_{i,29}, r_{i,27}) & . & \hat{\sigma}^2_{29} & \cdots & . \\ \vdots & \vdots & \vdots & \vdots & \vdots & \cdots & \vdots \\ cov(r_{i,65}, r_{i,25}) & . & cov(r_{i,65}, r_{i,27}) & \cdots & cov(r_{i,65}, r_{i,29}) & \cdots & \hat{\sigma}^2_{65} \end{bmatrix}$$

Income process: How I estimated it

6. The Variance-Covariance matrix according to an AR(1) process is given by

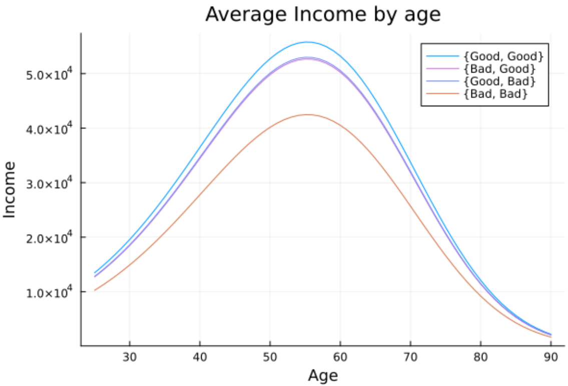
$$\Sigma = \begin{bmatrix} \sigma_\nu^2 + \sigma_\eta^2 + \sigma_\kappa^2 & . & . & . & . & \cdots & . \\ . & \sigma_\nu^2 + \sigma_\eta^2 + \sigma_\kappa^2 & . & . & . & \cdots & . \\ \sigma_\kappa^2 + \rho^2\sigma_\nu^2 & . & \sigma_\nu^2 + \sigma_\eta^2 + \sigma_\kappa^2 & . & . & \cdots & . \\ . & \sigma_\kappa^2 + \rho^2\sigma_\nu^2 & . & \sigma_\nu^2 + \sigma_\eta^2 + \sigma_\kappa^2 & . & \cdots & . \\ \sigma_\kappa^2 + \rho^4\sigma_\nu^2 & . & \sigma_\kappa^2 + \rho^2\sigma_\nu^2 & . & \sigma_\nu^2 + \sigma_\eta^2 + \sigma_\kappa^2 & \cdots & . \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ . & \sigma_\kappa^2 + \rho^{38}\sigma_\nu^2 & . & \sigma_\kappa^2 + \rho^{36}\sigma_\nu^2 & . & \cdots & . \\ \sigma_\kappa^2 + \rho^{40}\sigma_\nu^2 & . & \sigma_\kappa^2 + \rho^{38}\sigma_\nu^2 & . & \sigma_\kappa^2 + \rho^{36}\sigma_\nu^2 & \cdots & . \end{bmatrix}$$

