US Health and Aggregate Fluctuations

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Motivation

- Spending on Health is an important item in the government budget, both across OECD countries, and across time: It is the 2nd most important (after education) with 6.5 % of GDP, with US being the leader with 15 % of GDP. Moreover, health spending as a percentage of GDP has been on the rise during the last 60 years in US(Hall and Jones 2007, JPE), as well as in OECD countries(OECD Health Data).
- It is a stylized fact that sick time represents a significant proportion (3-9.5%) of total working time in OECD countries (CES-Ifo Dice Database 2011).
- That imposest a non-trivial cost on the OECD economies, that ranges between 11.6-17.9 % of GDP.
- Health spending is an important part of the fiscal policy over the business cycle.

Motivation and Literature Review

- Health can have significant effect on hours, and fluctuations in hours are responsible for 2/3 of the fluctuation in output, the rest is due to productivity.
- In the model, health will be general well-being, i.e lack of obesity, alcohol abuse, smoking, drug addiction.
- In data, health of a nation measures vary over the business cycle and co-move with real output and productivity. That is an indication that good health is at least partially responsible for higher productivity.
- By endogeneizing health in a DSGE model, we will isolate part of the exogenous TFP variability. Our work is be in line with the agenda set by Prescott in his 1998 IER paper "Needed: A theory of Total Factor Productivity."

Literature Review

- In American Time Use Survey (ATUS) from 2009, people who do sports spend approximately 30 % of their leisure exercising.
- In this sense, as pointed by Zweifel (2009, Ch.3) "health can be produced." It can be viewed as an intangible and non-transferrable capital stock, which depreciates over time.
- Individuals can dedicate time and effort to improve health, e.g. through exercising, vacation, good diet and recreation, but such investment will produce uncertain outcomes.
- In addition, there is no market for health.
- The model in this chapter expands on Grossman's (1982, 2000) partial equilibrium model.
- Health shocks are like investment-specific shocks (Greenwood et al. 1997), like TFP shocks. TFP variation can be attributed to better health of employees. In US higher health of the aggregate population corresponds to periods of higher productivity.

Model Description

- There is a representative household, as well as a representative firm.
- Each household owns physical capital and labor, which it supplies to the firm.
- Time can be spent working, exercising, being sick, or dedicated to leisure.
- In addition, households derive utility from health, but need to invest in it, as the stock of invisible health capital depreciates over time.
- The perfectly-competitive firm produces output using labor and capital.
- The government uses tax revenues from consumption expenditure, labor and capital income to finance: (1) spending on healthcare (input in health investment function), (2) government transfer payments.

Representative Household's Problem

As in Grossmann (2000), the household acts competitively by taking prices $\{w_t, r_t\}_{t=0}^{\infty}$ and policy variables $\{\tau_k, \tau_h, M_t, T_t^h\}_{t=0}^{\infty}$ as given. Subject to the initial condition for private capital and health $\{K_0^h, G_0^h\}$, it chooses $\{C_t^h, H_t^{wh}, H_t^{gh}, G_t^h, I_t^h, K_{t+1}^h\}_{t=0}^{\infty}$ to maximize

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \ln(C_t^h) + \psi \ln(G_t^h) + \theta \frac{(L_t^h)^{1-\mu}}{1-\mu} \right\}$$

s.t.

$$\begin{aligned} H_t^{wh} + H_t^{gh} + H_t^{sh} + L_t^h &= 1 \\ H_t^{sh} &= BG_t^{-\xi} \\ G_{t+1}^h &= I_t^{gh} + (1-\delta^g)G_t^h \\ I_t^{gh} &= Z_t M_t^{\varphi} (H_t^g)^{1-\varphi} \\ K_{t+1}^h &= I_t^h + (1-\delta)K_t^h \\ C_t^h + I_t^h \leq (1-\tau_k) r_t K_t^h &+ (1-\tau_h) w_t H_t^{wh} - T_t^h + \Pi_t^h. \end{aligned}$$

