“On the Concept of Health Capital and the Demand for Health”

The Journal of Political Economy, 1972

The Grossman Model

September 6, 2016

Last Class

- Introduced the idea of modeling the demand for health through Wagstaff's four quadrant diagram.
- This diagram is simply a graphical illustration of a consumer's utility maximization problem subject to some budget constraint and some health production process.
- We showed graphically how the optimal bundle of medical care and composite good may differ upon changes in income, relative prices, or technology.

Michael Grossman

- American health economist currently at City University of New York Graduate Center
- Director of the Health Economics Program at the National Bureau of Economic Research (NBER)
- Co-editor of the *Review of Economics of the Household*
- Extremely influential in the field of health economics

The Grossman Model

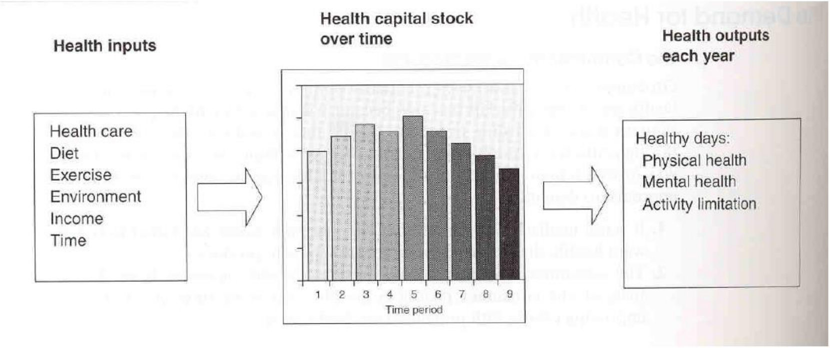
- The first theoretical model in health economics that attempts to model the commodity “good health” as opposed to modeling only medical care.
- Treats health as both a consumption good, i.e. we get utility from feeling healthy, and an investment good, i.e. we can invest in our health and be more productive members of society.
- Dynamic, Finite-Horizon in nature, with multiple periods and an endpoint, a point of health deterioration (death).

Characteristics of the Model

Grossman (1972) showed us that health demand differs substantially from traditional demand theory:

1. Consumers don't want medical care, per se, but instead they want health and demand medical care inputs to produce it.
2. Consumers do not purchase health, they produce it by combining time inputs and and inputs of health care.
3. Health lasts for more than one period, and does not depreciate instantly. Hence, it can be treated like a capital good.
4. Health can be treated both as a consumption good and an investment good.

Treating Health like Physical Capital



Features of the Model

- People invest in themselves, i.e. they invest in their health.
- Individuals demand "good health", hence they indirectly demand medical care inputs. They also demand "home goods", which are all other enjoyments of life.
- Two distinct capital types: Health Capital and Human Capital
- Individuals invest in health capital through both market inputs of health care and nonmarket activities such as diet or exercise.
- Distinction between home goods and market goods: consumers *produce* home goods with inputs of market goods and their own time.
- Production function depends on the level of education of the producer, i.e. human capital.

Features of the Model

- Health depreciates at a certain rate as individuals age, and people “choose” their length of life.
- Health is endogenous and depends on the resources allocated to its production.
- Individuals are constrained by time, and they allocate time to market and nonmarket activities.
- Increasing the stock of health allows individuals to be more productive.
- Once again, consumers both realize utility from health today, and invest in health for tomorrow.

Preview of Results of the Model

The "shadow price" of health depends on many other variables besides the price of medical care, i.e. age and education.

Shifts in these other variables alter the optimal amount of health and alter the demand for investment.

1. The shadow price of health rises with age if the rate of depreciation of health rises over the life cycle.
2. The shadow price of health falls with education if more educated people are more efficient producers of health.
3. Under certain conditions, an increase in the shadow price of health may simultaneously reduce the quantity of health demanded and increase the quantity of medical care demanded.

A Model of Health

Recall that health can be treated both as a consumption good and an investment good.

Consider a agent that obtains utility from both Health and other enjoyments of life, call them Home Goods:

$$U(H, Z),$$

where H represents an individual's stock of health and Z represents a vector of "home goods."

Home goods might be the many enjoyments of life such as watching T.V., reading, watching the sun set, watching Bama beat Auburn. Home goods might also include other leisure activities such as cooking, cleaning, or doing laundry. Home goods need not be Tangible. Also, keep in mind that Z is a "composite good", meaning that it is a composition of many different goods.

Production of Health and Home Good

Not only does the agent consume health and home good, but she produces it. We discussed the last classes how we might exposit the Production Process of Health.

