Limited Self-Control and Longevity

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Abstract. This paper proposes a new framework to discuss self-control problems in the context of life-cycle health and longevity. Individual decisions are conceptualized as the partial control of impulsive desires of a short-run self by a rationally forward-looking long-run self. The short-run self strives for immediate gratification through consumption of health-neutral and unhealthy goods. The long-run self reflects the long-term consequences of unhealthy behavior on health outcomes and longevity and invests time and money to improve current and future health. The model is calibrated with data from the U.S. and used to provide an assessment of the impact of imperfect self-control on unhealthy consumption, health investments, lifetime health, and the age at death.

Keywords: self-control, unhealthy behavior, health investments, aging, longevity.
JEL: D11, D91, E21, I10, I12.

1. Introduction

Several manifestations of bounded rationality have been suggested to better explain health behavior (Cawley and Ruhm, 2012) but so far the problem of limited self-control has not been analyzed in the context of an economic life cycle model of endogenous health and longevity.[1] A series of empirical studies have provided evidence for imperfect self-control as a driver of impulsive consumption and low investment in general (Shiv and Fedorikhin, 1999; Baumeister, 2002; Ameriks et al., 2007) and as driver of unhealthy consumption like overeating (Crescioni et al., 2011; Stutzer and Meier, 2016), alcohol consumption (Lyvers, 2000), and smoking (Kan, 2007; Fletcher et al., 2009; Daly et al., 2015). Inferences about causality, however, are difficult to obtain from empirical studies because there exists no counterfactual or treatment group.

Here, I suggest addressing this problem with counterfactual computational experiments. I integrate the dual-self model (Fudenberg and Levine, 2006) into the life cycle model of health deficit accumulation (Dalgaard and Strulik, 2014), calibrate it for a Reference American, and then simulate behavior and health outcomes of the same person with perfect self-control.

The dual-self model formalizes the notion that humans are neither mere "cold" long-run planners nor mere "hot" affective persons by considering individuals consisting of a rational long-run self who partly controls the impulsive actions of a short-run self. The health deficit model is particularly suitable for the discussion of unhealthy behavior on the deterioration of bodily function and premature death. It uses a metric, the frailty index, which has been established in gerontology (based on Mitnitski et al., 2002) and which allows for a straightforward calibration of the model. Calibrated with data on smoking as unhealthy consumption, the model suggests that the Reference American could live 4 to 8 years longer if he would not suffer from self-control problems and behave as the long-term planning agent assumed in conventional life-cycle models.

2. The Model

Consider an individual who derives utility from consuming health-neutral goods c and unhealthy goods u and faces the utility function

$$U(c,u) = \frac{\left[\beta c^{\psi} + (1-\beta)(u+\zeta)^{\psi}\right]^{\frac{1-\sigma}{\psi}} - 1}{1-\sigma}, \tag{1}$$

[1]Outside the life cycle model, economic theory has addressed the impact of self-control on smoking and obesity (Gruber and Koszegi, 2001; Cutler et al., 2003; Ruhm, 2012).

in which σ determines the elasticity of intertemporal substitution and ψ determines the elasticity of substitution between health neutral goods and unhealthy goods. The parameter β determines the general desirability of unhealthy consumption and the parameter ζ is a device to introduce abstention from unhealthy consumption, $\zeta \geq 0$.

Following Fudenberg and Levine (2006), the individual is conceptualized as a dual self. The impulsive short-run self neglects the long-run consequences of consumption. It has access to liquid funds $\tilde{w}$ and maximizes (1) subject to the budget constraint $\tilde{w} = c + qu$, in which q is the relative price of unhealthy goods. Unhealthy consumption desired by the short-run self is then given by:

$$u = u_s \equiv \max \left\{ 0, \; \frac{\tilde{w} - \chi\zeta}{\chi + q} \right\}, \qquad \chi \equiv \left[\frac{1-\beta}{q\beta} \right]^{\frac{1}{\psi - 1}} \tag{2}$$

and the desired health neutral consumption is $c = c_s \equiv \chi(u + \zeta)$. Unhealthy consumption is increasing in liquid funds and declining in the price of unhealthy goods q. By inserting u_s and c_s into (1) we obtain the immediate gratification $U(c_s, u_s)$ desired by the short-run self.

The long-run self faces the same utility function (1), plans life cycle decisions from now until death, and takes the impact of unhealthy consumption on health into account. The long-run self spends some income on health care and savings and faces the budget constraint

$$\dot{k} = w + rk - c - qu - ph, \tag{3}$$

in which k is financial wealth, r is the interest rate, w is non-financial income, h is health expenditure, and p is the relative price of health.