Household's Optimality Conditions

The optimality conditions from the household's problem, together with the transversality condition (TVC) for physical capital are as follows:

$$C_t^h : \frac{1}{C_t} = \lambda_t^1$$

$$K_{t+1}^h : \lambda_t^1 = \beta E_t \lambda_{t+1}^1 \left[\alpha \frac{Y_{t+1}}{K_{t+1}} + (1-\delta) \right]$$

$$H_t^{wh} : \theta (1 - H_t^g - H_t^s - H_t^w)^{-\mu} = \lambda_t^1 (1-\alpha) \frac{Y_t}{H_t^w}$$

$$H_t^{gh} : \lambda_t^2 = \frac{\lambda^1 (1-\alpha) \frac{Y_t}{H_t^w}}{(1-\varphi) Z_t M_t^{\varphi} (H_t^g)^{-\varphi}}$$

$$G_{t+1}^h : \beta \{ \frac{\psi}{G_{t+1}} + \frac{\theta B \xi G_{t+1}^{-\xi-1}}{(1 - H_{t+1}^g - H_{t+1}^s - H_{t+1}^w)^{\mu}} + \lambda_{t+1}^2 (1 - \delta^g) \} = \lambda_t^2$$

$$TVC : \lim_{t \to \infty} \beta^t \frac{1}{C_t^h} K_{t+1} = 0.$$

Household's Optimality Conditions (cont'd)

- The last FOC shows the optimality condition for intertemporal allocation of health.
- If we are to have an interior solution, the household equates the benefits and costs.
- The discounted benefit has three parts: First, a higher health level tomorrow brings higher utility - this is the direct effect.
- Second, better health means less sick time, hence indirectly more time to work and consumption.
- Thirdly, higher health means higher undepreciated health level and thus less replenishment is needed to get back to the old level.
- The cost is that a larger replenishment was done in the previous period.

Representative Firms's Problem

There is a representative firm, producing a homogeneous final product using a production function that requires physical capital, K_t and labor hours H_t^w. The representative firm acts competitively by taking prices $\{w_t, r_t\}_{t=0}^{\infty}$ and policy variables $\{\tau_k, \tau_h, G_t, H_t^g, T_t\}_{t=0}^{\infty}$ as given. Accordingly, K_t, H_t^w are chosen every period to maximize static aggregate profit,

$$\Pi_t = A_t K_t^{\alpha} (H_t^w)^{1-\alpha} - r_t K_t - w_t H_t^w$$

Labor and capital receive their marginal products, i.e

$$\begin{aligned} w_t &= (1-\alpha)\frac{Y_t}{H_t^w} \\ r_t &= \alpha \frac{Y_t}{K_t} \end{aligned}$$

Government Sector

Government purchases health care M_t, financed by levying proportional taxes on capital and labor income, and lump-sum taxes. Thus,

$$M_t = \tau_k r_t K_t + \tau_h w_t H_t^w + T_t.$$

Government takes market prices $\{w_t, r_t\}_{t=0}^{\infty}$, $\{H_t^w, K_t\}$ as given. Only three of the four $\{M_t, T_t, \tau_k, \tau_h\}$ policy instruments can be exogenously set. We will choose the tax rates τ_k and τ_h on capital and labor income to be deterministic, and $\{M_t\}$ will follow AR(1) process. Then the path for $\{T_t\}$ will be endogenously determined as a residual from the per-period budget balance constraint.

Stochastic processes for the policy variables

Assume that A_t, M_t, Z_t follow AR(1) processes in logs, in particular

$$\ln A_{t+1} = (1-\rho^a)\ln A_0 + \rho^a \ln A_t + \epsilon^a_{t+1},$$

The process for government spending on health care $\{M_t\}$ is

$$\ln M_t = (1-\rho^m)M + \rho^m \ln M_{t-1} + \epsilon^m_t,$$

The process for health investment productivity $\{Z_t\}$ is

$$\ln Z_{t+1} = (1-\rho^z)Z + \rho^z \ln Z_t + \epsilon^z_t.$$

Decentralized Competitive Equilibrium (DCE)