Agents invest in health capital through the use of Medical Care inputs and Time inputs (i.e. exercise, diet, etc.). Agents also invest in home good through the use of both Market Good inputs and Time inputs (for example: if we consider Bama beating Auburn as the home good, then Market Input might include a ticket to the game, and Time Input might include the travel time to get to the game)

The Production of Health and Home Good

Suppose the Production Processes for Health and Home Good are given by:

$$I = I(M, TH \mid E)$$
$$Z = Z(X, TZ \mid E),$$

where I and Z represent investment in health and home good, respectively, M represents Medical care inputs, X represents Market Good inputs, and TH and TZ are time inputs devoted to both the production of health and home good, respectively. E represents the level of human capital, or education, of the agent.

You might think of TH and TZ as leisure time, or time allocated to non-market activites.

The Production of Health and Home Good

$$I = I(M, TH \mid E)$$

$$Z = Z(X, TZ \mid E)$$

These production functions indicate that increased Medical Care and Time inputs lead to higher levels of Health Investment, and increased Market Good and Time inputs lead to higher levels of Home Good Investment.

Are we all able to produce health and home good with the same levels of efficiency? No. Those with higher levels of human capital are able to produce health and home good more productively than those with lower levels.

Constraints in the Model

What constraints do we all face in life?

Of course, we all face some budgetary constraint. We each earn a wage rate, and we are able to work on days that we are healthy. We will exhaust all of our income on the purchasing of Medical Care Inputs and Market Good Inputs. Hence, we might represent the budget constraint by:

$$(W * TW) + A = (P * M) + (V * X),$$

where W is the wage rate, TW is time spent working, A is some level of asset holdings, and P and V represent the prices of Medical Care Inputs and Market Good Inputs, respectively.

Constraints in the Model

We all face another very important constraint: Time. We have a finite amount of time to devote to labor and leisure activities. Let's represent time in units of days, and consider the period to be a full calendar year of days. Hence, we might represent the time constraint by:

$$\Omega = 365 = TH + TZ + TL + TW,$$

where TH is time invested in the production of health, TZ is time invested in the production of home good, TL is time lost to illness, and TW is time spent at the labor market.

The Agent's Problem

Taking all of the information that we have, we might exposit the Agent's constrained optimization problem:

$$\begin{aligned} \underset{\{I\}}{\textbf{Maximize}} \quad & U(H, Z) \\ \textbf{subject to} \quad & (W * TW) + A = (P * M) + (V * X), \\ & \Omega = TH + TZ + TL + TW \end{aligned}$$

Here, the agent chooses some level of health investment I.

Note that an agent faces the trade-off between consumption of health today, and investment in health for tomorrow. Also, remember that Health and Home Good production processes determine the efficiency of the agent's investment into the future.

The Agent's Problem

$$\begin{aligned} \underset{\{I\}}{\textbf{Maximize}} \quad & U(H, Z) \\ \textbf{subject to} \quad & W * TW = P_M * M + P_X * X, \\ & \Omega = TH + TZ + TL + TW \end{aligned}$$

How might we solve this constrained optimization problem? First, we might consider substituting the second constraint into the first. Then, we would likely solve this using the Lagrangian Method.

Note that here, we have treated this as a Static Problem, i.e. a problem of one period. In reality, however, when we make health decisions, we are solving a Dynamic Problem, i.e. a problem of multiple periods.

Creating a Dynamic Model

Grossman (1972) essentially took all of the information we have discussed thus far and constructed a dynamic model, i.e. one with multiple time periods.

Time Horizon: Finite-Horizon model with length of life endogenously determined

Death takes place when $H_t = H_{min}$

Objectives

Objectives The consumer seeks to maximize discounted lifetime utility from the consumption of both health H and home goods Z

The standard discount rate is used:

$$\beta^t = \frac{1}{(1+r)^t},$$

where r is the interest rate

β is considered a measure of a consumer's "patience" in choosing between consumption today and investment for tomorrow. A large value for β indicates that we discount the future drastically, in other words, we do not care that much about the future.

Intertemporal Utility Function

$$U = U(\phi_0 H_0, \ldots, \phi_n H_n, Z_0, \ldots, Z_n)$$

Consumers gather utility from consumption of health and consumption of home goods.

$h_t = \phi_t H_t$ represents the number of healthy days in a period.

ϕ_t is the service flow per unit stock, or the number of healthy days per unit stock. ϕ_t governs the rate at which we are able to convert our health stock into healthy days.

How Does Health Evolve?

The Law of Motion for Health:

$$H_{t+1} = H_t + I_t - \delta_t H_t$$

where I is investment in health, and δ_t is the rate of health depreciation.

Endowments

It is assumed that consumer's are endowed with some initial level of health stock H_0, some initial level of wealth A_0, and some intial level of human capital E_0

It is assumed that all values for variables are determined at the beginning of time. Consumers make all consumption/investment decisions at time $t = 0$, indicating that this is what is known as a "perfect foresight economy."

