

Health, Consumption and Inequality

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VERY PRELIMINARY

How to Assess Inequality

- We construct measures of Inequality between groups (today College Graduates vs those that have not finished High School (Dropouts)).
- These measures use the notion of Compensated Variation (how much money does one group have to receive to be indifferent between remaining in his group instead of being in another group).
- These Measures
 - Take into account differences in Mortality.
 - Take into account differences in Health.
 - Take into account that with more resources actions will be taken by the disadvantaged groups to improve mortality, health, and wellbeing.
- In doing so, we have developed, what we think are novel (but we are not sure) ways of measuring health improving technology with expenditures ([Cole, Kim, and Krueger(2014)] have estimated the role of *inconvenient activities*; [Peltzman(2009)] looks at mortality inequality alone).

Measuring Inequality

- How can we measure Inequality? How unequal are groups A and B?
- Economists use something called *Compensated Variation*:
 - How much would we have to give to people in A to make them indifferent between being in A or in B.
- This requires an imputation of what is it that they like. For today, we will think that all people like the same things.
- Inequality is a central public concern. Providing measures across groups helps us understand its implications better.

Consumption Based Measures of Inequality

Education and Wealth

- So how unequal are College Grads from those that did not graduate from High School (Dropouts for short)?
 - College Grads from 50 on consume over their remaining lifetime 81% more than Dropouts, so in principle it would take 81 additional cents per year for each dollar that the Dropouts consume to be as well off as College graduates.
 - [We made some adjustments: family size, but not others (leisure)].
- What about wealth? Top vs bottom quintiles (also at 50)?
 - They can still move up and down.
 - Households in the top quintile at age 50 seem to consume 51% more over their remaining lifetime which seems too little but
 - It is wealth not income
 - Our data set (PSID, HRS) surely misses the top 10% in wealth so this is not such a huge jump.

Not so Fast, Dropouts and the wealthy live longer

At 50 the Expected Longevity l_{50} of white males

Differences between socioeconomic types

	l_{50}	difference
		Education
Dropouts	75.6	0.0
High School	78.6	3.0
College Grads	81.9	6.3
		Wealth
q5	76.4	0.0
q4	78.4	2.0
q3	79.4	3.0
q2	80.0	3.6
q1	80.6	4.2

How much more is worth to be in another group?

- Need to compare value of consumption with value of being alive.
- Can a life have a price?
- According to many, yes. Big literature on this that values a life according to modern standards at about \$100,000-\$150,000 per year. This is what is called the Value of Statistical Life.
 - It is based on people's choices. (like the premium for dangerous wages)
- We set it at \$100,000 (2005) per year. Yields conservative estimates.
- It also requires an assessment of the decreasing value of consumption, that following standard practice in Economics is valued with logs.
- As people get richer, they value more to be alive: they will allocate an increasing share of their resources to live one more year.

The Trade-Off Between Consumption and Being Alive

- Consider a person that lives potentially forever, but
 - Each period can die with probability $1 - \gamma$. So her life expectancy is $\frac{1}{1-\gamma}$
- She discounts the future at rate β per period.
- We write the total value of consuming c while alive and having survival probability of γ as

$$\Omega(c, \gamma) = \sum_{t=0}^{\infty} \beta^t \gamma^t [\log c + \alpha] = \frac{\log c + \alpha}{1 - \beta\gamma}$$

- We need to find the α that is consistent with the \$100,000 per year value of life.
- We can do so by solving $\Omega_c dc + \Omega_\gamma d\gamma = 0$, making $d\gamma$ large enough to add one more year of life.

Details to derive α

- Value of Statistical Life measures the willingness to pay for an extra year of life. Proceed by

$$\Omega_c dc + \Omega_\gamma d\gamma = 0 \Rightarrow \frac{dc}{d\gamma} = -\frac{\beta}{1-\beta\gamma} \frac{u(c)}{u_c(c)} = -\frac{\beta}{1-\beta\gamma} (\alpha + \log c) c$$

- To map the Value of Statistical Life (VSL) into $\frac{dc}{d\gamma}$ note that:
 - With annuities, a payment da translates into a constant consumption flow:

$$dc = (1 - \gamma + r) da$$

- A change de in life expectancy requires a change in the survival prob of

$$d\gamma = (1 - \gamma)^2 de$$

▷ Hence

$$\text{VSL} = \frac{da}{de} = \frac{(1 - \gamma)^2}{1 - \gamma + r} \frac{dc}{d\gamma} = \left(\frac{1 - \gamma}{1 - \gamma + r} \right)^2 (\alpha + \log c) c$$