- Given the paths of the policy instrument $\{T_t\}_{t=0}^{\infty}$, the exogenous process followed by $\{A_t, Z_t, M_t\}_{t=0}^{\infty}$ and initial conditions for the state variables (K_0^h, G_0^h), a decentralized competitive equilibrium (DCE) is defined to be a sequence of allocations $\{C_t^h, G_t^h, H_t^{wh}, H_t^{gh}, I_t^h, K_{t+1}^h\}_{t=0}^{\infty}$ $\forall h$, prices $\{r_t, w_t\}_{t=0}^{\infty}$ and the tax rates $\{\tau_k, \tau_h\}$ such that (i) households maximize utility; (ii) firms maximize profits; (iii) all markets clear and (iv) the government budget constraint is satisfied in each time period.

Model Parameters

Table: Model Parameters

Parameter	Value	
β	0.988	Discount factor
μ	2	Frisch elasticity of labor supply
α	0.33	Productivity of capital
ψ	0.21	Relative weight on utility from health
θ	0.33	Relative weight on utility from leisure
δ	0.025	Depreciation rate of capital
δ^g	0.02	Depreciation rate of health
B	0.07	Scale factor of sick time
ξ	1.5	Elasticity of sick time to health
φ	0.0734	Share of spending on health out of total govt spending
A	1	Steady-state level of technology
z	1	Steady-state level of health shock
h_w	0.33	Time spent working
h_s	0.02	Time spent sick
h_g	0.02	Time spent exercising

Business Cycle Moments

Table: Model Evaluation

	US Data 1947:1-2008:4	Model	No health shock	Health Shocks only
σ_c/σ_y	0.69	0.61	0.64	0.14
σ_i/σ_y	2.97	3.11	2.89	4.34
σ_{h_w}/σ_y	0.85	0.6	0.28	1.5
σ_w/σ_y	0.81	0.77	0.8	0.52
σ_{h_w}/σ_w	1.05	0.78	0.35	2.91
$corr(c, y)$	0.61	0.79	0.84	0.38
$corr(i, y)$	0.75	0.91	0.9	0.99
$corr(h_w, y)$	0.82	0.64	0.8	0.99
$corr(w, y)$	0.59	0.8	0.98	-0.96
$corr(h_w, y/h)$	-0.08	0.05	0.64	-0.98
σ_g/σ_y	0.43	0.61	0.03	1.69
$corr(g, y)$	0.62	0.74	0.77	0.67
$\sigma_{\lambda^2}/\sigma_y$	1.88	1.45	0.28	3.98
$corr(\lambda^2, y)$	-0.45	0.13	0.81	-0.02
$\sigma_g/\sigma_{y/h}$	0.81	1.24	1.23	1.87
$corr(g, y/h)$	0.08	0.86	0.3	0.35

Correction of the good health measure with data (time series 1981:2005)

Life Expectancy at Birth, Total	0.4
Life Expectancy at Birth, Male	0.51
Adult mort rate male	-0.58
Adult mort. rate, female	-0.71
Potential Years of Life Lost(PYLL) males	-0.63
Potential Years of Life Lost(PYLL) females	-0.35
Suicide rate	-0.38
Cancer mort. rate males	-0.41
Cancer mort. rate	-0.31
Vaccination Rate Measles	0.29
Vaccination Rate DPT	0.42

Corr. of the good health measure with data (cross-section)

Percentage of adult population smoking daily	-0.31
Liver diseases and Cirrosis	-0.61
Consultations per Doctor	-0.61
Lung cancer mortality rate	-0.31
Suicide	-0.37
Male Life Expectancy at 65	0.57
Male Life Expectancy at birth	0.54
Male stroke mortality rate	-0.76
Female stroke mortality rate	-0.63
Male Cancer mortality rate	-0.47
Cervical Cancer Mortality	-0.42
Colorectal Cancer Mortality	-0.29
Female Ischemic heart disease mortality rate	-0.33
Prevalence of patients undergoing dialysis	-0.45
Prevalence of patients living with a functioning kidney transplant	0.56
Number of missing and damaget teeth	-0.54
Flu vaccination of elderly people	0.47
Potential Years of Life Lost male	-0.48