As they age, individuals accumulate health deficits D at a natural rate μ. The speed of health deficit accumulation is reduced by health investments and increased by unhealthy consumption. The evolution of health deficits is given by

$$\dot{D} = \mu \left[D - Ah^{\gamma} + Bu - a \right]. \tag{4}$$

The parameters A and γ determine the available medical technology. The parameter B determines the unhealthiness of u-consumption. The individual dies at endogenous age T when $\bar{D} > D(0)$ health deficits have been accumulated.

The long-run self maximizes lifetime utility

$$V = \int_0^T \mathrm{e}^{-\rho t} \left\{ U(c, u) - \omega \left[U(c_s, u_s) - U(c, u) \right] \right\} \mathrm{d}t. \tag{5}$$

The term in square brackets in (5) reflects the difference between the utility desired by the short-run self and actually experienced utility. The parameter ω measures the cost of self-control, i.e. the expression $\omega\left[U(c_s,u_s)-U(c,u)\right]$ measures the craving that the individual experiences when not conceding to the desires of the short-run self. For $\omega = 0$, the individual has perfect self-control.

The current value Hamiltonian associated with problem (1)–(5) is given by

$$H = (1+\omega)U(c,u) - \omega U(c_s,u_s) + \lambda_k\left[w + rk - c - qu - ph\right] + \lambda_D\mu\left[D - Ah^{\gamma} + Bu - a\right]. \quad (6)$$

The first order conditions with respect to consumption c, unhealthy consumption u, and health investments h are

$$0 = \frac{\partial U}{\partial c} - \frac{\lambda_k}{1+\omega} \quad (7)$$

$$0 = u\left[\frac{\partial U}{\partial h} - \frac{\lambda_k q - \lambda_D\mu B}{1+\omega}\right] \quad (8)$$

$$0 = \lambda_k p + \lambda_D\mu\gamma A h^{\gamma-1}. \quad (9)$$

The first term on the right-hand side of condition (7) is the marginal utility experienced from consuming one unit of health neutral goods. If ω were zero, the right-hand side of (7) would be equal to the marginal cost of consuming one unit, consisting of foregone saving multiplied by the shadow price of capital λ_k, as in the standard life cycle model. With limited self-control, $\omega > 0$ and the right-hand side is smaller than the marginal cost of consumption. This means that the left-hand side is also smaller than in the corresponding standard model such that individuals, ceteris paribus, consume more and save less since marginal utility is declining with increasing consumption.

Likewise, the first term in parentheses of condition (8) shows the marginal utility experienced from consuming one unit of the unhealthy good. If ω were zero, the second term in parentheses would be the marginal cost of consuming the unhealthy good, which accrues because of lower savings (marginal effect captured by $\lambda_k q$) and because of the quicker accumulation of health deficits (marginal effect captured by $\lambda_D\mu B$). Note that $\lambda_D < 0$ because health deficits contribute negatively to the objective function. With limited self-control, $\omega > 0$, and individuals devalue the costs of unhealthy consumption. This means that they consume more unhealthy goods and experience lower marginal utility from consumption.

Condition (9) requires that the marginal cost of health expenditure, given by $\lambda_k p$, is equal to the marginal benefit of health expenditure. The marginal benefit consists of the marginal impact on health deficit accumulation ($\mu\gamma A^{\gamma-1}$) multiplied by the contribution to the objective function of having one health deficit less ($-\lambda_D$).

How exactly life cycle plans are affected by self-control can only be determined by numerical analysis. The constrained-optimal plan fulfills the first order conditions, the costate equations, and the boundary conditions $k(0) = k_0$, $D(0) = D_0$, $k(T) = \bar{k}$, and $D(T) = \bar{D}$. The Appendix provides details on the solution of this free terminal-time problem.

