Beyond the Grossman's model.
Lecture 3

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Outline

1. Overview
   - Recap on Grossman's model
2. An alternative to the Grossman's model
   - The production of health as a stochastic process
   - State-dependent production of health: short run
   - Short term trade-off given good health
   - Short term trade-off given bad health
   - State-dependent production of health: long run
   - Complementarity/substitutability in the production of health?
3. Conclusions
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Recap on health

- Health is a capital stock that depreciates with time. It is both a production and a consumption good.
- Individuals choose health investments up to MU=MC
- Some predictions of the Grossman model have not been confirmed by empirical literature
- Main drawback: it is a deterministic model.

Conditional Health production functions

In short-run health status is a sequence of states (s, h):

- Assume 2 periods
- 4 possible states: hh, hs, sh, ss
- Markov process: probabilities remain constant over time

Transition and State Probabilities

	healthy in period 2	sick in period 2
healthy (h) in period 1	$1-\phi_{hs}$	ϕ_{hs}
sick (s) in period 1	$1-\phi_{ss}$	ϕ_{ss}
$\pi_{h,2}=(1-\pi)$	$\pi_{h,1}(1-\phi_{hs})+\pi_{s,1}(1-\phi_{ss})$	
$\pi_{s,2}=\pi$		$\pi_{h,1}\phi_{hs}+\pi_{s,1}\phi_{ss}$

ϕ_{hs}: probability of transition from healthy to sick

ϕ_{ss}: probability of transition from sick to sick

$\pi_{h,t}$: state probability of being healthy in period t

$\pi_{s,t}$: state probability of being sick in period t

Example (i)

- Probability of being healthy in period 2 is given by: $\pi_{h,2} = \pi_{h,1}(1 - \phi_{hs}) + \pi_{s,1}(1 - \phi_{ss})$
- Suppose initial health is known to the individual:
- If initially healthy $\Rightarrow \pi_{s,1} = 0$: Only way to influence health ϕ_{hs}
- If initially sick $\Rightarrow \pi_{h,1} = 0$: Only way to influence health ϕ_{ss}

Example (ii)

Two ways to influence transition probabilities:

- Time spent in favour of health (t^I) $\Rightarrow$ only in initial healthy state
- Medical care M $\Rightarrow$ only in initial sick state
- Formally:

$$\pi_{h,2} = \begin{cases} \pi_{h,2}[\phi_{hs}(t^I, \ldots,)] & \text{if healthy in period 1} \\ \pi_{h,2}[\phi_{ss}(M, \ldots,)] & \text{if sick in period 1} \end{cases}$$

- Conditional health production function
- The model has implications for each health state in the short and long term

Short-run optimisation and willingness to pay for health

Willingness to pay (WP) (H,C)= $\frac{MU_C}{MU_H} \Rightarrow MRS_{HC}$ or slope of IC

- State-dependent production function & state-dependent U
- In general:

$$EU = \sum_{t=0}^{T} \beta^t [(1 - \pi_t) u_h[C_{h,t}, H_t] + \pi_t u_s[C_{s,t}, H_t]]$$

- $\beta < 1$ subjective rate of time preferences
- $u_h[C_{h,t}, h] > u_s[C_{s,t}, s]$

Example: 2 periods

- In 2 periods, $\beta = 1$:

$$EU = (1-\pi_1)u_h[C_{h,1}, h] + \pi_1 u_s[C_{s,1}, s] + (1-\pi_2)u_h[C_{h,2}, h] + \pi_2 u_s[C_{s,2}, s]$$

- If initially healthy $\Rightarrow \pi_1 = 0$: Only decision variable C_{h1} (to simplify $C_{h,2} = C_{s,2} = C_2$)
- MWP: defined as WP to reduce π_2:

$$dEU = 0 = \frac{\partial u_h[C_{h,1}]}{\partial C_{h,1}} dC_{h,1} - \{u_h[C_2] - u_s[C_2]\}\, d\pi_2$$

$$-\frac{C_{h,1}}{d\pi_2}\bigg|_{dE_h=0} = -\frac{u_h[C_2] - u_s[C_2]}{\frac{\partial u_h[C_{h,1}]}{\partial C_{h,1}}}$$

- If sick in period 1:

$$-\frac{C_{s,1}}{d\pi_2} = -\frac{u_h[C_2] - u_s[C_2]}{\frac{\partial u_s[C_{s,1}]}{\partial C_{s,1}}}$$