Dynamic Constrained Optimization Problem

$$\begin{aligned} \underset{\{I_{t-1}\}}{\textbf{Maximize}} \quad & U(\phi_0 H_0, \ldots, \phi_n H_n, Z_0, \ldots, Z_n) \\ \textbf{subject to} \quad & W_t TW_t + A_0 = P_t M_t + V_t X_t, \\ & \Omega = TW_t + TL_t + TH_t + TZ_t \end{aligned}$$

where constraints are summed across a consumer's entire lifetime

Dynamic Constrained Optimization Problem

By solving for TW_t in the time constraint, and plugging it into the budget constraint, one obtains the single "full wealth" constraint:

$$P_t M_t + V_t X_t + W_t(TL_t + TH_t + TZ_t) = W_t \Omega + A_0 = R \equiv Wealth$$

According to the equation above, full wealth equals initial assets plus the present value of earnings an individual would obtain if he spent all of his time at work. The equilibrium quantities of H_t and Z_t can now be found by maximizing the intertemporal utility function subject to the lifetime full wealth constraint.

Dynamic Constrained Optimization Problem

$$\max_{\{I_{t-1}\}} U(\phi_0 H_0, \ldots, \phi_n H_n, Z_0, \ldots, Z_n)$$

subject to

$$R = \sum_{t=0}^{n} \beta^t \Big(P_t M_t + V_t X_t + W_t (TL_t + TH_t + TZ_t) \Big),$$

where we let $C_t = P_t M_t + W_t TH_t$ and $C_{1t} = V_t X_t + W_t TZ_t$

Here, C_t and C_{1t} represent the costs of investing in health and in home good, respectively

Equilibrium Behavior

To solve the constrained optimization problem:

1. Set up the Lagrangian function
2. Take First-Order Condition with respect to the choice variable: gross investment in period $t-1$
3. Set FOC equal to zero
4. Solve the system of equations

Equilibrium Behavior

$$\mathcal{L} = U(\phi_0 H_0, \dots, \phi_n H_n, Z_0, \dots, Z_n) + \lambda \left(R - \sum_{t=0}^{n} \beta^t (C_t + C_{1t} + W_t TL_t) \right)$$

FOC:

$$\frac{\partial \mathcal{L}}{\partial I_{t-1}} = 0$$

$$\frac{\partial U}{\partial h_t} \frac{\partial h_t}{\partial H_t} \frac{\partial H_t}{\partial I_{t-1}} + \frac{\partial U}{\partial h_{t+1}} \frac{\partial h_{t+1}}{\partial H_{t+1}} \frac{\partial H_{t+1}}{\partial I_{t-1}} \; + \; \dots \; + \; \frac{\partial U}{\partial h_n} \frac{\partial h_n}{\partial H_n} \frac{\partial H_n}{\partial I_{t-1}}$$

$$= \lambda \bigg[\beta^{t-1} \frac{dC_{t-1}}{dI_{t-1}} + \beta^t W_t \frac{\partial TL_t}{\partial H_t} \frac{\partial H_t}{\partial I_{t-1}}$$

$$+ \beta^{t+1} W_{t+1} \frac{\partial TL_{t+1}}{\partial H_{t+1}} \frac{\partial H_{t+1}}{\partial I_{t-1}} + \; \dots + \; \beta^n W_n \frac{\partial TL_n}{\partial H_n} \frac{\partial H_n}{\partial I_{t-1}} \bigg]$$

Predictions of the Model

"Assuming that the rate of depreciation grows larger as individual's grow older, then increases in depreciation cause the supply curve of health capital to shift upward, hence reducing the quantity of health demanded over the life cycle."

If depreciation grows, it becomes very costly to hold health capital, and hence the individual will consume remaining health and inevitably reach death.

Predictions of the Model

"Given a relatively inelastic demand curve for health, individuals would desire to offset part of the reduction in health capital caused by an increase in the rate of depreciation by increasing their gross investments. This means that sick time, TL_t, will be positively correlated with M_t over the life cycle"

In others words, as people get older, they have more sick days, and they increase medical care inputs. This is precisely what we see with our elderly population within the U.S.

Criticisms of the Grossman Model

Laporte (2015)

1. Suffers from a fundamental indeterminacy with regard to the optimal level of investment in health.
2. Predicts that increased medical care inputs leads to improvements in health.
3. Does not make current health behavior dependent on the past.
4. Does not predict that health declines with lower socio-economic status.
5. Does not preclude an individual choosing to live forever.

Next Class

- We will move away from health theory and into empirics.
- Econometrics and Linear Regression (Chapters 1-5 in "A Guide to Econometrics" by Peter Kennedy)
- Group Project paper selection due by Friday September 6.