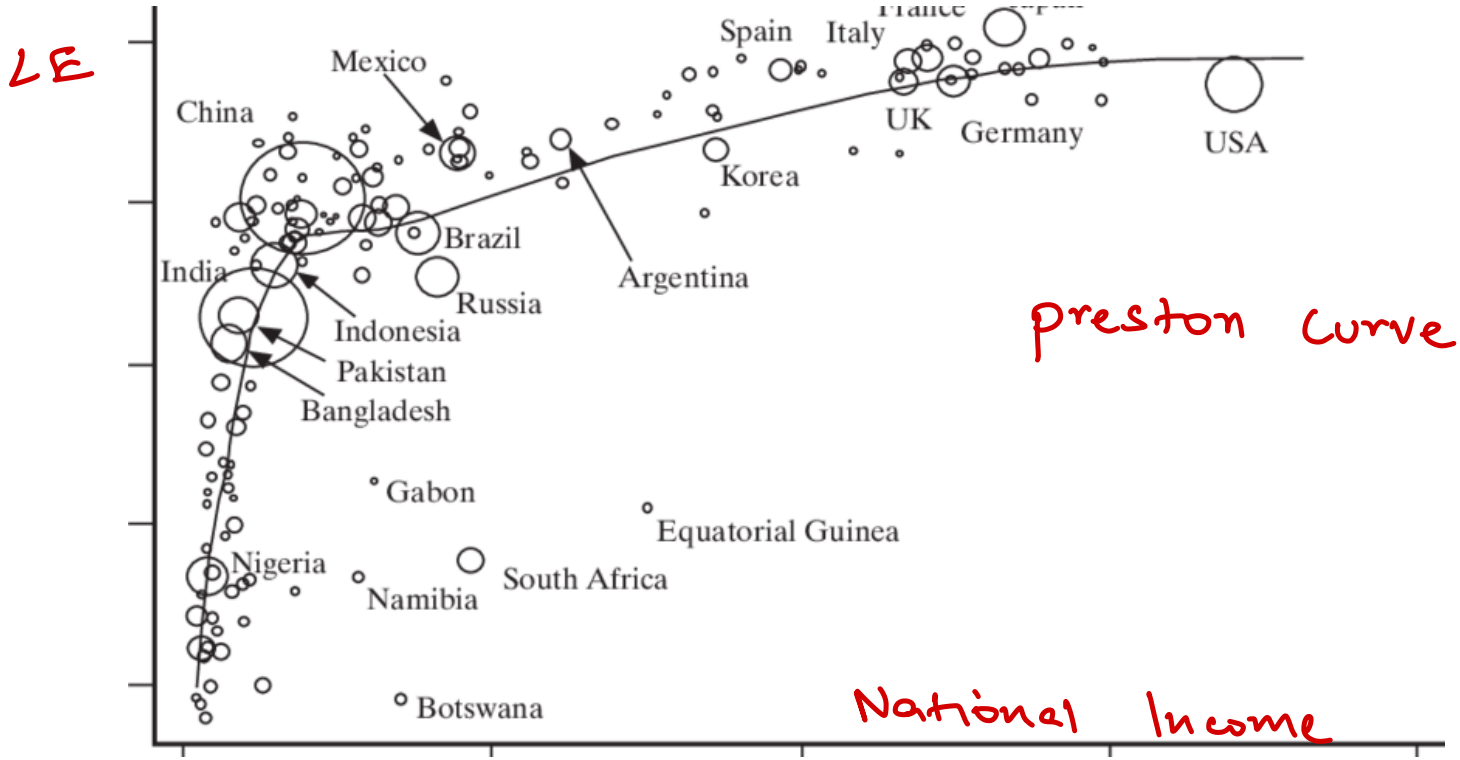
Health Economics
Health Production Function
Demand for Healthcare

What you need to remember from this lecture?

1. Health is affected by (a) genetics, (b) individual actions, (c) socio-economic determinants (income, education), (d) public health.
2. (b) Individual actions could be modelled by Grossman Human Capital Model:
   - 2.1 Main Assumption: Health is a stock that evolves due to accumulated stock in previous time-period and investments made to improve health.
   - 2.2 Key Insight: To maximize their utility, individuals make trade-offs and **choose less than maximal health**.
3. (c) Socio-economic determinants: Gender, Income, and Education etc.
   - 3.1 Income: Absolute Income and Relative Income matter
   - 3.2 Education: Strong gradient for health behaviours, and preferences.

Social Circumstances (Socio-Economic Determinants)

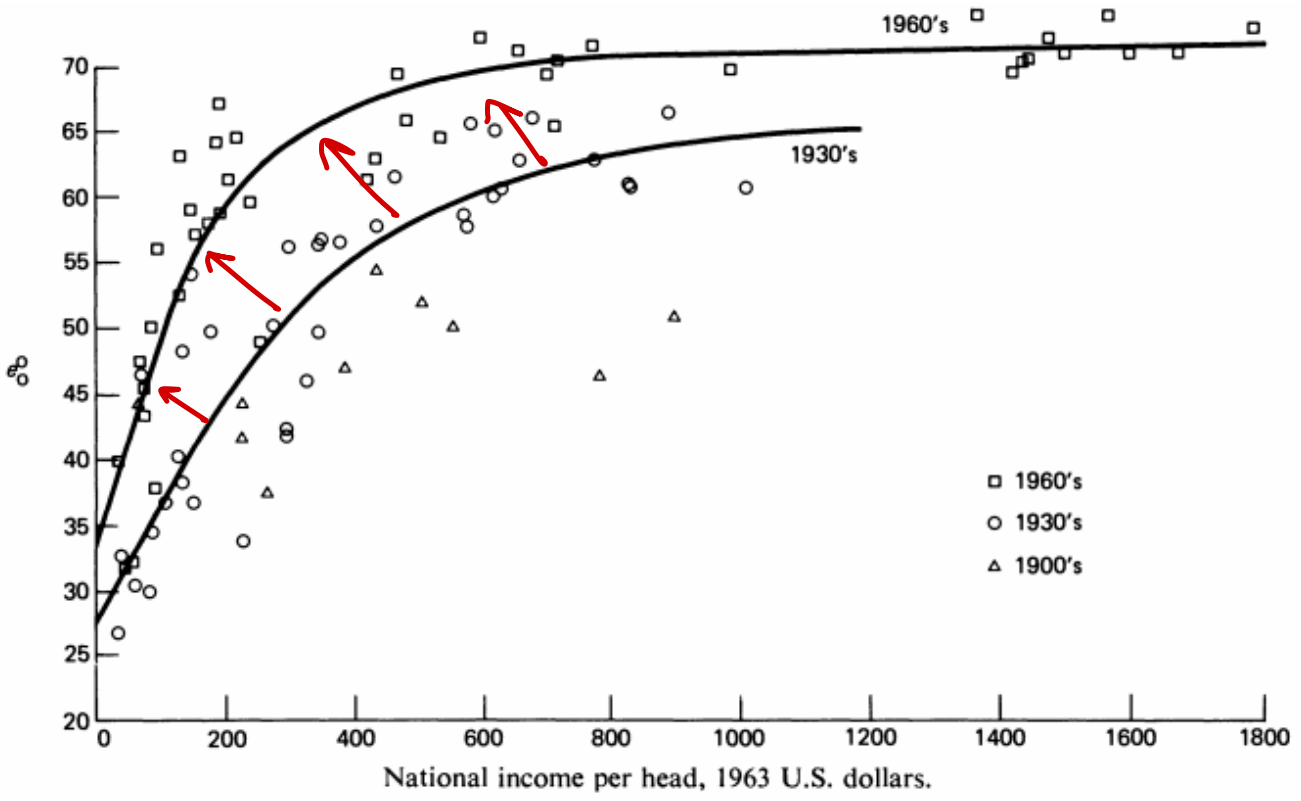
Determinants: National Income Across Countries



1. Association of Life-Expectancy (LE) and national income.
   1.1 LE rises rapidly (slowly) among low-income (rich) countries
2. 'Hinge-point': flattening of curve
   2.1 On left: Infectious diseases are prominent, 50% of deaths under age 5
   2.2 On right: Chronic diseases' death are prominent, few child deaths.
   2.3 "Diseases moved from bowels and chests of infants to arteries of elderly".