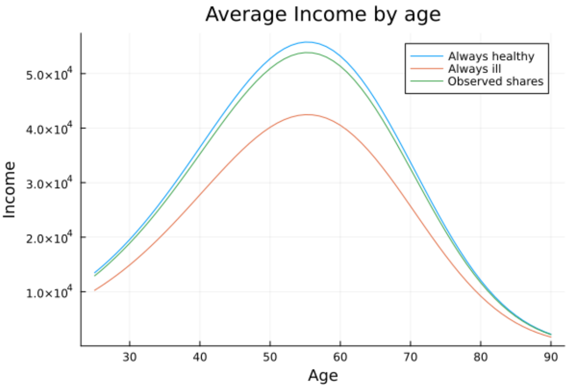
Income process: Regressions

	(1)	(2)	(3)	(4)
		dependent variable: $\log(y)$		
$\mathbb{1}\{p_{t-1} = bad\}$	-0.119***		-0.113***	-0.0515
	(0.0368)		(0.0366)	(0.0407)
$\mathbb{1}\{m_{t-1} = bad\}$		-0.0916***	-0.0847***	-0.0579**
		(0.0219)	(0.0216)	(0.0223)
$\mathbb{1}\{p_{t-1} = bad\} \times \mathbb{1}\{m_{t-1} = bad\}$				-0.164**
				(0.0678)
Age_t	0.0737	0.0698	0.0682	0.0684
	(0.0565)	(0.0563)	(0.0562)	(0.0562)
Age_t^2	0.000758	0.000803	0.000840	0.000843
	(0.00120)	(0.00120)	(0.00120)	(0.00120)
Age^3	-0.0000171*	-0.0000173*	-0.0000176*	-0.0000176**
	(0.00000893)	(0.00000892)	(0.00000891)	(0.00000892)
Constant	7.418***	7.533***	7.565***	7.546***
	(1.268)	(1.258)	(1.255)	(1.252)
Observations	20,172	20,120	20,116	20,116

Clustered standard errors in parentheses at the individual level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Income process: Results





AR(1) process results

Health transition process

Transition probabilities

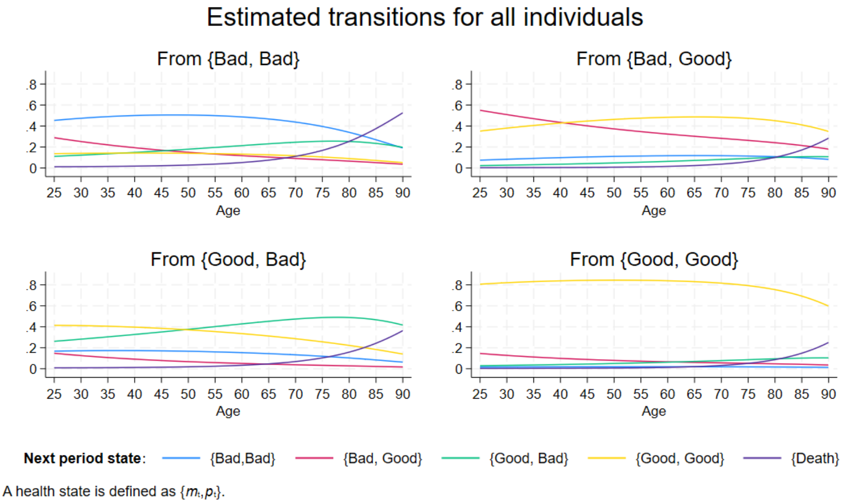
What I have done:

- Included "death" as a 5th health state.
- Estimated health transition process using a multinomial logit model.

The probability of in the next period being in state j conditional on being in state k today, having age a_t and being of sex s_t equals to:

$$Pr(h_{t+1} = j | h_t = k, s_t, a_t) = \frac{exp\left\{\beta_0^j + \beta_k^j \mathbb{1}\{h_t = k\} + \beta_w^j \mathbb{1}\{s_t = woman\} + \beta_{a,1}^j a_t + \beta_{a,2}^j a_t^2\right\}}{\sum_{s=1}^{5} exp\left\{\beta_0^s + \beta_k^s \mathbb{1}\{h_t = k\} + \beta_w^s \mathbb{1}\{s_t = woman\} + \beta_{a,1}^s a_t + \beta_{a,2}^s a_t^2\right\}}$$

Transition probabilities by age



Regression results Empirical vs Estimated transitions

Memory in the Health process

In the previous presentation, I received the suggestion to test whether including mental health as a second health variable could help rationalize the memory process documented in the literature on physical health. For this purpose, I estimate the following logit model:

$$Pr(p_{t+1} = B | h_t, \tau_B) = \Lambda \left(\sum_{\tau=1}^{T-1} a_\tau^B \mathbb{1}\{\tau_B = \tau\} + a_T^B \mathbb{1}\{\tau_B \geq T\} + f_{age}^{h_t}(t) \right)$$

I will also run this regression using m_{t+1} as the outcome variable. This is the same equation estimated by De Nardi, Paschenko, and Porapakkarm (2024) but without health types.

