Optimal Demand for Medical and Long-Term Care

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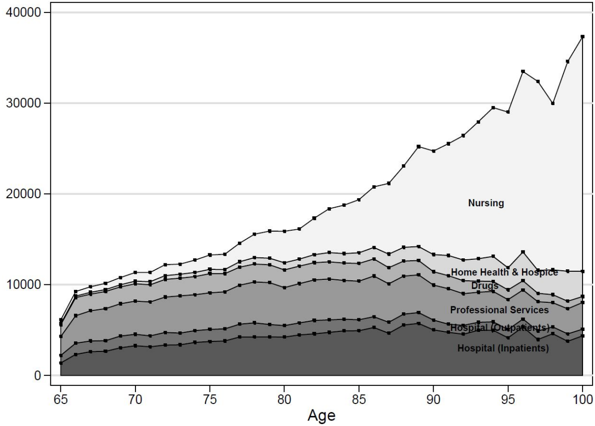
Motivation

- LTC expenditure constitute large share in total health expenditure
- LTC is driving force behind increasing health expenditure in old age



- so far: little distinction between medical and LTC care (in health econ. theory)

- however, medical and LTC differ in the course of aging

  1. medical care cures and prevents health deficits
  2. LTC provides help for daily routine (with ADL and IADL)

- How does LTC expenditure react to higher income and better medical technology? Interesting for at least two reasons...

  1. LTC expenditure is quantitatively important
  2. effect is a priori ambiguous: lower dependency levels for given age vs. higher life expectancy

This paper

Economic model of human aging which

- captures health behavior of individuals over their whole life cycle
- distinguishes between medical care and LTC
- replicates the age trajectories of medical and LTC expenditure
- evaluates the effects of higher income and better technology on LTC expenditure

We also contribute to the "Red Herring" hypothesis (Zweifel et al., 1999)

- time to death drives rising health expenditure for the old rather than increasing age
- especially interesting for LTC expenditure

How we age

2 theories of aging and longevity:

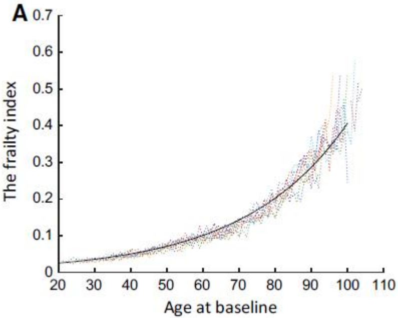
1. Conventional paradigm: accumulation of health capital (Grossman, 1972)

$$\dot{H} = f(h) - \delta H$$

2. Alternative: accumulation of health deficits (Dalgaard-Strulik, 2014)

$$\dot{D} = \mu [D - f(h)]$$

The Frailty Index (Mitnitski and Rockwood)



Age-specific cross-sectional trajectories for the 9 cycles of the NPHS. The solid line represents the average exponential fit, slope parameter 0.035. Source: Mitnitski and Rockwood (2016).

- index of human functionality
- large number of binary variables on deficits
- ranging from mild (reduced vision) to near lethal (stroke)

$\rightarrow$ deficits correlate exponentially with age:

$$D(t) = E + Be^{\mu \cdot t}$$
$$\dot{D}(t) = \mu(D(t) - E)$$

Plan of the Talk

1. set up a model of health deficit accumulation and personal care
2. calibrate it using insights from gerontology
3. obtain parameter estimates by fitting the model to observed health behavior and outcomes
4. analyze the effects of higher income and better medical technology on LTC expenditure

Life-Time Utility

Individuals maximize

$$V = \int_0^T e^{-\rho t} S(D) u(c) \, \mathrm{d}t$$

$$\text{with} \qquad u(c) = \begin{cases} \frac{c^{1-\sigma}-1}{1-\sigma} & \text{for } \sigma \neq 1 \\ \log(c) & \text{for } \sigma = 1 \end{cases}$$

- c: consumption
- $S(D)$: survival function
- $\frac{1}{\sigma}$: intertemporal elasticity of substitution
- ρ: time preference rate

Medical Care

Medical care slows down the accumulation of health deficits:

$$\dot{D} = \mu(D - Ah^{\gamma} - a)$$

with

- h: medical care
- μ: force of aging
- a: environmental factors
- A, γ: health technology with $0 < \gamma < 1$

Examples: doctor visits, hospital stays, drugs etc.