Source: World Development Indicators CD-ROM, World Bank (2002)

Determinants: National Income Across Countries

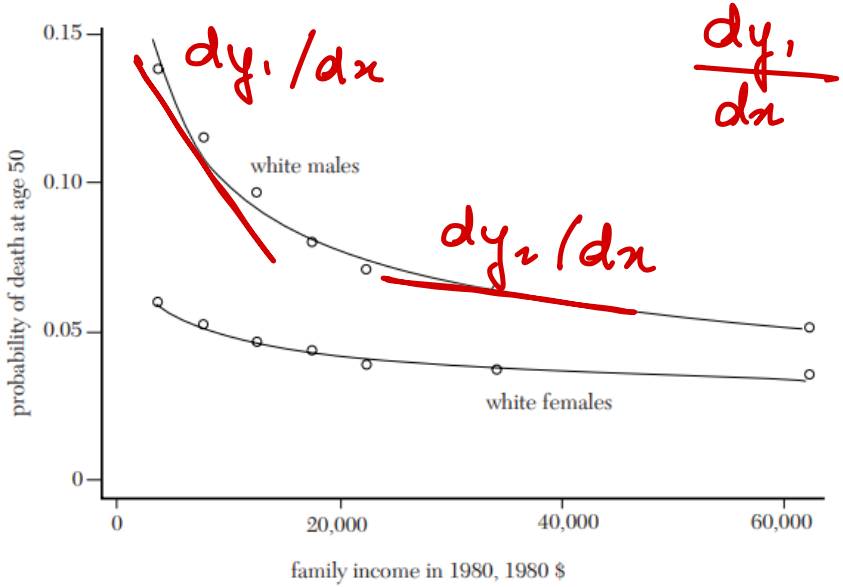


Does that mean we should redistribute income from high-income countries to low-income countries?

Source: Preston1975

Determinants: Health and Income - AIH

1. Absolute Income Hypothesis: Health is affected by income level and not inequality.
   - 1.1 Not Income itself but education, goods purchased by income.
   - 1.2 Family with income of $50000 has 25% less mortality than family with income less than $5000.
   - 1.3 If increase everyone's income: Take money from rich and give it to poor. Marginal utility of $1 is more for poor. Their health improves more than the worsening of rich people's health. On balance, the average health will improve.



Source: Deaton2003

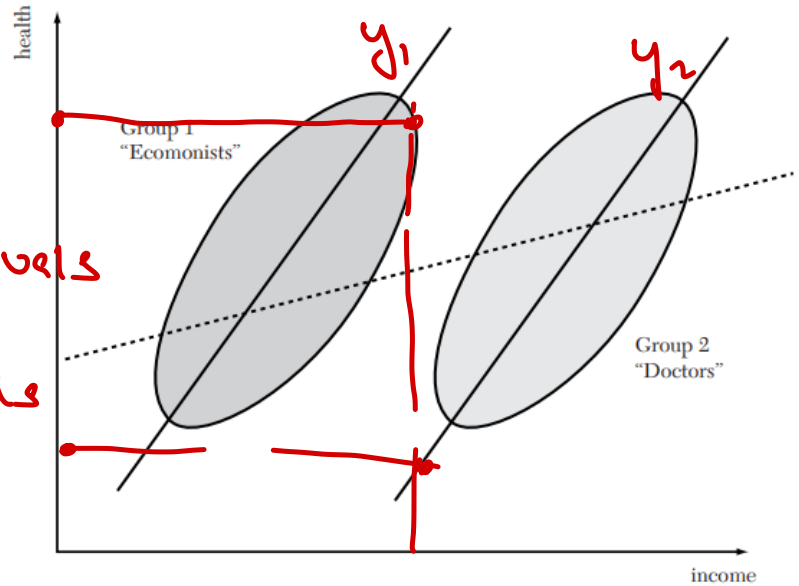
Determinants: Health and Income - RIH

people compare income in a reference group and not on an absolute basis. Lower rank in their group → high stress → ↓health

1. Relative Income Hypothesis: Income relative to aspirational level.
   $h_i = \bar{h} + \alpha(y_{is} - y_s)$
2. Higher income people have better *material* resources. Houses, food.
3. *Rank* is important. At work it determines power, stress. (Marmot 1997)
4. "If health for relatively low income is lower, then higher inequality makes the poor even more poorer in relative terms, and so it will worsen the average population health".
5. But how do we find the reference groups?

Source: Deaton2003

Determinants: Health and Income - RIH



For the same level of income, two individuals may have drastically different health levels due to their ranks within groups.

overall $\frac{dy}{dx}$

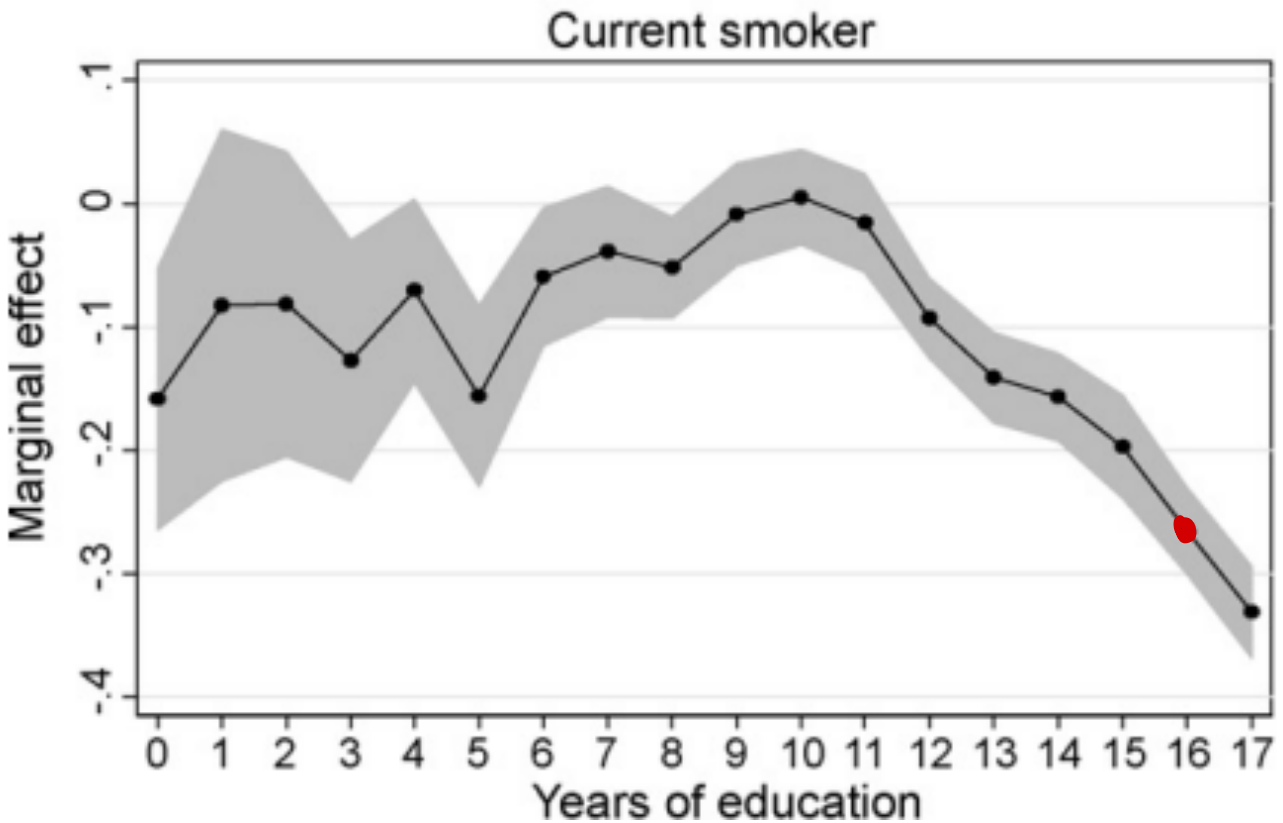
within group $\frac{dy}{dx}$ > aggregate $\frac{dy}{dx}$

1. Absolute Income - Average health across groups is same.
2. Relative Income - Within each group, health depends on relative income.
3. Pooled analysis: Flat broken line:
4. Inequality determines degree of flatness. Ratio of within-group income equality to between-group inequality
   - 4.1 Move groups apart, between-group inequality increases, flatter line.
   - 4.2 Stretch the ellipse, within-group inequality increases, steeper line.