Memory in the Health process: Bad health

	T=5	T=4	T=3	T=2	T=1	T=5	T=4	T=3	T=2	T=1
			Physical health					Mental health		
a_2^B	0.209	0.229	0.773***	1.408***		0.096	0.189	0.600***	1.191***	
	(0.253)	(0.187)	(0.142)	(0.091)		(0.279)	(0.184)	(0.123)	(0.077)	
a_3^B	1.031***	0.960***	1.731***			1.098***	1.194***	1.706***		
	(0.345)	(0.218)	(0.125)			(0.321)	(0.191)	(0.106)		
a_4^B	0.956***	1.749***				1.201***	1.766***			
	(0.329)	(0.166)				(0.283)	(0.147)			
a_5^B	1.974***					1.748***				
	(0.237)					(0.204)				
$\mathbb{1}\{p_t = B\}$	-0.0987	0.949	0.332	0.152	0.628	0.776	0.163	-0.393	-0.437	0.163
	(1.450)	(1.093)	(0.828)	(0.651)	(0.487)	(1.368)	(1.013)	(0.759)	(0.559)	(0.387)
$\mathbb{1}\{p_t = B\} \times age_t$	0.0963*	0.0546	0.0753**	0.0810***	0.0888***	0.041	0.058	0.073*	0.074***	0.075***
	(0.050)	(0.039)	(0.030)	(0.024)	(0.019)	(0.050)	(0.038)	(0.029)	(0.022)	(0.016)
$\mathbb{1}\{p_t = B\} \times age_t^2$	-0.0003	-0.0005	-0.001***	-0.001***	-0.001***	-0.0003	-0.0004	-0.0006*	-0.0006**	-0.0006***
	(0.0004)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0004)	(0.0003)	(0.0003)	(0.0002)	(0.0001)
Observations	7,855	11,837	16,797	23,017	33,993	7,725	11,646	16,566	22,759	33,728

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Memory in the Health process: Mixed process

	T=5	T=4	T=3	T=2	T=5	T=4	T=3	T=2
	Physical health process				Mental health process			
$a^B_{2,phy}$	0.252	0.235	0.764***	1.334***	0.232	0.119	-0.003	0.257**
	(0.261)	(0.193)	(0.143)	(0.093)	(0.328)	(0.228)	(0.158)	(0.098)
$a^B_{3,phy}$	0.960**	0.917***	1.646***		0.293	0.303	0.446***	
	(0.346)	(0.224)	(0.128)		(0.377)	(0.274)	(0.127)	
$a^B_{4,phy}$	0.734*	1.666***			0.803*	0.575***		
	(0.361)	(0.175)			(0.229)	(0.156)		
$a^B_{5,phy}$	1.858***				0.548**			
	(0.245)				(0.203)			
$a^B_{2,men}$	-0.332	-0.054	-0.089	0.277**	0.133	0.180	0.587***	1.127***
	(0.426)	(0.248)	(0.163)	(0.097)	(0.281)	(0.186)	(0.125)	(0.078)
$a^B_{3,men}$	0.042	0.135	0.398**		1.052**	1.147***	1.630***	
	(0.409)	(0.221)	(0.127)		(0.321)	(0.192)	(0.110)	
$a^B_{4,men}$	0.822**	0.650***			1.165***	1.670***		
	(0.275)	(0.160)			(0.287)	(0.149)		
$a^B_{5,men}$	0.444*				1.690***			
	(0.214)				(0.205)			
Observations	7,733	11,671	16,610	27,984	7,715	11,634	22,745	33,715

Standard errors in parentheses. $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Model

Model Overview

- Demographics:
  - Agents enter at 25, dies at 90
  - They are endowed with shocks of physical and mental health that determine health, $h_t = (m_t, p_t)$
  - Uncertain lifespan: $\phi_t(h_t)$ is unconditional survival probability up to age t
  - $\zeta_t(h_t) = \frac{\phi_t(h_t)}{\phi_{t-1}(h_{t-1})}$ is conditional survival probability
- Earnings dynamics:
  - The income process follows the structure presented in the previous section.