(Using $\beta(1 + r) = 1$)

Details to derive α

- We use
 - VSL = \$100,000
 - $c = \$33,657$ (Total household expenditure per adult minus health expenditure, NIPA 2005)
 - $\gamma = 0.965$ ($e_{50} = 28.8$ years for white males)
 - $r = 3.5\%$
- We obtain
 - $\alpha = 1.55$
 - $u(c) = 11.98$
 - $\Omega(c) = \frac{1+r}{1-\gamma+r} u(c) = 177.84$
- We are now in business to calculate welfare differences when longevities differ.

So how much is the extra life of different groups worth?

- How much extra consumption has to be given to the low type to be as happy as (indifferent) the high type?
- We ask how much do people in group i need to get be indifferent between remaining in group i and switching to group 1 but keeping their own survival probabilities.
- Currently they consume $\{c^1, c^i\}$ and have survival probabilities $\{\gamma^1, \gamma^i\}$.
- We need to solve for x in

$$\frac{\log c^1 + \alpha}{1 - \beta\gamma^1} = \frac{\log (1+x)c^i + \alpha}{1 - \beta\gamma^i}$$

How much extra consumption has to be given to the low type to be as happy as (indifferent)

Welfare difference between types

	Due only to Consumption	Due to Consumption and Life Expectancy
Education Bw Dr. & Coll	0.81	6.45
Wealth Between 1 & 5 Quint	0.51	2.91

But ...

Endogeneity of Life Duration:

- Could it be that the low groups could have used the extra resources to increase their life duration?
- This would have
 - 1 Reduced differences in life durations.
 - 2 Reduced the size of inequality because of a much more efficient use of the resources.
- The assessment requires an adjustment based on how much more longevity money can buy: Need to measure health technology.
- We need to separate how much of the life expectancy is intrinsic to the type (either it was settled before or because of selection) and how much can be bought.
- We use theory (a revealed preference argument) to back out this technology using data on consumption c^i , health expenditures x^i , and expected longevity $\ell_{50,i}$ across types.

Backing out the life extending technology

- Take two types, say college and dropout.
- Assume survival probability takes the following functional form:

$$\gamma^i(x^i) = \lambda_0^i + \lambda_1 \frac{(x^i)^{1-\nu}}{1-\nu}$$

- This form is flexible: it can impute all the advantage as being intrinsic to the type ($\lambda_1 = 0$) or as being the result of having more resources ($\lambda_0^i = 0$) or in between. (It could also be the result of different preferences on non-monetary investments that we will ignore.)
- We have to specify 4 parameters (ν , λ_1 , and the two λ_0^i) in addition to the preference parameters that we have used (β , α).
- We do need a model of health investment to do this.

A model of health investment

- *Perpetual Youth* model with choice of consumption c_t and medical expenditure x_t
- Types i differ in resources and survival probability technology $\gamma^i(x)$. Actual survival is a combination of both.
- Health investment at t increases survival probability only at t .
- External (Internal) Life annuities: extra return on savings of $1/\gamma^i$
 - All individuals of type i are identical, so they make the same choices. Terms in red exist under the interpretation (that today we will ignore) of having annuities depend on own rather than aggregate behavior.
- Preferences

$$\sum_{t=0}^{\infty} \beta^t [\prod_{s=1}^{t-1} \gamma^i(x_s)] [\log c_t + \alpha]$$

- Budget constraint:

$$c_t + x_t + \gamma^i(x_t) a_{t+1} = a_t (1 + r)$$

Solving this model (what will the person do?)

$$V^i(a) = \max_{c, x, a'} \left\{ u(a(1+r) - x - \gamma^i(x) a') + \beta \gamma^i(x) V^i(a') \right\}$$

- The solution satisfies

$$u_c(c^i) = \frac{\beta \gamma^i(x^i) (1+r)}{\gamma^i(x^i)} u_c[(c^i)'] = \beta (1+r) u_c[(c^i)']$$

$$u_c(c^i) \left[1 + \frac{d\gamma^i(x^i)}{dx} a' \right] = \beta \frac{d\gamma^i(x^i)}{dx} V^i(a')$$