Source: Deaton2003

Determinants: Health and Education - Smoking

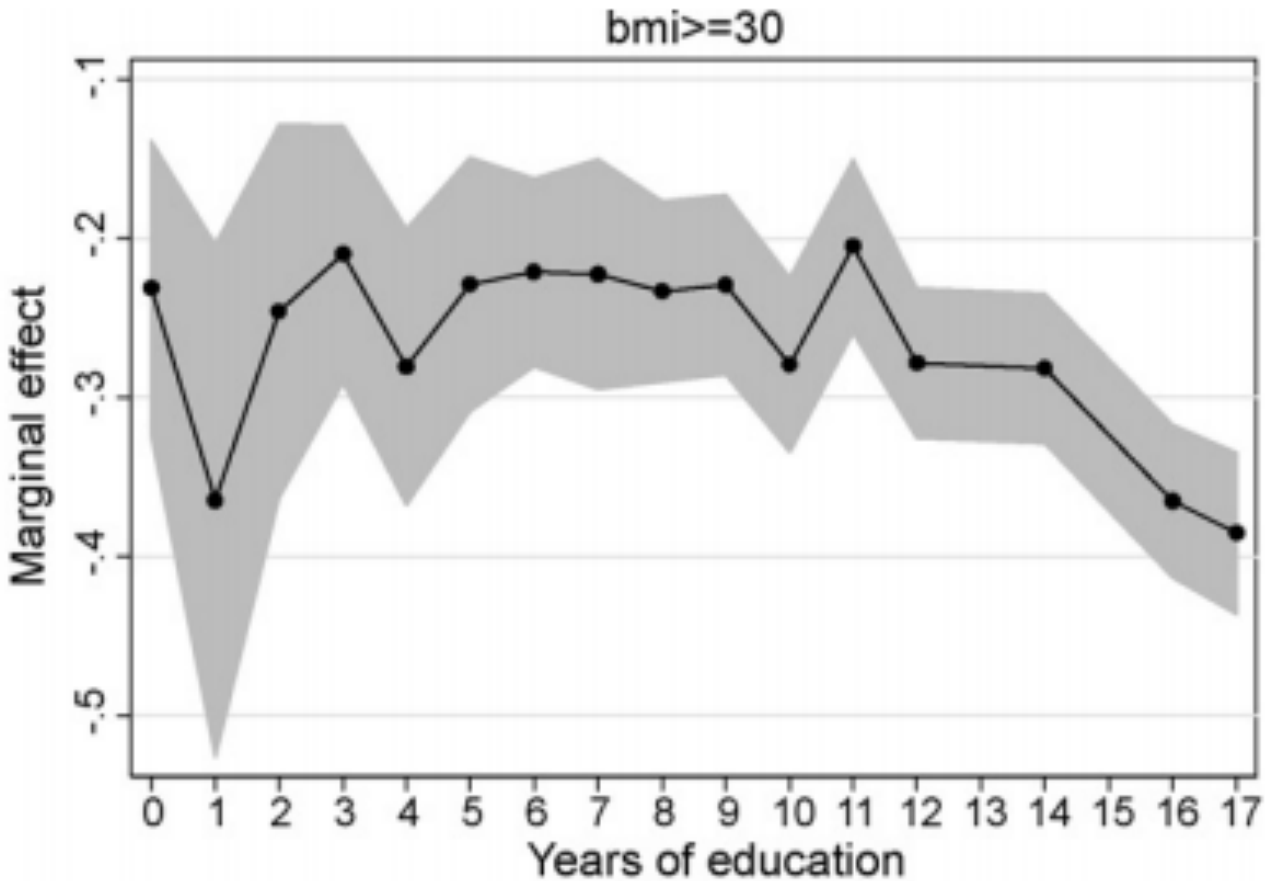
1. Smoking: Each year of education is associated with 3 percentage point reduction in smoking
   - 1.1 College graduate is 12 percentage points less likely to smoke than high-school grad
   - 1.2 Smoking is associated with 6 years of reduction in life.



Source: Cutler2010

Determinants: Health and Education - Obesity

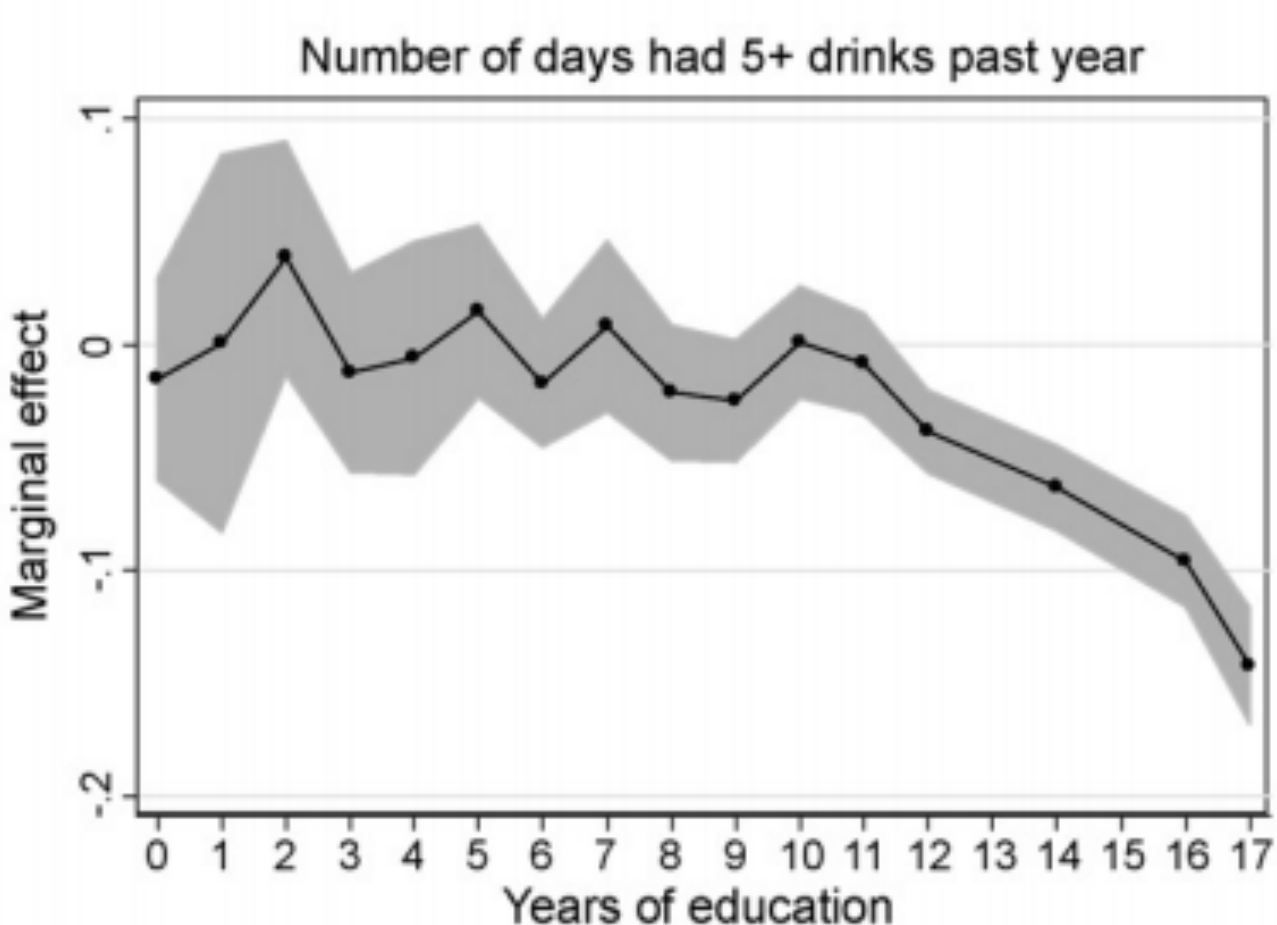
1. Obesity: Each year of education is associated with 1.4 percentage point reduction in obesity
   1.1 Declines sharply over 12 years of education.