Preferences

- Time-Separable preferences
- Constant discount factor β
- Utility depends on consumption and mental and physical health
- Utility function (similar to Palumbo (1999)):

$$u(c_t, p_t, m_t) = \delta(p_t)\psi(m_t)\frac{c_t^{1-\gamma}}{1-\gamma}$$

- Health-related utility shifters:
  - $\delta(p_t)$ for physical health
  - $\psi(m_t)$ for mental health

Health Process

- The health variable h_t consists of:
  - Mental health (m_t)
  - Physical health (p_t)
- Each component has two possible states: good or poor health.
- Health evolves according to a first-order Markov process:

$$\pi^h_{p,m,t} = Pr(h_{t+1} = k | m_t, p_t, t)$$

- The probability of being in health state k in the next period depends on:
  - Current mental health state (m_t)
  - Current physical health state (p_t)
  - Age (t)

Earnings dynamics

- Earnings have deterministic and stochastic components:

$$\log y_{i,t} = \beta_0 + \alpha(t) + f(X) + \theta \mathbb{1}\{m_t = bad\} + \gamma \mathbb{1}\{p_t = bad\} + \mu \mathbb{1}\{m_t = bad \wedge p_t = bad\} + \kappa_i + \log \varepsilon_t$$

  - κ_i: individual fixed effect
  - $\alpha(t)$: polynomial capturing common life cycle component
  - $f(X)$: deterministic function of gender and human capital
  - θ: elasticity of wage w.r.t. mental health
  - γ: elasticity of wage w.r.t. physical health
  - μ: elasticity of wage w.r.t the interaction between mental and physical health.

- $\log \varepsilon_t$ follows an AR(1) process:

$$\log \varepsilon_t = \rho \log \varepsilon_{t-1} + \eta_t, \quad \eta_t \sim N(0, \sigma_\eta^2)$$

Model Timing

1. Beginning of period: Individual's health status (mental and physical) and productivity shock are realized.
2. Individual consumes and saves.
3. End of period: Survival shock hits.

Note: This timing is similar to De Nardi et al. (2010).

Individual's Decision Problem

- State variables: $(a_t, m_t, p_t, \varepsilon_t)$
- Choice variables: consumption c_t, savings a_{t+1}
- Value function:

$$
\begin{aligned}
V_t(a_t, m_t, p_t, \varepsilon_t) = \max_{c_t, a_{t+1}} \{ & u(c_t, p_t, m_t) + \\
& \beta \zeta_{t+1}(m_{t+1}, p_{t+1}) \mathbb{E}_t [V_{t+1}(a_{t+1}, m_{t+1}, p_{t+1}, \varepsilon_{t+1})] \}
\end{aligned}
$$

- Constraints:

$$
\begin{aligned}
c_t + a_{t+1} &\leq (1 + r_t) a_t + y_t(p_t, m_t, \varepsilon_t) \\
a_{t+1} &\geq 0
\end{aligned}
$$

Estimation procedure

Part of the parameters are assumed:

- $\beta = 0.96$
- $r = 0.03$

For the remaining parameters, I follow a two-step strategy:

1. Estimate parameters identified out of the model:
   - Health transition and mortality
   - Income dynamics
2. Estimate utility parameters matching wealth accumulation by age groups (6 10-year groups) and health status (4 groups).

Future Considerations and Model Extensions

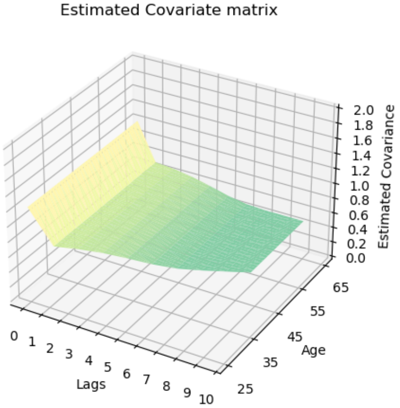
- Compare the proposed model with a model where health only affects income and survival.
- Bequest motives
- Include pensions after retirement

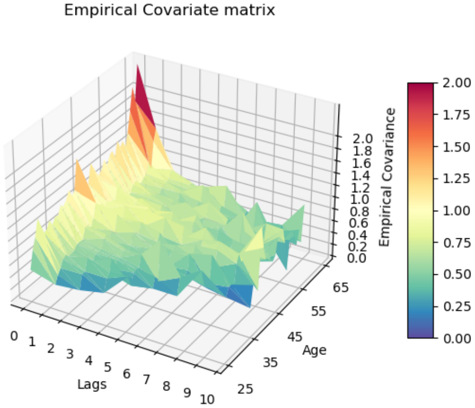
Thank you!

