Microeconomic principles of production/consumption of health.
Lecture 2

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Outline

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Recap on health

- Health is an asset ⇒ Production good
- Inputs: a) medical services (curative care); and b) our own effort (preventative care)
- More health increases utility ⇒ Consumption good
- This model was developed by Grossman (1972)
- Simplified version contains 2 time periods only
Preferences and Utility

- Utility describes level of satisfaction that consumers obtain from goods:
  \[ U = U(X_1, X_2, \ldots, X_n) \]

- Marginal Utility: additional utility from one more unit of good \( X \):
  \[ MU_{X_i} = \frac{\Delta U}{\Delta X_i} \text{ OR } \frac{\partial U}{\partial X_i} \]

- Rational consumers

- Utility Maximisation as wellbeing maximisation
Indifference curves (IC)

Visits to the dentist \([X_1]\)

Visits to the hairdresser \([X_2]\)

Properties

- Complete
- Transitive: if $a \succeq b$ and $b \succeq c$, then $a \succeq c$
- Non-satiable
IC: comparison between utilities

- Comparing different bundles:
  \[ \Delta U = MU_{X_i} \Delta X_i \]

- But \( \Delta U \) must be the same for all bundles:
  \[ MU_{X_1} \Delta X_1 = MU_{X_2} \Delta X_2 \]

- It follows that MRS is:
  \[ \frac{\Delta X_1}{\Delta X_2} = \frac{MU_{X_1}}{MU_{X_2}} \]

- From graph, from a to b individual gave up 2 visits to doctors to gain 6 visits to the hairdresser

- \( MU(\text{visits to dentist}) = 3 \times MU(\text{visit to hairdresser}) \) as \( MRS = \frac{2}{6} \)

- Diminishing Marginal Utility of consumption from convexity of IC
Application: Patients’ choice of hospital in NHS

- Department of Health (DH) experiment in 2002 giving patients choice of National Health Service (NHS) hospital for surgical procedure
- Selected sample: patients who had been waiting 6+ months for elective treatment
- Discrete Choice Experiment (DCE): with bundle of choices with different characteristics (RUM)
- Every additional hour of travel time = 2 months reduction in waiting time
- Choices depended on patients’ socioeconomic and demographic characteristics
Budget constraint and maximisation

- Non-satiable IC but budget constraint (BC)
- Consumers maximise utility subject to income and prices:

\[
\sum_{i=1}^{n} X_i P_i \leq I
\]

- Budget line indicates bundles of goods $X$ and $Y$ that consumers can purchase, given constraints on income and prices $P_X$ and $P_Y$
- Slope: $\frac{P_X}{P_Y}$
- Utility Maximisation s.t. BC:

\[
MRS_{XY} = -\frac{dY}{dX} = \frac{MU_X}{MU_Y} = \frac{P_X}{P_Y}
\]
Max. $U$ s.t. $BC$

Common criticisms

- Self-interest, rationality and utility maximisation usually criticised as over simplistic especially by other researchers in the health care sector.
- But “caring” and addiction can be included in $U$.
- Health and health care specific characteristics: a) uncertainty and b) asymmetric information.
Application: Rational addiction and price elasticity of demand

- Becker and Murphy (1988): addicted people maximise utility consistently over time
- \( U \) depends on addictive and non-addictive goods:
  \[
  U(t) = U[Y(t), X(t), S(t)]
  \]
- Addiction: increase in \( X \) at \( t \), increases \( X \) at \( (t+1) \)
- Price elasticity of demand lower in SR than in the LR.
Determinants of demand (i)

Demand curve describes relation between prices and quantity

- Price: if $P$ decreases $Q$ rises $\Rightarrow$ Law of demand
- Are prices of medical treatments different?
- “Money” prices vs. ”Time” prices (Acton, 1973)
Demand functions

Determinants of demand (ii)

- Income: shifts BC up
- Normal vs. Inferior goods
- Normal goods: a) necessity and b) luxury
Demand functions

Determinants of demand (iii)