Source: Cutler2010

Determinants: Health and Education - Alcohol

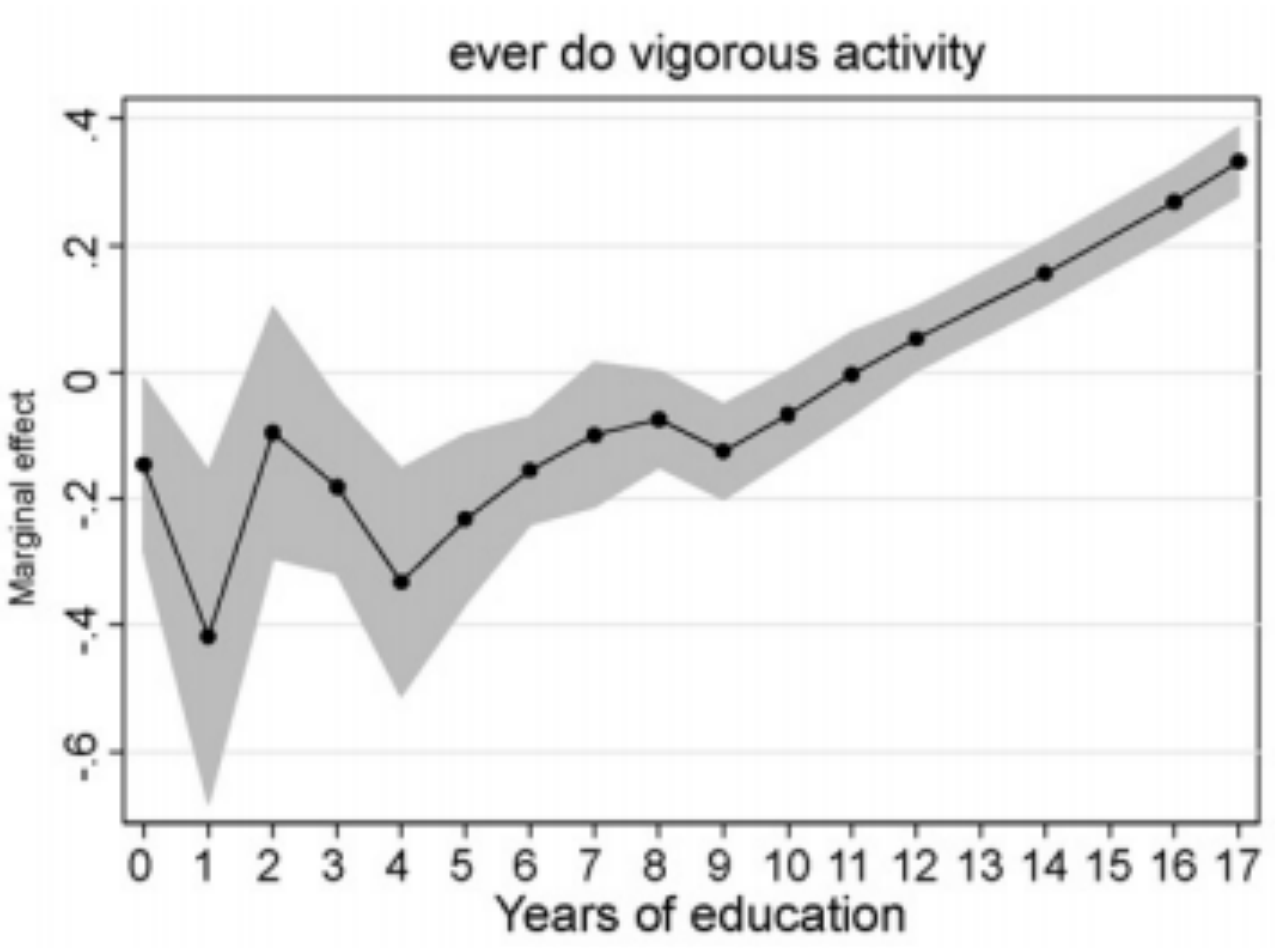
1. Heavy Drinking (5 or more drinks): Each year of education is associated with 1.8 percentage point reduction in heavy drinking
   1.1 Better educated are more likely to drink.
   1.2 Better educated are less likely to drink heavily when they drink.



Source: Cutler2010

Determinants: Health and Education - Exercise

1. Better educated are more likely to exercise vigorously (preventive behaviour).

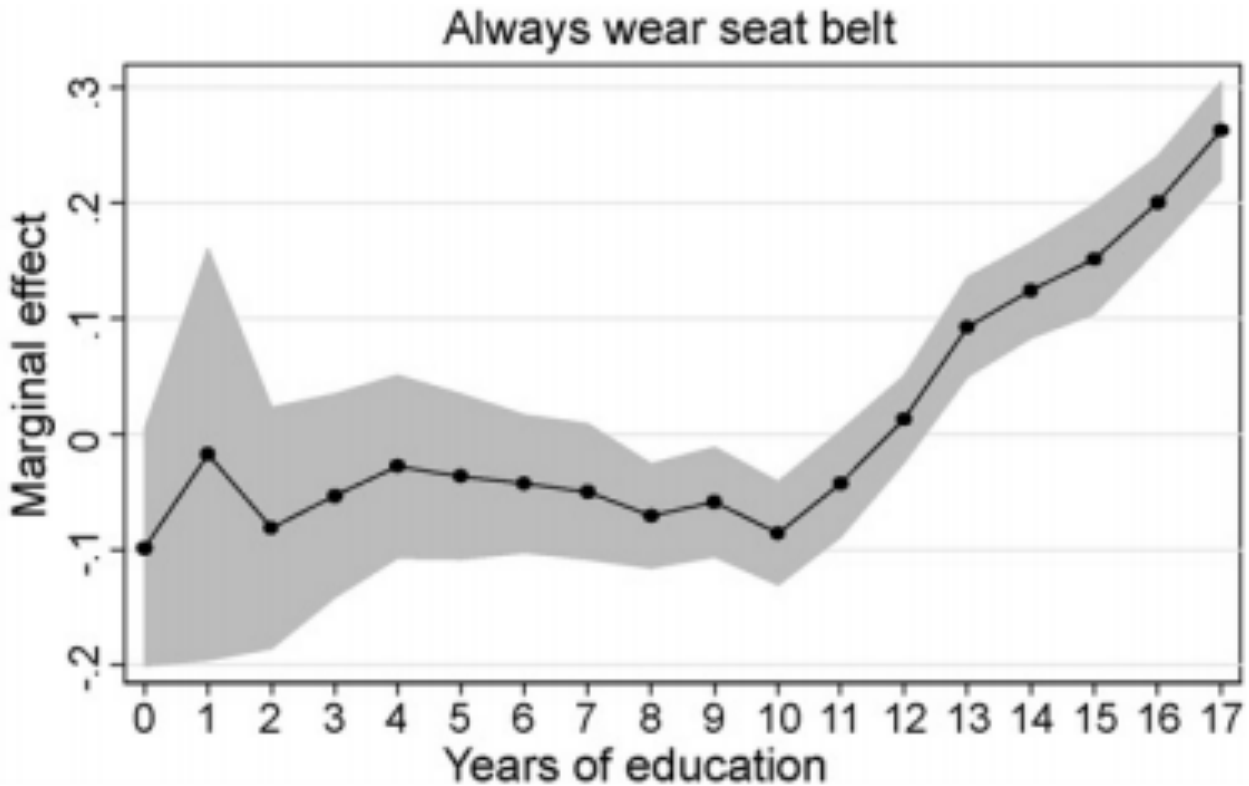


Source: Cutler2010

Determinants: Health and Education - Seat Belts

1. Better educated are more likely to use seat belts (preventive action).
2. "about 78 per cent said they own child restraints, but only 55 per cent use them all the time". Singapore 2019
   2.1 "Almost half of parents who have cars said their children felt uncomfortable in restraints." Singapore 2019

Preventive behaviour is high in higher education people



Source: Cutler2010

Human Capital Model

Grossman HC model

Background: Basic Setup for Optimisation

1. Preferences defined by Utility

$x_i \in$ Goods / Services

$$U = U(x_1, x_2, ..., x_{n-1}, x_n)$$

2. Constrained by budget: Income, which constrained by wages (per hour) and time.

Budget constraint

$$T \times W = Y = P_{x_1}X_1 + P_{x_2}X_2 + ... + P_{x_{n-1}}X_{n-1} + P_{x_n}X_n$$

3. Max U$= (x_1, x_2, ..., x_{n-1}, x_n)$ s.t.
$Y = P_{x_1}X_1 + P_{x_2}X_2 + ... + P_{x_{n-1}}X_{n-1} + P_{x_n}X_n$

Find the tangent between Indifference curve (Utility from bundles of Xs) and Budget line

Step 1: Preferences: Human Capital Model (Grossman)

Grossman model links everyday decisions to utility over entire lifespan.