Implications

- MRS between C and π
- Numerator: MRS is ratio of utilities differences (or MU), the greater it is the greater MWP
- Denominator: the greater the loss in utility, the smaller the MWP
- MWP may be state-dependent $\Rightarrow MU_C$ is state dependent

State-dependent production process

- Individuals can influence health only through probabilities;
- Individuals' effort can only influence production in a state of good health;
- Health status is not only the result of a production process but also the effect of a stochastic input factor

Consumption services produced: short run

- In the healthy state, only self care (i.e. time in favour of health t^I) can have an impact on health:

$$\pi = \pi(t^I)$$

- Input of consumption and time (Becker, 1965):

$$C_h = C_h(X, t^C)$$

- Healthy individuals earn labour income (with wage exogenous to health) and finance purchase of consumption:

$$wt^W = cX_h$$

- Time available for consumption:

$$1 = t^C + t^I + t^W$$

Production possibilities in illness state

- In the ill state, only medical care can have an impact on health:

$$\pi = \pi(M)$$

- Input of consumption and time are required to the production of consumption services (like in healthy case):

$$C_s = C_s(X, t^C)$$

- With social security income in the event of sickness dow not depend on working time:

$$\bar{Y} = cX + pM$$

- Time constraint comprises only time for consumption and medical services

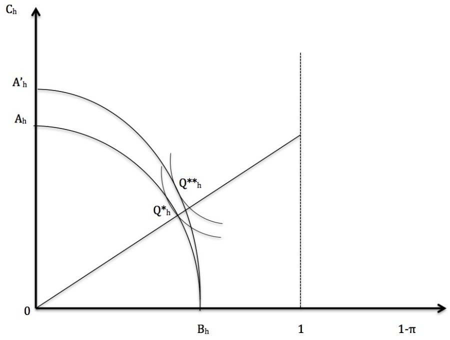
$$1 = t^C + \mu M$$

State-dependent production process: good health

- If choosing lower t^I, choose a probability distribution containing unfavourable states with increased probability;
- Trade-off is a transformation curve in a $(C_h, 1-\pi)$ space;
- Shape of transformation curve is given by its slope, the Marginal Rate of Transformation (MRT):

$$\frac{dC_h}{d(1-\pi)} = \frac{\frac{\partial C_h}{\partial t^C}}{\frac{\partial \pi}{\partial t^I}} < 0$$

Short-term: good health



Short-term: good health (cntd.)

Implications of the model:

- Increase in the real wage rate($\frac{w}{c}$): no short-run effect, as increase in labour income compensates the increase of the opportunity cost of consumption;
- Technological change in the household($\frac{\partial C_h}{\partial t^C}$): because it is a labour-saving measure, it increases the time spent on consumption, assuming that the productivity of self-care time does not change, the transformation curve moves from A_h to $A_h^{'}$

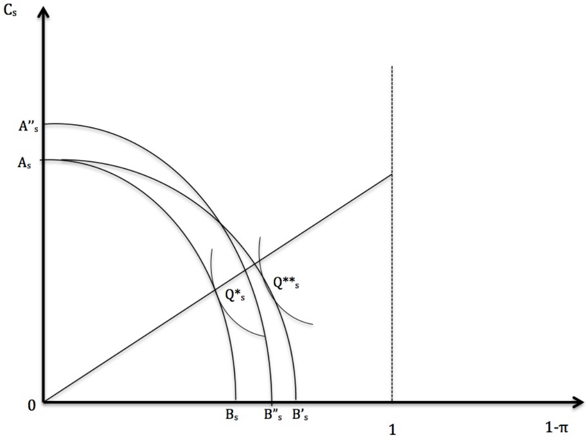
State-dependent production process: bad health

- Shape of transformation curve is given by its slope, the Marginal Rate of Transformation (MRT):

$$\frac{dC_s}{d(1-\pi)} = \frac{\frac{\partial C_s}{\partial t^C}\mu}{\frac{\partial \pi}{\partial M}} + \frac{\frac{\partial C_s}{\partial X}\frac{p}{c}}{\frac{\partial \pi}{\partial M}} < 0$$

- Numerator 1: Utilisation of M requires time to be spent by the patient
- Numerator 2: Medical services and consumption compete for Income

Short-term: bad health



Short-term: bad health (cntd.)