- Assume $\beta(1+r) = 1$. Then the solution is stationary ($a' = a$)

$$c^i = (c^i)'$$

$$(c^i)^{-1} = \left[\beta V^i(a') - \frac{a'}{c^i} \right] \lambda^i (x^i)^{-\nu} =$$

$$(c^i)^{-1} = \left[\frac{\beta (\log c^i + \alpha)}{1 - \beta (\lambda_0^i + \lambda_1 \frac{(x^i)^{1-\nu}}{1-\nu})} - \frac{a'}{c^i} \right] \lambda^i (x^i)^{-\nu}$$

Taking Stock: We have the following 4 equations

- Optimal Choices for both types

$$(c^i)^{-1} = \frac{\beta (\log c^i + \alpha)}{1 - \beta \left(\lambda_0^i + \lambda_1 \frac{(x^i)^{1-\nu}}{1-\nu} \right)} \lambda^i (x^i)^{-\nu}$$

- The values of life expectancy for both types

$$\gamma^i = \lambda_0^i + \lambda_1 \frac{(x^i)^{1-\nu}}{1-\nu}$$

- We can solve for the four unknowns in red using those equations.
- This tells us how easy is to transform money into health and how much of the differences in life expectancy are intrinsic to those groups.

An insight: ν can be identified independently

- If we rewrite the optimal choice condition and take the ratio between types, we obtain

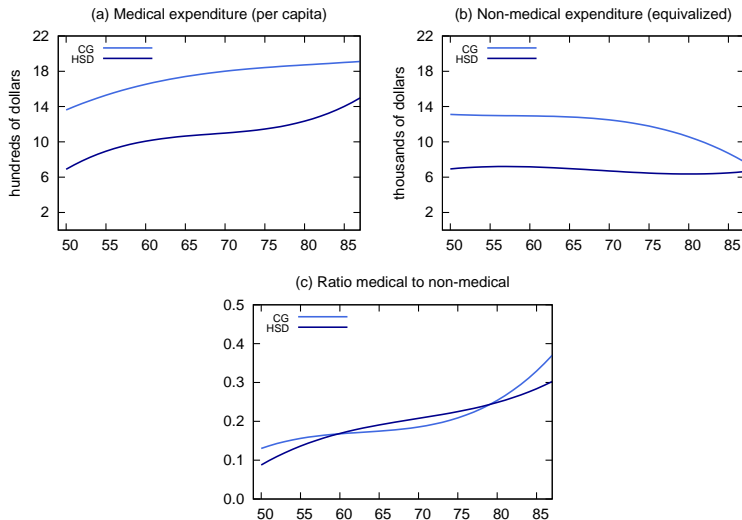
$$\frac{c_1}{c^i} = \frac{(\log c^i + \alpha) (1 - \beta \gamma_1)}{(\log c_1 + \alpha) (1 - \beta \gamma^i)} \left(\frac{x_1}{x^i} \right)^\nu$$

- The ratio $\frac{x}{c}$ for a given type gives us λ_1 .
- The observed live expectancies of each types give us λ_0^i of each type
- We are now ready to see what the data tells us

What we have in the data:

- PSID 2005-2013, white males aged 50-88
- Out of Pocket Medical Expenditures
 - hospital / nursing home
 - doctors
 - prescriptions / in-home medical care / other services
 - health insurance premia
- Non-medical expenditure
 - Non-durable goods and services in PSID 2005-2013
(*excluding education and medical*)

Let's look at the Data



Summarizing the Data

Inputs

	Coll Grad	Dropout	CG-Dr
Longevity at 50 (HRS)	81.9	75.6	6.3
Health Expenditures (PSID)	1,660	986	68.4%
Relative to Cons	0.1647	0.1526	7.9%

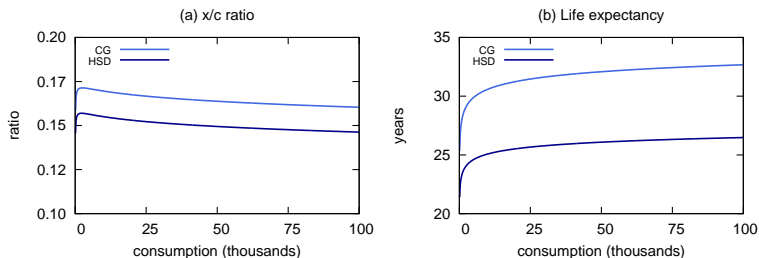
- The higher medical expenditures to consumption ratio for the college graduates confirms that indeed life duration is more important the richer people are.
- But not by a lot. So maybe money does not buy so much life expectancy.