Health plays **three** roles in Grossman model:

1. Health as **consumption** good. Direct contribution to utility.
   $U = U(H)$ Having higher health → ↑ utility (direct)
2. Health as **investment** good. Increases productive time which enables to get more health and income (more utility). (indirect)
   $U = U(H, Y(H))$ Having higher health → ↑ T → ↑ Y → ↑ Utility
3. Health as **capital** good. Stock appreciates or depreciates over time.
   $H_t = H(H_{t-1}, T_t^H, M_t)$
   $H_t = f(H_{t-1}, T_t^H, M_t)$ → time spent on health; → action done to increase health; ↳ health before

Grossman Model - Health as Consumption Good - Role 1

1. *Preferences*: Single-period utility: $U_t = U(H_t, Z_t)$
   1.1 H_t: **level** of health;
   1.2 Z_t is composite good comprising everything else.

Trade-offs:

1. Tradeoffs(?): Smoking may $\uparrow Z_t$ but $\downarrow H_t$
2. Tradeoffs(?): Jogging may $\uparrow Z_t$ and $\uparrow H_t$
3. Health *care* enters through effect on H_t

Grossman Model - Health as Investment Good - Role 2

Time is limited in a day. Divide it into four activities:
$T^T = T^W + T^L + T^H + T^S$ Working | Leisure | Health | Sick
T^t: Total Time;

1. T^W: Time spent Working;
2. T^L: Time spent in Leisure;
3. T^H: Time spent in Health seeking activities;
4. T^S: Time spent in Sickness.

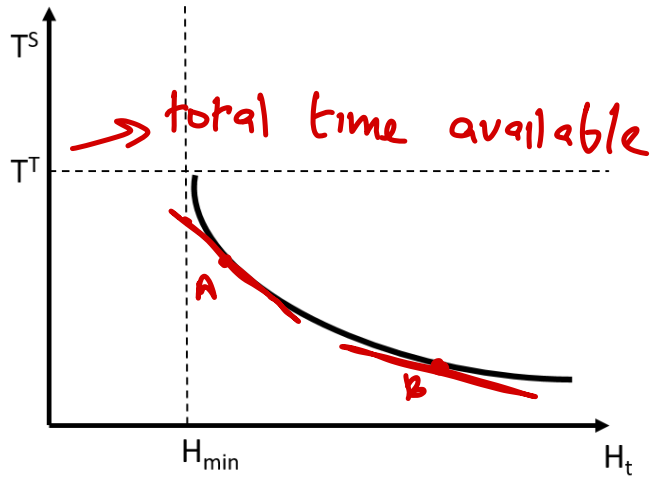
Each activity can $\uparrow$ or $\downarrow$ utility:

1. T^W: Each hour Working provides **income**. Income $\rightarrow \uparrow$H or $\uparrow$L $\rightarrow \uparrow$Z;
2. T^L: Each hour in Leisure $\rightarrow \uparrow$ Z $\rightarrow \uparrow$ U();
3. T^H: Each hour in Healthy activity $\rightarrow \uparrow$ H $\rightarrow \uparrow$ U();
4. T^S: Each hour in Sickness does not increase H or Z so no increase in utility.$\star$

- It takes time away from W, L, H so it can decrease utility.
- T_S **is involuntary: It is entirely determined by H**.$\star$

Grossman Model - Health as Investment Good - Role 2

Illness-Avoidance Curve



$\left|\frac{dy_A}{dx}\right| > \frac{dy_B}{dx}$

∴ Slight increase in health initially leads to large benefits in T_S ↓

Relation between H and sick time T^S

1. Higher the level of H, lesser the time spent in sickness: T^S
2. $T^P = T^T - T^S = T^W + T^L + T^H$
3. Diminishing marginal returns to time from Health.
   - 3.1 Steeper portion (towards left): If very sick, then additional health contributes substantially to productive time .
   - 3.2 Flatter portion (towards right): If very healthy, then additional health contributes very little to productive time.

Any investment in health reduces T^S and increases T^P.

Grossman Model - Health as Capital - Role 3

1. Health: $H_t = H(H_{t-1}; T_t^H, M_t)$; health has autocorrelation
2. Other Goods: $Z_t = Z(\ \times\ ; T_t^Z, J_t)$. Z_t has no autocorrelation
3. Initial levels:
   - 3.1 At each t, H_t starts at H_{t-1}. Past stock of health affects today's health
   - 3.2 H_{t-1} is given at t and cannot be changed.
   - 3.3 At each t, Z_t starts at 0. Yesterday's leisure does not affect today's leisure.
4. Inputs:
   - 4.1 Time spent in each T^H, T^Z;
   - 4.2 M_t: Inputs like vaccines or gym equipment into health during t;
   - 4.3 J_t: Inputs into Z like movie tickets.

Step 2: Budget Constraint

Budget constraint: Spending cannot exceed earnings
(No borrowing or bequests assumed in this model).

Time constraint also imposes income constraint.

1. Total time spent working: T^W. Earns wage of w per hour.
2. Total income: $Y_t = w.T^W$
3. Spend income on M_t and J_t.
4. $p_M.M_t + p_J.J_t \leq w.T^W = Y_t$
5. $p_M.M_t + p_J.J_t = w.T^W = Y_t$ [Assume no savings]

Recap

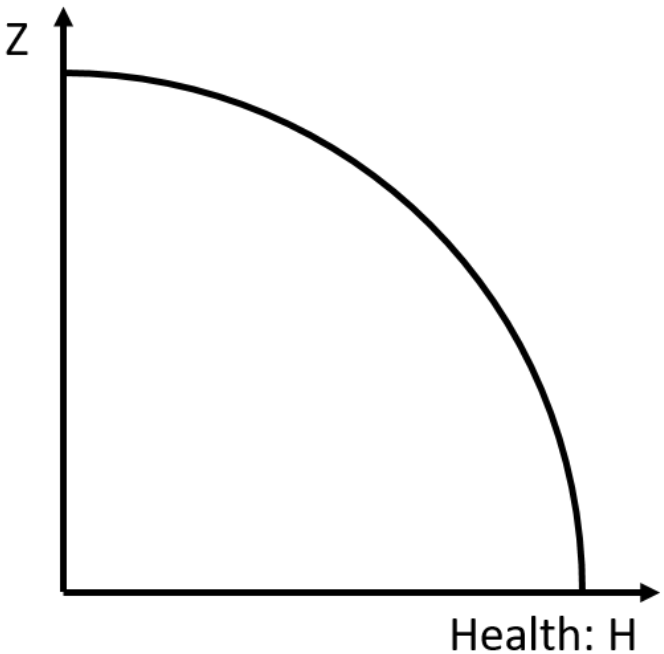
Until now:

1. Health as Consumption Good: $U_t = U(H_t, Z_t)$
2. Health as Investment Good: More T^P, more of H and Z.
3. Health as Capital Good: $H_t = H(H_{t-1}; T_t^H, M_t)$;

Next:

1. **Within investment good: optimal choice between H and Z**
   - 1.1 **Decide between H and Z**
   - 1.2 Decide between T^W and T^Z
2. Returns from health as capital good.

Step 3: Utility Maximization: Production Possibilities Frontier (PPF)

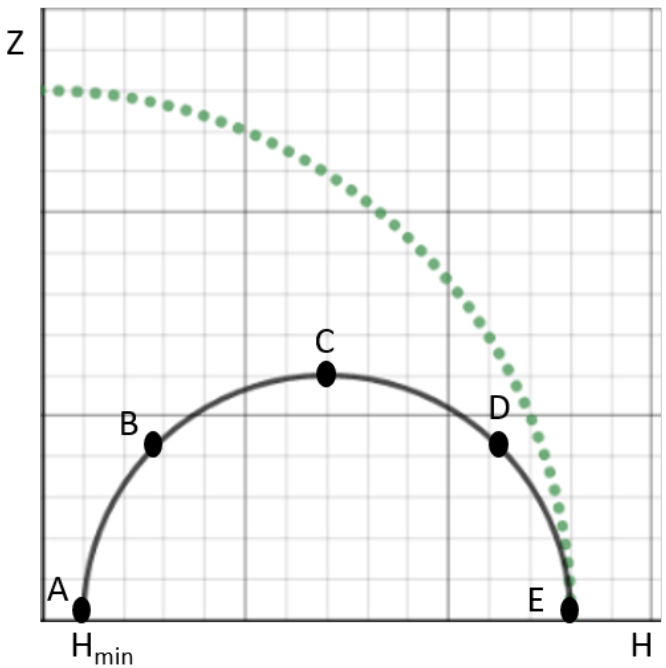


Traditional Production Possibilities Frontier (PPF)

- Two goods: Z (Y-axis) and H (axis)
- If spend all resources on H, none for Z.
- If spend all resources on Z, none for H.
- But if H = 0 or low, then no health to produce any Z.