Appendix

Income process: Results

Back | $\rho =$ 0.9854 | $\sigma^2_\kappa =$ 0.4420 | $\sigma^2_\epsilon =$ 0.4594 | $\sigma^2_\nu =$ 0.2949 |





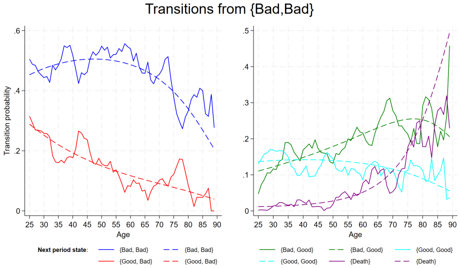
Transition probabilities: Estimates

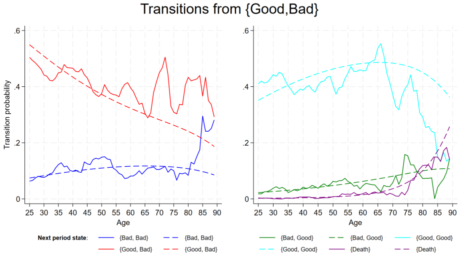
	$h_{t+1} = \{Bad, Bad\}$		$h_{t+1} = \{Bad, Good\}$		$h_{t+1} = \{Good, Bad\}$		$h_{t+1} = \{Good, Good\}$	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
$h_t = \{Bad, Good\}$	-0.226	0.288	2.233***	0.000	-0.005	0.983	2.536***	0.000
$h_t = \{Good, Bad\}$	-0.733***	0.000	-0.403**	0.044	1.127***	0.000	1.377***	0.000
$h_t = \{Good, Good\}$	-1.931***	0.000	0.741***	0.000	0.091	0.569	3.200***	0.000
$\{sex_i = Woman\}$	-1.362	0.344	-1.041	0.449	-1.649	0.242	-0.663	0.616
$Age_{i,t}$	0.025	0.471	-0.014	0.653	0.026	0.405	0.036	0.212
$Age^2_{i,t}$	-0.001***	0.008	-0.001**	0.011	-0.001**	0.017	-0.001***	0.000
$\{sex_i = Woman\} \times Age_{i,t}$	0.075	0.146	0.041	0.404	0.078	0.114	0.021	0.639
$\{sex_i = Woman\} \times Age^2_{i,t}$	-0.001	0.135	-0.0002	0.537	-0.001*	0.085	-0.001	0.693
Constant	3.500***	0.010	4.052***	0.000	2.032**	0.024	2.226**	0.008
N	33,494							
Pseudo R^2	0.9764							

Clustered standard errors at the individual level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Back

Health transitions: Estimation's fit

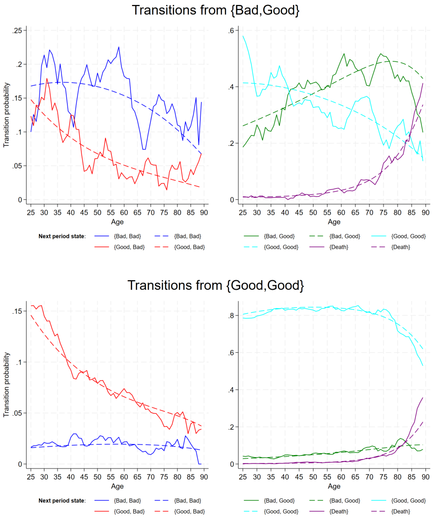




A health state is defined as $\{m_t, p_t\}$.

Health transitions: Estimation's fit

Back



A health state is defined as $\{m_t, p_t\}$.