Estimates

	College Grads	Dropouts
ν		1.13
λ_1		0.027
λ_0^i	0.976	0.969
γ	0.969	0.961

- The interpretation is that λ_0^i are the maximum life expectancy after 50 if all the money in the world was spent in trying to make it as big as possible.
 - College grads can make it to 91.4 on average under the best health care.
 - Dropouts can make it to 82.0 on average under the best health care.
- Most of longevity differentials cannot be fixed after 50 with money.

A picture of the health technology



- The ratio x/c declines (very mildly) with c : medical spending more a necessity than a luxury
- But higher types spend more because they have higher λ_0 , which makes health investments more profitable

Some Counterfactuals

Outputs			
	Coll Grad	Dropout	Diff w Coll G
Data	31.90	25.60	6.30
Dropouts \times as Coll Gr		26.02	5.88
College G \times as Dropouts	31.27		0.63

- Dropouts spending in health care as college graduates close 6.7% of gap.
- College graduates spending in health care as dropouts still have 90% of the actual gap.

The adjusted size of inequality

Welfare difference between types

	Due only to Cons.	Due to Cons. and Exogenous	With Choice of Health Investment
Education Bw Dr. & Coll	0.81	6.45	4.75
Wealth Between 1 & 5 Quint	0.51	2.91	

- Sizable but not enormous difference. The extra resources are spent so that consumption per year is 4.7 times larger and health investment expenditures per year are 4.4 times larger instead of all in consumption.
- Life expectancy of Dropouts goes up by 1 year closing about one sixth of the gap.

What about Health?

Taking Health into Account

- We have abstracted from differences in health across people, but
- We want to reassess our findings by looking at the role of investments that extend life via maintaining health.
- A natural way to proceed is to postulate that
 - Survival conditional on health h , depends on type (education) i , and health investments (x) to get $\gamma^i(x, h)$.
 - Health transitions also depend on health h , type (education) i , and health investments (x) to get $\Gamma_{h,h'}^i(x)$.

Some prior information restricts options

- Our earlier research ([Pijoan-Mas and Ríos-Rull(2015)]) showed that short term (two years ahead) survival only depends on self assessed health status and not on education type.

We take this to mean that

- 1 Survival conditional on health is sufficient and no type specific advantage exists.
 - 2 Investments in health care only affect the evolution of health and not survival. If it did, educated people with more resources would have invested more and got better outcomes, which they did not.
- Therefore we are left with an exogenous γ_h and a function $\Gamma_{h,h'}^i(x)$ where we observe the optimal choice.

A model with investments in health: Other Issues to Deal with

- 1 Complete markets: Annuities
- 2 Complete markets: State Contingent Markets
 - Guarantees stationarity.
 - Allows us to ignore issues of financial risks associated to health that are (likely) second order.
- 3 Again, market prices depend on aggregate, not individual behavior.
- 4 The budget constraint becomes

$$c + x + \gamma_h \sum_{h'} q_{h,h'}^i a'_{h'} = a(1 + r)$$

- 5 Equilibrium (zero profit) requires $q_{h,h'}^i = \Gamma_{h,h'}^i(x^*)$

A model with investments in health

Today we abstract from health affecting utility

- We write it already in recursive form

$$V^i(a, h) = \max_{c, x, a'} u(c) + \beta \gamma_h \sum_{h'} \Gamma_{h, h'}^i(x) V^i(a', h')$$

- With optimizing conditions (again assuming $\beta = 1 + r$) and noting that there are finitely many h

$$u_c(c_h) = u_c(c'_{h'}), \quad \forall h' \quad \rightarrow c_h = c'_{h'} \quad \forall h'$$

$$u_c(c_h) = \beta \gamma_h \sum_{h'} \frac{\partial \Gamma_{h, h'}^i(x)}{\partial x} V^i(a', h').$$

- With strict concavity in $\Gamma_{h, h'}^i$, we also get constant a' and x_h .