3. Calibration

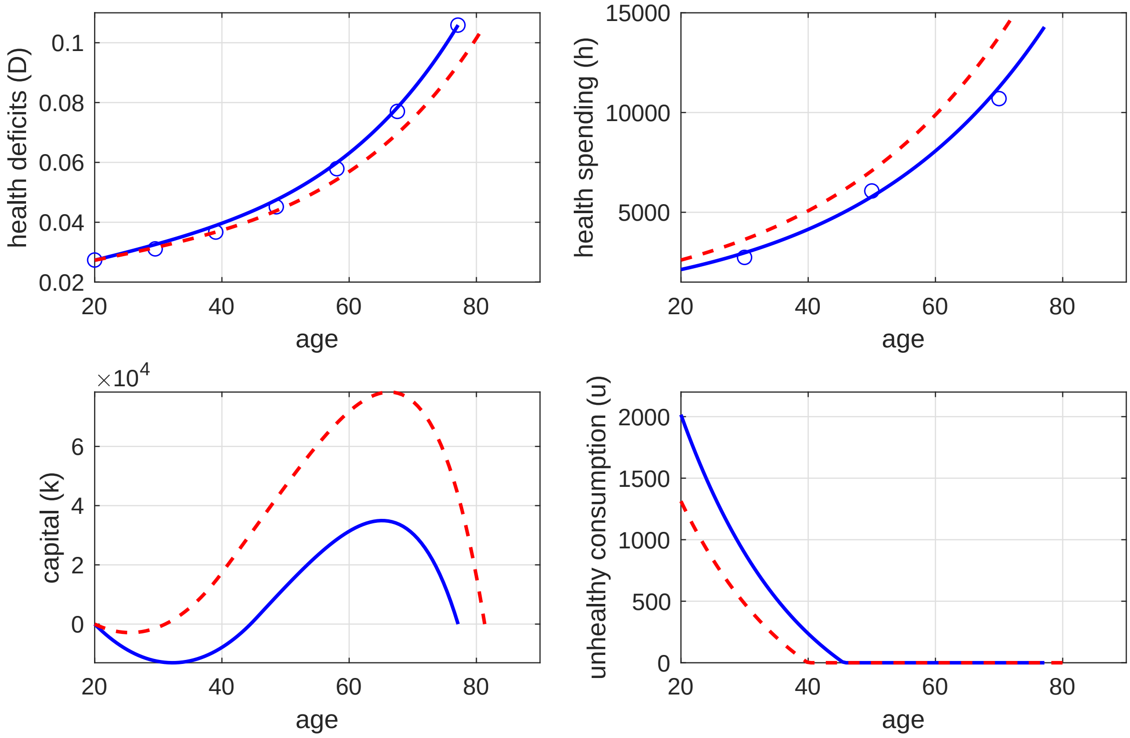
The model is calibrated for an average 20-year-old American male in the year 2010. The Appendix contains the details of the calibration. All parameter values are summarized below Figure 1. The benchmark specification of ω is related to Kovacs (2016) who estimates the temptation parameter for Gul and Pesendorfer (2001) preferences, which can be mapped into an estimate of ω. To see how, notice that maximizing $U(c,u) - \omega\,[U(c_s, u_s) - U(c,u)]$ is the same as maximizing $U(c,u) - \frac{\omega}{1+\omega}U(c_s, u_s)$. This means that our utility function is structurally identical with temptation preferences where $\omega/(1+\omega) \equiv \lambda$ is the temptation parameter. Using consumer expenditure data for the US, Kovacs (2016, Table 5) estimates $\lambda = 0.2$, implying $\omega = 0.25$.

In order to quantify unhealthy consumption, I conceptualize it as smoking and calibrate the non-predetermined parameters A, B, β, γ, σ, ψ, and ζ jointly with ω such that: the model predicts the actual accumulation of health deficits over a lifetime (as estimated by Mitnitski et al., 2002); death occurs at the moment when $\bar{D} = 0.106$ health deficits have been accumulated at an age of 77.1 years (male life expectancy in 2010); health expenditure matches health care expenditure of American men in 2010 at the age of 35 and 70 (MEPS, 2010); the Reference American spends on average \$ 364 per year on the unhealthy good and quits smoking for good at age 45; and that consumption of the unhealthy good costs about 7 years of life.

The implied price elasticity of demand for the unhealthy good is -0.48, which is in the middle of the empirical estimates of the demand elasticity for cigarettes (Chaloupka and Warner, 2000). As another plausibility check, I calculate the value of life (VOL) of the Reference American. The VOL uses an "util" $u'(c)$ to convert lifetime utility into a monetary term. The benchmark calibration predicts a VOL of about \$ 5.9 million at age 20. This value corresponds well to Murphy and Topel's (2006, Fig. 3) estimate of a VOL of about \$ 6.5 million for American men at age 20.

4. Results

The life cycle health behavior of the Reference American is shown in Figure 1 by solid lines. Dots in the D-panel indicate the actual health deficits at the specific ages according to Mitnitski et al. (2002) and dots in the h-panel indicate actual health expenditure according to MEPS (2010). High health expenditure at old age is financed by savings in middle age, as shown in the lower left panel. Unhealthy consumption is high when the Reference American is young and then falls steeply with increasing age, as shown in the lower right panel.



Blue (solid) lines: limited self-control ($\omega = 0.25$; $T + 20 = 77.1$). Red (dashed lines): perfect self-control ($\omega = 0$; $T + 20 = 81.3$). Parameters: $\beta = 0.37$, $\gamma = 0.19$, $\mu = 0.043$; $\rho = 0.07$; $\sigma = 1.035$; $\zeta = 650$; $a = 0.013$; $p = q = 1$; $A = 0.00173$; $B = 3 \cdot 10^{-6}$; D(0)=0.0273; $\bar{D} = 0.106$; $r = 0.07$; $w = 27,928$. Dots indicate actual health deficits (from Mitnitski et al., 2002; left panel) actual health expenditure (from MEPS, 2010; right panel).