Is traditional PPF valid for Health? [Differences!] no :(

Utility Maximization: Modified PPF for Health (1/4)

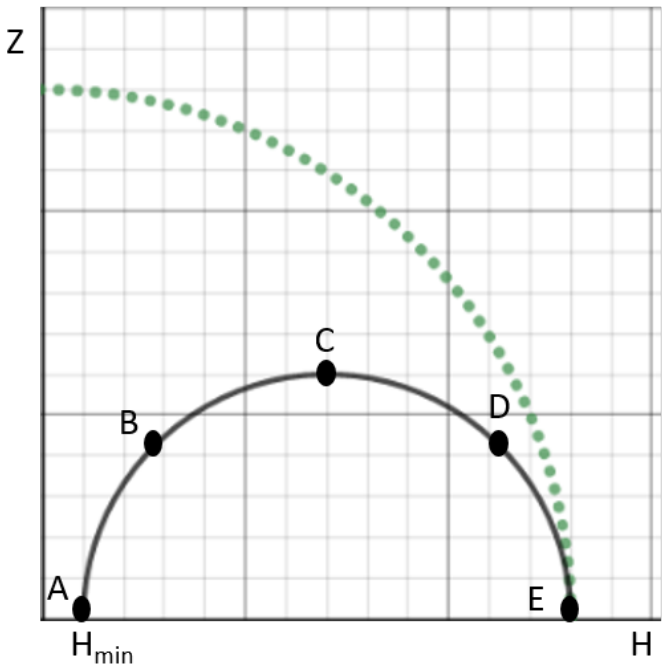


1. A: Basic survival: H_{min} either sick or tending
   - 1.1 No productive time $\rightarrow T^P = 0 \rightarrow$ Z=0;

   to health
2. B: $H > 0 \rightarrow T^P > 0 \rightarrow Z > 0$;
   - 2.1 Health is low: Steeper portion of illness-avoidance curve (n-2 slides) :
   - 2.2 Small improvements in health $\rightarrow$ large increase in productive time
     - (Rise over run from A to B).
   - 2.3 Free-lunch zone: $\uparrow$Z without $\downarrow$H.

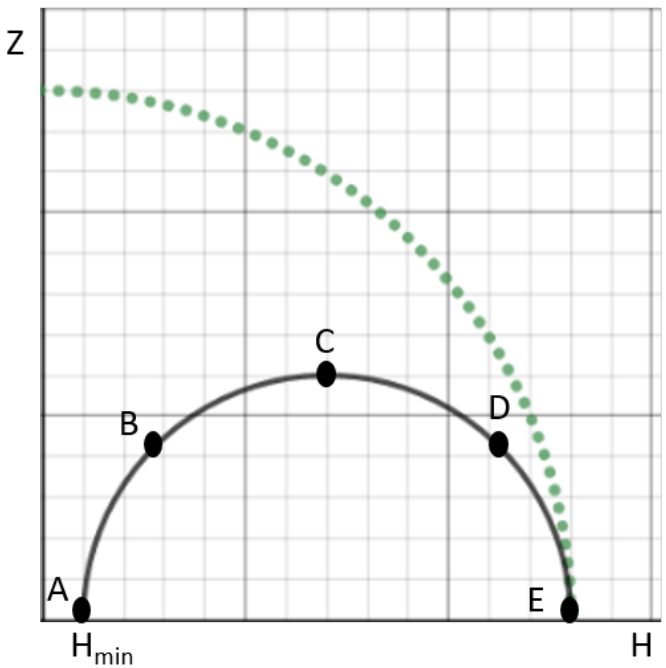
Slope positive so both Z and H can increase by investment in H

Utility Maximization: Modified PPF for Health (2/4)



1. C: 1 hour of $T^H \rightarrow$ 1 hour of T^P.
2. H is not maximum because T^H is not maximum;
3. Z is at maximum;
4. If shift resources **from H** to Z (towards left), H will fall, sickness will outweigh gain in resources for Z.
5. If shift resources **to H** (to $\uparrow T^P$ to $\uparrow$ Z) (towards right). Increase in H does not yield extra productive time to offset the time to produce H.

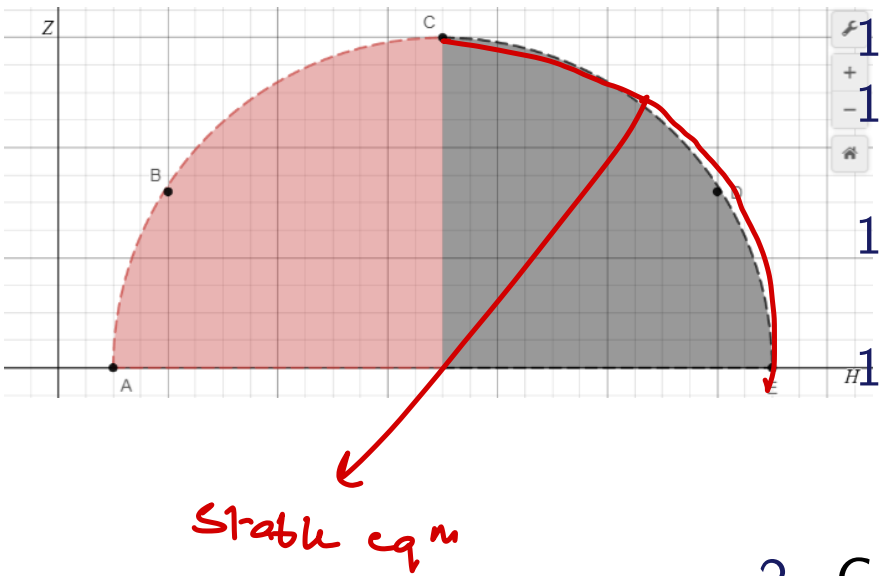
Utility Maximization: Modified PPF for Health (3/4)



1. D: Trade-off zone (from C to E):
   - 1.1 Flatter part of illness-avoidance curve.
   - 1.2 1 unit increase in H yields less than 1 unit decreases in sickness time;
   - 1.3 To obtain more H, must shift greater and greater resources away from Z.

2. E: All time and money spent on H.
   $Z = 0$ and $H = H_{max}$. Possible? No?

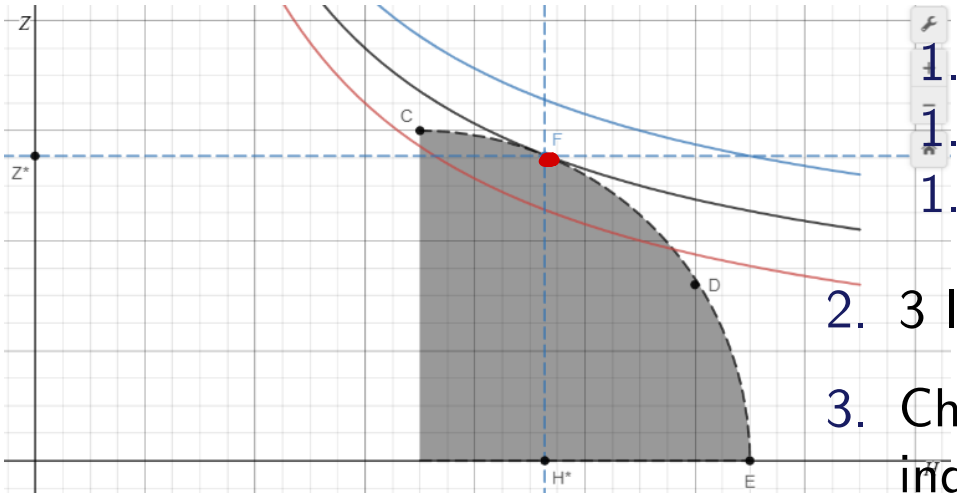
Utility Maximization: Modified PPF for Health (4/4)



1. A or B (Free-lunch Zone from A to C):
   - 1.1 Increase both ↑H and ↑ Z.
   - 1.2 Money-on-the-table. Can increase both without any trade-off.
   - 1.3 Not optimal to not increase both because both increase utility.
   - 1.4 This zone does not provide stable equilibrium.