Characterizing

- Let's use again the utility function

$$\log c + \alpha$$

- Let's pose for simplicity two health levels $h = \{g, b\}$, and

$$\Gamma_{gg}^i(x) = \lambda_{0,g}^i + \lambda_{1,g} \frac{x^{1-\nu_g}}{1-\nu_g}$$
$$\Gamma_{bg}^i(x) = \lambda_{0,b}^i + \lambda_{1,b} \frac{x^{1-\nu_b}}{1-\nu_b}$$

- This technology requires estimating 8 parameters

$$\{\lambda_{0,g}^i, \lambda_{0,b}^i, \lambda_{1,g}, \lambda_{1,b}, \nu_g, \nu_b\}$$

Data that we use

- Preference Parameters: $\{\beta, \alpha\}$

- Expenditures in Health by Type and Health:

$$\{x_h^i\} \quad \text{for } h \in g, b, i \in \{C, D\}.$$

- Consumption data by type

$$c^i \quad \text{for } i \in \{C, D\}.$$

- Survival Probabilities by health:

$$\gamma_h \quad \text{for } h \in g, b.$$

- Actual Health Transitions by health today, health tomorrow and type:

$$\Gamma_{h,h'}^i \quad \text{for } h, h' \in g, b, i \in \{C, D\}.$$

We have 8 equations to solve for the 8 parameters

- The 4 observed health transitions for i and h .
- The 4 first order conditions for i and h

$$\frac{1}{c^i} = \beta \gamma_h \lambda_{1,h} (x_h^i)^{-\nu_h} (V_g^i - V_b^i)$$

- The only problem here are the 4 values for i and h , which are given by

$$V_h^i = u(c^i) + \beta \gamma_h \left[\Gamma_{h,h_g}^i (x_h^i) V_g^i + (1 - \Gamma_{h,h_g}^i (x_h^i)) V_b^i \right]$$

- But they are easily solved given the observed survival and transitions and consumptions

$$\begin{pmatrix} V_g^i \\ V_b^i \end{pmatrix} = \left[I - \beta \begin{pmatrix} \gamma_g & 0 \\ 0 & \gamma_b \end{pmatrix} \begin{pmatrix} \Gamma_{gg}^i & 1 - \Gamma_{gg}^i \\ \Gamma_{bg}^i & 1 - \Gamma_{bg}^i \end{pmatrix} \right]^{-1} \begin{pmatrix} u(c^i) \\ u(c^i) \end{pmatrix}$$

Using Algebra to Make things very simple

- Define

$$b_h^i = c^i (V_g^i - V_b^i)$$

- Then

$$\left(\frac{x_h^i}{x_h^1} \right)^{\nu_h} = \frac{b^h}{b^1}$$

Which permits us to identify independently ν_h

- Use optimization conditions to identify $\lambda_{1,h}$, for $h \in \{g, b\}$.
- Expressions for health transitions yield the $\lambda_{0,h}^i$ for i and $h \in \{g, b\}$.

Analysis

- How to compare welfare?
- At a given health level h the fraction of type i is μ_h^i .
- Then the Average value of type i is $V^i = \sum_h \mu_h^i V_h^i$
- We can compare without letting them choose how much extra consumption we have to give to the average people in type i (Dropouts) to be indifferent with type 1.

Findings

- Initial differences in health are large between college and dropouts.

$$\mu_g^c = .94 \quad \text{Coll Grads are in great health}$$

$$\mu_g^d = .59 \quad \text{Dropouts are not}$$

- Health matters a lot: Conditional on always having the same health

$$E_g = 82.8 \quad \text{Life duration if always in good health}$$

$$E_b = 69.5 \quad \text{Life duration if always in bad health}$$

- College transitions are better Health matters a lot: Conditional on always having the same health

$$\frac{\Gamma_{gg}^c}{\Gamma_{d_{gg}}} = 1.15 \quad \text{College are better at remaining in good health}$$

- Still need to adjust transitions, produce estimates of parameters compute counterfactuals and measure the Compensated Variation.
- But these preliminary numbers point to the fact that the welfare numbers remain large and that transfers late in life do not fix the large disparities.

Conclusions

- We have discussed how to incorporate life expectancy jointly with consumption to construct a measure of inequality.
- We have found vastly larger numbers than those associated to consumption alone.
- Even when taking into account the adapting behavior of people.
- In doing so, we have produced new estimates of a health production function. These numbers are preliminary so they will likely change somewhat.
- We need to have a tighter link between Demographics and Economics.

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