$\rightarrow$ medical care increases life expectancy

Personal Care

Personal care can be either carried out autonomously at no cost or by a third party (LTC)

$$LTC(D) = P(D)L(D)$$

with

- $P(D)$: probability of demanding LTC for given D (extensive margin)
- $L(D)$: LTC demand if LTC is required (intensive margin)
- $P'(D) > 0$, $L'(D) > 0$

Examples: daily routine like cleaning and moving the body etc.

$\rightarrow$ personal care is required to survive but is not intended to improve the state of health

Budget Constraint

Wealth accumulation:

$$\dot{k} = w + (r + m)k - c - ph - qLTC(D)$$

with

- w: wage rate
- p and q: relative prices of medical care and LTC

We assume perfect annuities: effective interest rate is sum of

- return on capital r
- instantaneous mortality rate $m = -\frac{\dot{S}}{S}$

Maximization Problem

Summarizing, individuals maximize

$$\int_0^T e^{-\rho t} S(D) u(c) \, \mathrm{d}t,$$

subject to

- $D(0) = D_0$, $D(T) = D_T$
- $k(0) = k_0$, $k(T) = k_T$
- $\dot{D}$
- $\dot{k}$
- $LTC(D) = P(D)L(D)$

free-terminal-time problem

Euler Equations

Hamiltonian:

$$\mathcal{H} = S(D)u(c) + \lambda_D \mu(D - Ah^{\gamma} - a) + \lambda_k \left(w + (r+m)k - c - ph - qLTC(D)\right)$$

Consumption growth:

$$\frac{\dot{c}}{c} = \frac{r - \rho}{\sigma}$$

Health expenditure growth:

$$\frac{\dot{h}}{h} = \frac{(r+m) - \mu + \frac{1}{\lambda_D}\left[\lambda_k q(P'(D)L(D) + P(D)L'(D)) - S'(D)u(c)\right]}{1 - \gamma}.$$

Calibration: Uncertain Survival and LTC

- biologists emphasize: age does not explain death (Arking, 2006)
- health deficits explain death

Survival Function

$$S(D) = \frac{1+\omega}{1+\omega \mathrm{e}^{\xi D}}$$

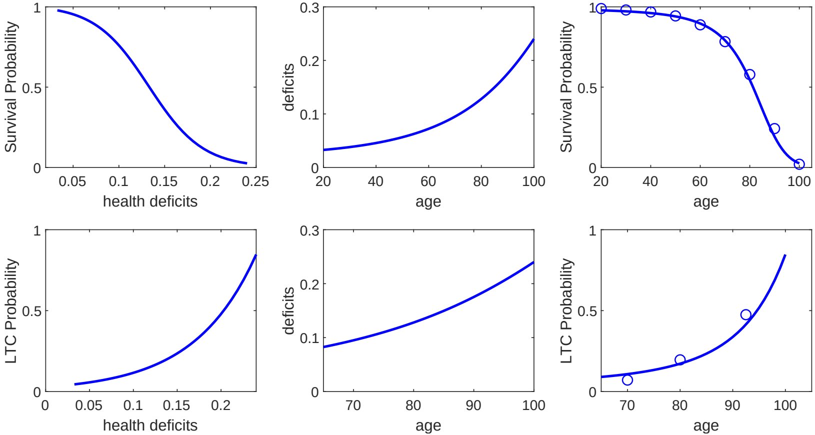
The extensive margin of LTC

$$P(D) = \kappa e^{\epsilon D}$$

The intensive margin of LTC

$$L(D) = E + BD$$

Health-Dependent Survival and LTC probability



Left Panels: Assumed survival function $S(D)$ (top) and LTC probability function $LTC(D)$ (bottom), Middle panels: Estimated Association D(t) (Mitnitski et al., 2002a). Right panel: Predicted (line) and empirically observed (dots) association between age and survival probability (top) (data from NVSS (2016)) and between age and LTC probability (bottom) (data constructed from CDC (2013)).