2. C to E (Trade-off zone from C to E)
   - 2.1 Pick a combination here
   - 2.2 But which one - depends on tastes i.e. preferences over H and Z (indifference curves - next)

Utility Maximization - PPF and Indifference Curve



1. Recall
   - 1.1 Preference: Indifference curve.
   - 1.2 Budget Constraint: PPF
   - 1.3 Utility Maximization: Tangent
2. 3 Indifference curves: rank Utility.
3. Chose F (tangent of PPF and indifference curve)
4. Optimal combination: (H*, Z*)
5. $H* < H_{max}$
   - 5.1 Sacrifice H to gain Z

Key insight from Grossman model: to maximize their utility, individuals make trade-offs and **choose less than maximal health**. $\star$

Recap

Until now:

1. Health as Consumption Good: $U_t = U(H_t, Z_t)$
2. Health as Investment Good: More T^P, more of H and Z.
3. Health as Capital Good: $H_t = H(H_{t-1}; T_t^H, M_t)$;

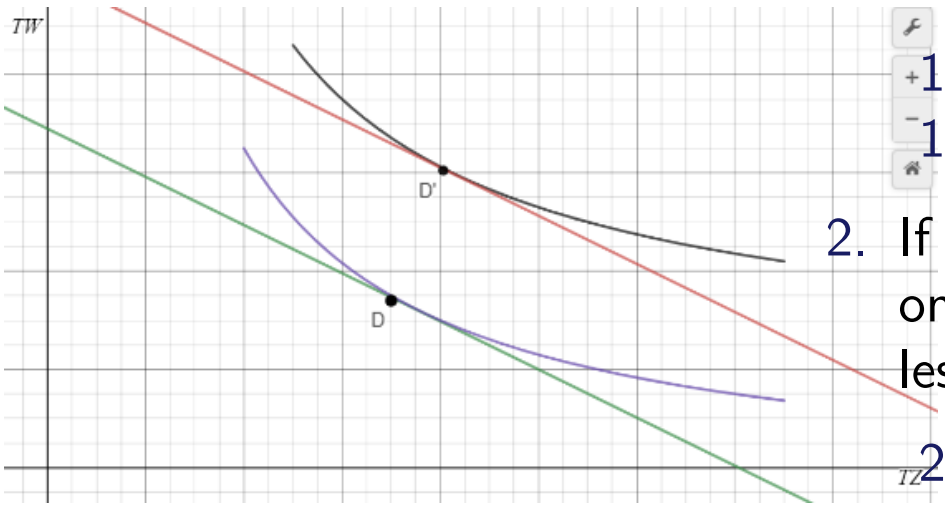
Next:

1. Within investment good: optimal choice between H and Z
   - 1.1 Decide between H and Z
   - 1.2 **Decide between T^W and T^Z**
2. Returns from health as capital good.

Increase in $T^Z \rightarrow \uparrow Y \rightarrow \uparrow H$

Labor-Leisure-Health Trade-off

1. To decide between H and Z: Trade-off between T^W, T^L, T^H, T^S
2. $T^P + T^S = T^T$ and
   - 2.1 T^P = f(H); T^P increases in H, but has diminishing marginal returns.
   - 2.2 T^S is involuntary;
   - 2.3 Left with distribution of T^P within Work, Leisure, and Health.



1. Assume individual has decided T^H
   - 1.1 Left with decision for T^W, T^L
   - 1.2 Chose D (Tangent)
2. If in **previous** period spent **more** time on H (T^H_{t-1}), enter with more H and less T^S
   - 2.1 More T^W, T^L: PPF Shifts
   - 2.2 Chose D' with higher utility

OR **current** period spend **less** on H (T^H_t), with same T^S, more T^W, T^L
But Lower(?) H in future time-period?

Utility Maximization - Multi-Time Period

1. $U = U\Big((H_0, Z_0), (H_1, Z_1), ..., (H_{\theta-1}, Z_{\theta-1}), (H_\theta, Z_\theta)\Big)$
   - 1.1 H_t and Z_t are health and other goods in time period t=0,,,θ;
   - 1.2 θ is the length of lifespan;
   - 1.3 Individuals can choose θ.
2. $U = U(H_0, Z_0) + \delta U(H_1, Z_1) + \delta^2 U(H_2, Z_2) + \delta^\theta (H_\theta, Z_\theta)$
   - 2.1 $\delta \subset (0, 1)$ is the time-discount factor.
3. Health as capital good: $H_t = H[(1-\gamma)H_{t-1}, T^H, M_t]$
   - 3.1 Appreciates with investment, depreciates with sickness.
   - 3.2 γ **is the rate of depreciation for health.**

Recap

Until now:

1. Health as Consumption Good: $U_t = U(H_t, Z_t)$
2. Health as Investment Good: More T^P, more of H and Z.
3. Health as Capital Good: $H_t = H(H_{t-1}; T_t^H, M_t)$;

Next:

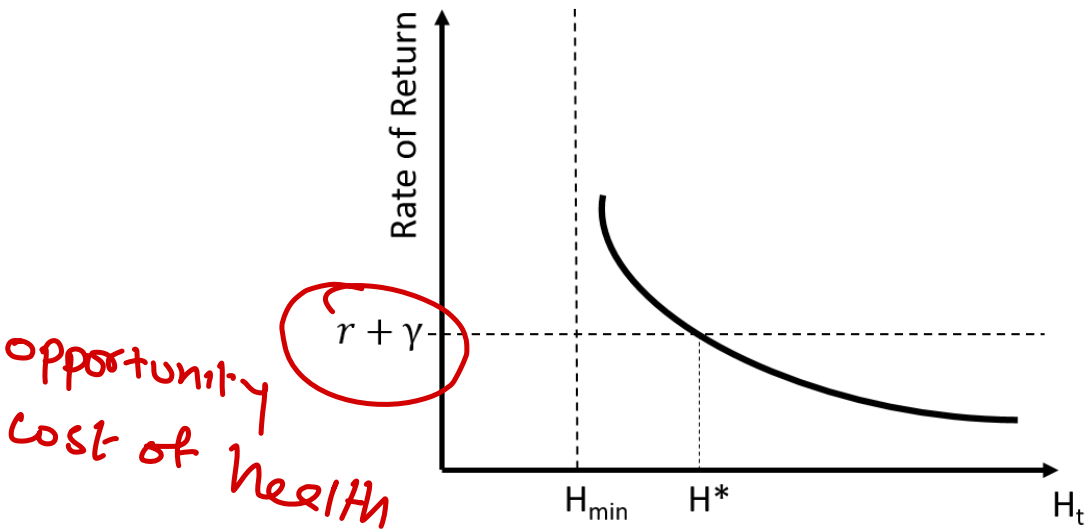
1. Within investment good: optimal choice between H and Z
   - 1.1 Decide between H and Z
   - 1.2 Decide between T^W and T^Z
2. **Returns from health as capital good.**

Health as Capital Good (1/3)

1. $U = U(H_0, Z_0) + \delta U(H_1, Z_1) + \delta^2 U(H_2, Z_2) + \delta^\theta (H_\theta, Z_\theta)$ (1)
2. $H_t = H[(1-\gamma)H_{t-1}, T^H, M_t]$
3. Health as capital good:
   - 3.1 Appreciates/Depreciates over time due to investments/withdrawals.
   - 3.2 Has its own rate of return.
4. Depreciation over time:
   - 4.1 γ is the rate of depreciation for health.
5. Rate of Return: If invest in health H in any time period (3 features):
   - 5.1 Multi-period effects: Health and Utility in (1) that and (2) subsequent time-periods go up (equation 1).
   - 5.2 Initial value matters: The 'increase' in utility or 'return' on health investment depends on initial H (equation 2).
   - 5.3 Diminishing marginal returns to health (see fig on next slide):
     - Marginal lifetime returns to health are high at low levels of health;
     - Marginal lifetime returns to health are low at high levels of health.