In order to asses what an estimated self-control value of $\omega = 0.25$ means, I rerun the model and set $\omega = 0$, i.e. I impose unlimited self-control, and keep everything else from the benchmark calibration. The implied life cycle trajectories are shown by dashed lines. Given unlimited self-control, the Reference American reduces smoking and quits smoking earlier in life. Moreover, he saves substantially more and spends more on health, particularly in old age. As a consequence, he develops health deficits more slowly and dies later, at age 81.3. Thus, imperfect self-control costs the Reference American 4.2 life years.

The robustness of these findings is explored with a sensitivity analysis, shown in Table 1. Case 1 repeats the benchmark run from Figure 1. Without self-control problems the individual would spend $\Delta h/h = 21.3\%$ more on health, reduce unhealthy consumption by $\Delta u/u = 68.6\%$, and live $\Delta T = 5.4$ years longer. Case 2 shows that for $\omega = 0.50$ the individual would smoke about 65% less, spend about 1/3 more on health and live almost 8 years longer. If self-control declines further and $\omega = 1$, as for case 3, the individual would smoke more than 80% less if he had unlimited self-control. This result can be related to the study by Fletcher et al. (2009) who find that individuals assigned to a high-self-control group smoke 94% less than individuals assigned to a low-self-control group. If we thus conceptualize a value of $\omega = 1$ (or higher) as low self-control and assume that the Reference American has average self-control, the implied ω would be closer to 0.5 than 0.25. Altogether this suggests that the average American loses between 4 and 8 years of life lost due to self-control problems in consumption and health behavior.

Table 1: The Impact of Self Control on Health Behavior and Longevity

case	change	remark	$\Delta u/u$	$\Delta h/h$	ΔT
1	–	benchmark	-45.4	16.4	4.2
2	$\omega = 0.5$	lower self-control	-65.3	33.1	7.9
3	$\omega = 1$	low self-control	-82.6	69.5	14.6
4	$\psi = -0.25$	low elast. of substitution	-33.4	13.0	2.9
5	$B = 10^{-6}$	u less unhealthy	-40.9	22.7	2.0
6	$q = 0.5$	u less expensive	-48.4	16.0	4.4
7	$\tilde{w} = 0.1w$	less temptation	-52.2	14.3	3.9

The table shows the impact of self-control by reducing ω to zero; ΔT is measured in years, changes in unhealthy consumption $\Delta u/u$ and health expenditure $\Delta h/h$ are measured in percent.

Case 4 sets ψ to -0.25 implying that the elasticity of substitution between unhealthy and health-neutral goods is 0.8 (instead of 2). It also implies a reduction of the price elasticity of demand for the unhealthy good to -0.32. The unhealthy good is now more complementary to ordinary consumption and thus reduced by less when self-control improves. If the Reference American had perfect self-control, u would decline by 33% and h increase by 13%, implying that together, 2.9 years of life could be saved by perfect self-control.

Case 5 makes consumption less unhealthy by reducing B to 10^{-7}, implying that 2.0 years of life could be saved by abstaining from unhealthy consumption. This value would be at the lower end of the empirical estimates for cigarettes and at the upper end of the estimates for alcohol. The calibration requires an increase of β and a reduction of A because otherwise, the Reference American would consume the unhealthy good too much and/or live too long. With these adjustments, the transition to perfect self-control would save 2.0 years of life by reducing unhealthy consumption by 41% and increasing health expenditure by 23%.

Case 6 shows that prices play only a minor role. If we reduce the price of the unhealthy good by half, the outcome is similar as for the benchmark case, with a 72% reduction of unhealthy consumption and a 4.4 year gain in longevity from perfect self-control. Finally, we consider a reduction of liquid funds for spontaneous consumption. If only 10% (instead of 100%) of wage income were at disposal for consumption, the decline of unhealthy consumption would be 37% (instead of 45%) "only" 3.9 years of life could be gained from perfect self-control.

5. Conclusion

This paper has proposed a dual-self life cycle model of endogenous health behavior and endogenous health outcomes in order to assess the role of limited self-control on longevity. The model suggests that about 4 to 8 years of life are lost due to limited self-control. If the price elasticity of the unhealthy good, or its unhealthiness is calibrated using values from the lower bound of empirical estimates, the model suggest a lower bound of about 2 years of life lost due to limited self-control.

A discussion paper (Strulik, 2018) includes further analyses on the role of income, liquid funds, and prices on health behavior and an extension towards self-control in physical exercise. It also discusses the related literature, limitations, and possible extensions.

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