Beyond the Grossman’s model.
Lecture 3

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October 15, 2013
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
   - Summary
   - References
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

<table>
<thead>
<tr>
<th>Healthy (h) in period 1</th>
<th>Healthy in period 2</th>
<th>Sick in period 2</th>
</tr>
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<tbody>
<tr>
<td>Sick (s) in period 1</td>
<td>1 - $\phi_{hs}$</td>
<td>$\phi_{hs}$</td>
</tr>
<tr>
<td></td>
<td>1 - $\phi_{ss}$</td>
<td>$\phi_{ss}$</td>
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</tbody>
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\[
\begin{align*}
\pi_{h,2} &= (1 - \pi) \\
\pi_{s,2} &= \pi \\
\pi_{h,1}(1 - \phi_{hs}) + \pi_{s,1}(1 - \phi_{ss}) &= \pi_{h,1}\phi_{hs} + \pi_{s,1}\phi_{ss}
\end{align*}
\]

- $\phi_{hs}$: probability of transition from healthy to sick
- $\phi_{ss}$: 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 \( \phi_{hs} \)
  - If initially sick \( \Rightarrow \pi_{h,1} = 0 \): Only way to influence health \( \phi_{ss} \)
Example (ii)

Two ways to influence transition probabilities:

- Time spent in favour of health \((t^I)\) ⇒ only in initial healthy state
- Medical care \(M\) ⇒ 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 $\pi_2$:

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

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

- 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 ⇒ $MU_C$ 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 does 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):

\[
\frac{dC_h}{d(1 - \pi)} = \frac{\partial C_h}{\partial t^c} \frac{\partial t^c}{\partial \pi} < 0
\]
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** $(\frac{\partial C_h}{\partial t})$: 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):

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

- 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
Implications of the model:

- **Technological change in the household**: little effect on behaviour in the ill state;

- **Technological change in medicine** \( \left( \frac{\partial \pi}{\partial M} \right) \): flatter frontier with a shift from \( A_s B_s \) to \( A_s' B_s' \) with new optimum \( Q_s^{**} \);

- **Increased density of supply** \( (\mu) \): 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: \( T_h = \frac{1}{\pi} \);
- 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):
  \[
  \frac{dC_H}{dT_h} = \frac{\partial C_h}{\partial t^C} \left[ \frac{\partial T_h}{\partial \pi} \frac{\partial \pi}{\partial t^I} - 1 \right] \geq 0
  \]
- Sign ambiguous and depends on
  \[
  \frac{\partial T_h}{\partial \pi} \frac{\partial \pi}{\partial t^I} \geq 1
  \]
- It indicates returns to additional hour spent on health
**Solution**

- Critical value \( \frac{\partial \pi}{\partial t^l} \) is given by:

\[
\frac{dC_h}{dT_h} \geq 0 \iff \left| \frac{\partial \pi}{\partial t^l} \right| \geq \left| -\pi^2 \right|
\]

- For individual with healthy prospects (\( \pi \) is small), small value implying that \( t^l \) 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: \( T_s = \frac{1}{\pi} \);  
- 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):  
  \[
  \frac{dC_s}{dT_s} = - \frac{\partial C_s}{\partial t^C} \left[ \frac{\partial T_s}{\partial \pi} \frac{\partial \pi}{\partial M} - \mu \right] + \frac{\partial C}{\partial X} \frac{p}{c} \frac{\partial T_s}{\partial \pi} \frac{\partial \pi}{\partial M} \]
  \[
  < 0
  \]
- Transformation curve is strictly decreasing implying that no investment, only M. But it costs time (\( \mu \)) 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, $t'$ increases, $\pi$ 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, $t^I$ has no effect
- But increased $M$, reduces duration of sick period allowing $t^I$ to increase
- Complementarity between $t^I$ 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
Zweifel et al. (2009) chapter 3: pp. 89-117