- Prices of other goods
- Complements vs. substitutes
- Tastes and Lifestyles
- Population size and composition
- Price elasticity in demand: Percentage change in quantity divided by the percentage change in price
- Income elasticity of demand: Percentage change in quantity divided by the percentage change in income
Summary

- Preferences and Utility (IC and its properties)
- Budget constraint (max. U)
- Demand functions (its determinants)
- All ingredients of Grossman model
Set-up

Two time periods with discounting factor $\beta \leq 1$. Maximisation is given by:

$$\max_{H_1, t^l, M, X_0, X_1} U = U(t^s(H_0), X_0) + \beta U(t^s(H_1), X_1)$$

s.t.

$$H_1 = H_0(1 - \delta) + I(M_0, t^l)$$

$$A_0 + w_0(1 - t^s(H_0) - t^l) + \frac{w_1(1 - t^s_1(H_1))}{R} = pM + cX_0 + \frac{cX_1}{R}$$

Set-up the Lagrangean with multipliers $\mu, \lambda > 0$, $H_0$ is predetermined
Solution

The derivatives are given by:

\[
\frac{\partial L}{\partial H_1} = \beta \frac{\partial U}{\partial t^s} \frac{\partial t^s}{\partial H_1} - \frac{\lambda}{R} w_1 \frac{\partial t^s}{\partial H_1} - \mu = 0
\]  
(1)

\[
\frac{\partial L}{\partial t^l} = \mu \frac{\partial l}{\partial t^l} - \lambda w_0 = 0
\]  
(2)

\[
\frac{\partial L}{\partial M} = \mu \frac{\partial l}{\partial M} - \lambda p = 0
\]  
(3)

\[
\frac{\partial L}{\partial X_0} = \frac{\partial U}{\partial X_0} - \lambda c = 0
\]  
(4)

\[
\frac{\partial L}{\partial X_1} = \beta \frac{\partial U}{\partial X_1} - \frac{\lambda}{R} c = 0
\]  
(5)
Solution (cntd.)

Dividing (2) by (3):

\[
\frac{\partial I}{\partial t} = \frac{w_0}{p}
\]

(6)

Dividing (4) by (5):

\[
\frac{\partial U}{\partial X_0} = \beta R
\]

(7)

Solve (5) for \(\lambda/R\) and substitute in (1):

\[
-\beta \frac{\partial t^s}{\partial H_1} \left[ \frac{w_1}{c} \frac{\partial U}{\partial X_1} - \frac{\partial U}{\partial t^s} \right] = \mu
\]

(8)

Using (3) and (4):

\[
\mu = \frac{\partial U}{\partial X_0} \frac{p}{c}
\]

(9)
The solution is given by substituting (9) into (8):

\[- \beta \frac{\partial t^s}{\partial H_1} \left[ \frac{w_1}{c} \frac{\partial U}{\partial X_1} - \frac{\partial U}{\partial t^s} \right] = \frac{\partial U}{\partial X_0} \frac{p}{c} \frac{\partial I}{\partial M} \]

That is, \( MU = MC \) of health investments
Marginal Utility of Health Investments

- $MU > 0$ if $\frac{\partial t^s}{\partial H_1} < 0$ and $\left[ \frac{w_1}{c} \frac{\partial U}{\partial \chi_1} - \frac{\partial U}{\partial t^s} \right] > 0$. Effectiveness of health investments;

- Pure Consumption Model: $t^s < 0 \Rightarrow \frac{\partial U}{\partial t^s} < 0$

- Pure Investment Model: $t^s < 0 \Rightarrow -\beta \frac{\partial t^s}{\partial H_1} > 0$ and $\frac{w_1}{c} > 0$
Marginal Cost of Health Investments

\[
\frac{\partial U}{\partial X_0} \Rightarrow \text{Subjective loss from sacrificing consumption in favour of health;}
\]

\[
\frac{\partial I}{\partial M} \Rightarrow \text{Effectiveness of medical services;}
\]

\[
\frac{p}{c} \Rightarrow \text{Price deflation factor}
\]
Conclusion

- Health affects wealth and vice versa;
- Health is both a production and a consumption good;
- As production, individual decides how much time and medical services to use for health production;
- As consumption, individual enjoys health and has to trade it against consumption of other goods;
- This trade-off is formalised by the MU = MC
- Closed form solutions to the model require specification of the production (i.e. $I(M_0, t^I)$) and the utility (i.e. $U(t^s(H_1), X_1)$) functions
The Demand for Medical Services