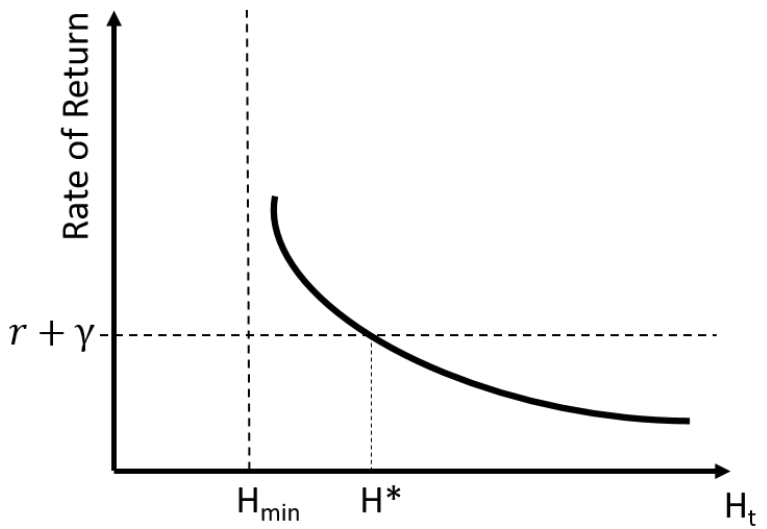
Health as Capital Good (2/3)

1. **Marginal Efficiency of Capital (MEC) curve**: Shows how efficient each unit of health capital is in increasing lifetime utility or the rate of return on investment in health.
   - 1.1 Diminishing marginal returns to health:
     - Marginal lifetime returns to health are high at low levels of health;
     - Marginal lifetime returns to health are low at high levels of health.

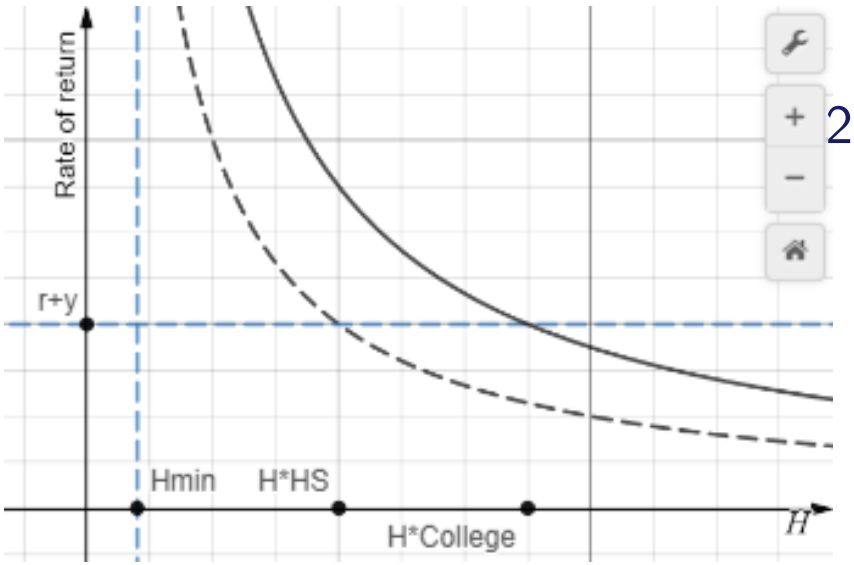


Health as Capital Good (3/3)

1. Cost of investing in Health: : Opportunity cost (r) + Depreciation (γ)
   - 1.1 **Opportunity cost**: tradeoff from other resources.
     Invest savings to earn interest (r)?
   - 1.2 **Depreciation cost**: due to sickness /aging (γ)
     - Higher the depreciation, need to invest more and more.
     - Depreciation increases over time (due to aging)
2. Equilibrium:
   - 2.1 If Invest in Health, then return from health should be atleast $(\gamma + r)$
   - 2.2 H^*: marginal cost of investment $(r + \gamma)$ equals marginal benefit of investment.



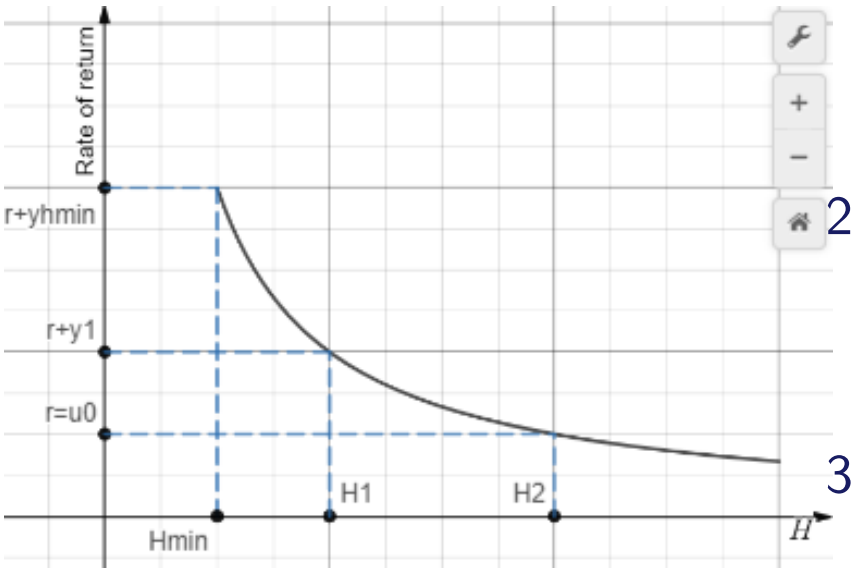
Grossman Model - Applications - Health and SES



$\frac{\partial H_{educ}}{\partial T^H} > \frac{\partial H_{un\text{-}edu}}{\partial T^H}$

1. Individuals with more education/ wealth have longer life-expectancy:
2. **Grossman: More efficient producers of health**.
   - 2.1 **For each hour of T^H, higher educated gets more H**.
   - 2.2 **Upward shift of MEC**. Higher health returns for each unit investment.
3. For Same r+γ, College Educated enjoy more H:
   - 3.1 Since more efficient at producing H, invest more in H until MC = MB
   - 3.2 High school educated less efficient in producing H; Invest more in Z than H.

Grossman Model - Applications - Aging and Health



1. Why health deteriorates with age?
   Curve shift downward
   - 1.1 Why not invest to keep health up high at all points? not optmal/
2. $H_t = H(1-\gamma)H_{t-1}, T^H, M_t)$ high δ/r
   - 2.1 Depreciation rate (γ) increases over time.
3. When γ increases:
   - 3.1 Cost of capital increases $\uparrow (r+\gamma)$
   - 3.2 Invest more and more to maintain same level of health.
   - 3.3 Less willing to spend time and money on H, and more on Z.
   - 3.4 H keeps declining until it reaches H_{min}
   - 3.5 At this point, all time is spent in sickness. Cannot produce H or Z.

Conclusion Need to Remember

1. Health is affected by genetics, individual actions, socio-economic determinants (income, education), public health.
2. Individual Actions could be modelled by Grossman Human Capital Model
   2.1 Health is a stock that evolves due to accumulated stock in previous time-period and investments made to improve health.
3. Some other socio-economic determinants are: Income and Education
   3.1 Income: Absolute Income and Relative Income matter
   3.2 Education: Strong gradient for health behaviours, and preferences.

Appendix: Lagrangean Function

1. *Preferences*: Utility: $U_t = U(x_1, x_2)$
2. *Budget Constraint*: $Y_t = p_{x1}X_1 + p_{x2}X_2$
   - 2.1 Prices p_{x1}, p_{x2}
   - 2.2 Income Y_t
3. *Utility Maximization* (Cost Minimization) subject to budget constraint
4. $max\, U_t$ s.t. $Y_t = Y_t = p_{x1}X_1 + p_{x2}X_2$
5. Use Lagrange multiplier method (see handout)
6. $\mathcal{L} = U_t + \lambda(Y_t - p_{x1}X_1 + p_{x2}X_2)$
7. First Order Conditions (FOC) : $\frac{\partial \mathcal{L}}{\partial \lambda}, \frac{\partial \mathcal{L}}{\partial x_1}, \frac{\partial \mathcal{L}}{\partial x_2}$
   - 7.1 Optimum is where the indifference curve is tangent to the budget line.