Calibration Strategy

Given a set of externally determined parameters, we estimate the "free" parameters σ, ρ, μ, A, a, B, E, and $\bar{D}$ to match (for the year 2012)

1. a life expectancy of 77.2 years
2. life-cycle medical care expenditures at age 30, 50, 70, and 90
3. per user LTC expenditure at age 75, 93
4. a maximum lifespan of 100 years

Table 1a: Externally Determined Parameters

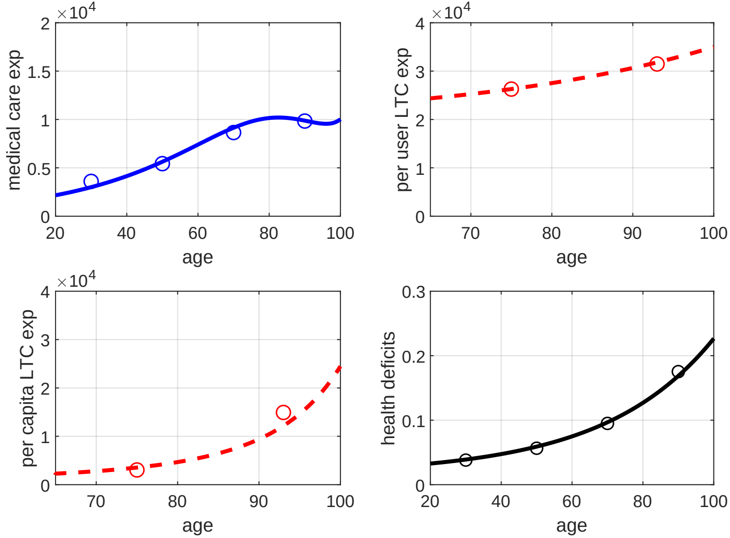
ω	ξ	κ	ϵ	D_0	γ	w	r	p	q	τ
0.11	34	0.028	14.2	0.0328	0.2	30,324	0.07	1	1	0.383

Table 1b: Calibration Results

σ	ρ	μ	A	a	$\bar{D}$	B	E
1.17	0.06	0.033	0.00123	0.011	0.23	75000	18000

- "true" value of σ close to one (Chetty, 2006)
- pooled estimate of $\mu = 0.033$ lies in between Mitnitski at al.'s (2002) estimate for women (0.031) and men (0.043)

Results



×10^4
medical care exp
age
×10^4
per user LTC exp
age
×10^4
per capita LTC exp
age
health deficits
age

Higher Income and Better Technology

We are particularly interested how higher income and better technology affects LTC expenditure for two reasons

1. LTC expenditure is crucial for health expenditure in old age
2. interesting trade-off for LTC expenditure: increasing life span vs. better health (and thus lower dependency rates for given age)

The "Red Herring" Hypothesis (Zweifel et al., 1999):

- accounting for time of death, age has no impact on health expenditure
- implication here: rising life expectancy is neutral for LTC expenditure