Cobb-Douglas production function:

\[ I = M^{\alpha_M} (t^I)^{1-\alpha_M} e^{\alpha_E E} \quad \text{where} \quad 0 < \alpha_M < 1, \alpha_E > 0 \]

Cost-minimisation gives the structural demand function for medical services:

\[ \ln M = \text{const.} + \ln H_1 - (1 - \alpha_M) \ln p + (1 - \alpha_M) \ln w_0 - \alpha_E E \]

Higher health capital increases demand for medical services as derived demand for a factor of production.
Solution (cntd.)

Predictions of the model:

- The higher the price \( p \) of medical services, the smaller the quantity;
- The higher the initial wage \( w_0 \), the higher the demand for medical services;
- The higher the education level, the lower the demand for medical services;
The Demand for Health - Investment Model

Functional form:

\[ t^s(H_1) = \theta_1 H_1^{-\theta_2} \quad \text{where} \quad \theta_1 > 0, \theta_2 > 0 \]

So the demand for health is:

\[ \ln H_1 = const - \epsilon \alpha_M \ln p + \epsilon \alpha_M \ln w + \epsilon \alpha_E E \]

Substituting this demand in the demand for medical services, we get the reduced demand function of medical services:

\[ \ln M = const - (1 + \alpha_M(\epsilon - 1)) \ln p + (1 + \alpha_M(\epsilon - 1)) \ln w - (1 - \epsilon) \alpha_E E \]
Solution (cntd.)

Predictions of the model:

- The higher the price $p$ of medical services, the smaller the quantity of $H_1$;
- The higher the wage $w$, the higher the demand for health;
- The higher the education level, the higher the demand for health;
The Demand for Health- Consumption Model

Additive utility function:

\[ U = \alpha_1 (t^s)^{\alpha_2} + g(X) \]

The demand function for health:

\[ \ln H_1 = \text{const.} - k\alpha_M \ln p - k(1 - \alpha_M) \ln w + k\alpha_E E - k \ln \lambda \]

where \( k \equiv \frac{1}{1 + \alpha_2 \theta_2} \) < 1 is the elasticity of MU of less sick time with respect to \( H_1 \).
Solution (cntd.)

Predictions of the model:

- The higher the price $p$ of medical services, the lower the demand for health;
- The higher the wage $w_0$, the lower the demand for health;
- The higher the education level, the higher the demand for health;
The Demand for Medical Services

The reduced demand function for medical services can be derived by substituting the demand for health in the demand for medical services:

\[ \ln M = \text{const.} - [1 + \alpha_M(k - 1)] \ln p + (1 - k)(1 - \alpha_M) \ln w - (1 - k)\alpha_E E - k\ln \lambda \]
Implications of the Grossman Model

Predictions of the model:

- **Health**: health status and demand for medical services are positively correlated. But empirical evidence says otherwise (Wagstaff (1986) and Leu and Gerfin (1992));

- **Education**: education and demand for medical services are negatively correlated. Again, empirical evidence says otherwise (Wagstaff 1986);

- **Age**: is negatively correlated with demand for health, but positively correlated with demand for medical services. The latter is not confirmed by empirical evidence;
Main drawbacks

Neglects uncertainty:

- **Depreciation of health capital**: not affected by stochastic shocks;
- **Rate of depreciation**: also depends on unexpected shocks;
Conclusions

- Grossman Model: health is a capital stock that can depreciate. It is both a production and a consumption good;
- Some predictions particularly with regard to education are not confirmed by empirical evidence;
- It might confirm the view that health cannot be fully determined by individuals. We can only change the transition probabilities to and from health/ill states.
| Morris et al. (2012) Economic Analysis in Health Care (Chapter 2) pp.21-43 |
| Zweifel et al. (2009) chapter 3 pp.75-89 |
| Acton (1973) Demand for health care when time prices vary more than money prices, RAND. |