Implications of the model:

- Technological change in the household: little effect on behaviour in the ill state;
- Technological change in medicine ($\frac{\partial \pi}{\partial M}$): flatter frontier with a shift from $A_s B_s$ to $A_s B_s^{'}$ with new optimum Q_s^{**};
- Increased density of supply (μ): less time spent on medical services with new transformation curve $A_s^{''} B_s^{''}$;
- Extended coverage by health insurance ($\frac{p}{c}$): cheaper medical services, with additional income spent on consumption goods. New transformation curve $A_s^{''} B_s^{''}$.

State-dependent production process: long run

- T periods
- Current state “healthy”: Trade-off average duration of a future phase of good health and consumption;
- Current state “sick”: Trade-off average duration of a future phase of sickness and consumption.

State-dependent production process: good health

- Mean no. periods in good health: $T_h = \dfrac{1}{\pi}$;
- Time constraint:
$$T_h = t^C + t^I + t^W$$
- Slope of transformation curve is given by its slope, the Marginal Rate of Transformation (MRT):
$$\frac{dC_H}{dT_h} = \frac{\dfrac{\partial C_h}{\partial t^C}\left[\dfrac{\partial T_h}{\partial \pi}\dfrac{\partial \pi}{\partial t^I} - 1\right]}{\dfrac{\partial T_h}{\partial \pi}\dfrac{\partial \pi}{\partial t^I}} \gtrless 0$$
- Sign ambiguous and depends on $\dfrac{\partial T_h}{\partial \pi}\dfrac{\partial \pi}{\partial t^I} \gtrless 1$
- It indicates returns to additional hour spent on health

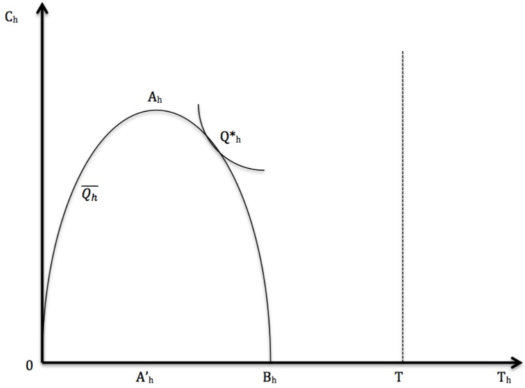
Solution

- Critical value $\frac{\partial \pi}{\partial t^I}$ is given by:

$$\frac{dC_h}{dT_h} \gtrless 0 \Leftrightarrow \left| \frac{\partial \pi}{\partial t^I} \right| \gtrless \left| -\pi^2 \right|$$

- For individual with healthy prospects (π is small), small value implying that t^I and T_h may attain higher values before h becomes a consumption good
- Critical value corresponds to A_h

Long-term: good health



State-dependent production process: bad health

- Mean no. periods in bad health: $T_s = \dfrac{1}{\pi}$;
- Time constraint:

$$T_s = t_s^C + \mu M$$

- Aim is to have shortest period of sickness as possible
- The Marginal Rate of Transformation (MRT):

$$\frac{dC_s}{dT_s} = -\frac{\frac{\partial C_s}{\partial t^C}\left[\frac{\partial T_s}{\partial \pi}\frac{\partial \pi}{\partial M} - \mu\right]}{\frac{\partial T_s}{\partial \pi}\frac{\partial \pi}{\partial M}} + \frac{\frac{\partial C}{\partial X}\frac{p}{c}}{\frac{\partial T_s}{\partial \pi}\frac{\partial \pi}{\partial M}} < 0$$

- Transformation curve is strictly decreasing implying that no investment, only M. But it costs time (μ) that could have been spent in consumption

Complementarity/substitutability in the state-dependent production of health?

- Theory of firm in production inputs
- Solution to decrease health expenditure?
- 2 ways: a) reduce price of healthy behaviours ; b) increase their productivity

Substitutability in the healthy state

- If in initial healthy state, t^I increases π falls
- Good health duration increase and utilisation of medical care defers. But:
- Life expectancy increases and total medical care during entire life cycle might NOT decrease

Complementarity in the sick state

- If in initial sick state, t^l has no effect
- But increased M, reduces duration of sick period allowing t^l to increase
- Complementarity between t^l and M

- Health is not deterministic
- Individuals can only affect the probability of transition or duration of health (sick) time
- But even then the effect of inputs on health is unknown
- We have seen the effects of inputs in a conditional state-dependent production function
- We considerered long and short run effects

References

- Zweifel et al. (2009) chapter 3: pp. 89-117