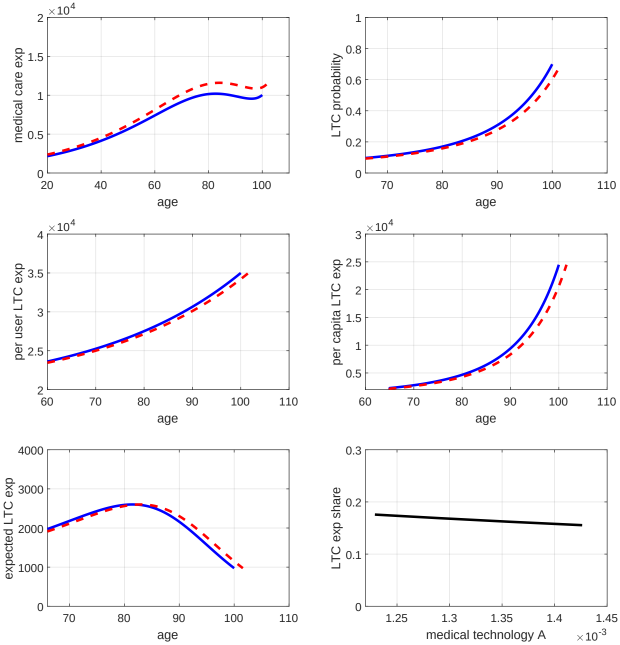

×10^4
medical care exp
age
LTC probability
age
×10^4
per user LTC exp
age
×10^4
per capita LTC exp
age
expected LTC exp
age
LTC exp share
medical technology A
×10^-3

Table 2: Evolution of Expenditures

case	exp LTC (PV)	exp medical (PV)	exp total (PV)	share LTC (PV)	life expectancy	elasticity
Technology						
$\hat{A} = 0.0100$	4.16 (2.65)	14.9 (10.2)	13.0 (10.1)	-7.85 (-6.75)	2.36	1.76 (1.12)
$0.5 * \hat{A}$	2.02 (1.38)	7.17 (5.03)	6.26 (4.97)	-3.99 (-3.42)	1.13	1.79 (1.22)
$1.5 * \hat{A}$	6.47 (3.92)	23.4 (15.5)	20.4 (15.3)	-11.6 (-9.87)	3.70	1.75 (1.06)
Income						
$\hat{w} = 0.0121$	1.13 (0.77)	19.8 (18.5)	16.5 (18.1)	-13.2 (-14.7)	0.63	1.79 (1.22)
$0.5 * \hat{w}$	0.54 (0.32)	9.47 (8.87)	7.90 (8.73)	-6.82 (-7.73)	0.31	1.74 (1.03)
$1.5 * \hat{w}$	1.67 (1.06)	31.0 (28.8)	25.8 (28.3)	-19.2 (-21.2)	0.95	1.76 (1.12)
Technology and Income						
$\hat{A} = 0.0100,\ \hat{w} = 0.0121$	5.46 (3.40)	37.7 (30.4)	32.1 (29.9)	-20.2 (-20.4)	3.11	1.76 (1.09)
$0.5 * \hat{w},\ 0.5 * \hat{A}$	2.59 (1.63)	17.3 (14.3)	14.7 (14.1)	-10.6 (-10.9)	1.47	1.76 (1.11)
$1.5 * \hat{w},\ 1.5 * \hat{A}$	8.57 (4.95)	61.9 (48.3)	52.5 (47.5)	-28.8 (-28.9)	4.95	1.73 (1.00)

All values as percentage deviation from the benchmark run in the year 2012. exp LTC, exp medical, and exp total refer to expected LTC expenditure, expected medical care expenditure, and expected total health expenditure, respectively. share LTC refers to the share of LTC expenditure in total health expenditure. PV refers to present value. Elasticity refers to the ratio of the percentage change between expected LTC expenditure and life expectancy.

Results Summary

Higher income and better technology:

1. lead to higher medical care expenditure and thus better health and higher life expectancy
2. lead to an increase in expected LTC expenditure: the effect of higher life expectancy dominates the effect of lower dependency levels for given age
3. elasticity between life expectancy and expected LTC expenditure is around 1.75 (1 in PV terms)
4. this elasticity is remarkably stable w.r.t different sizes of shocks to income and medical technology

Concluding Remarks

Historically, we observe a rather constant share of LTC expenditure in total health care expenditure

- our model predicts a higher increase in medical care expenditure than LTC expenditure
- reason: the expenditure-dampening effect of lower dependency levels
- hence, constant share of LTC expenditure attributed to factors outside the model (demographic change, informal care etc.)

Future Research

- personal care enters utility
- utility loss from loss of independence
- personal care provided by the partner