On the Optimal Distribution of Health Care Spending *

Preliminary Copy

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Laurence Ales
Carnegie Mellon University
ales@andrew.cmu.edu

Roozbeh Hosseini
Arizona State University
rhossein@asu.edu

Larry E. Jones
University of Minnesota
lej@umn.edu

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Abstract

How should society allocate health-care resources across individuals? In what ways is the current allocation of health-care inefficient? In this paper we study a model in which health status affects probability of survival and individuals are heterogeneous with respect to their labor productivity. We characterize the ex-ante efficient allocation with full information in this environment and show that heterogeneity in labor productivity introduces heterogeneity in level of health-care investment across individuals. More productive individuals should be healthier in order to survive longer and continue to contribute to output. This is socially optimal even if it is followed by complete redistribution of consumption resources. We compare the optimal allocation with what is observed in Medical Expenditure Panel Survey (MEPS). Although it is efficient to induce inequality in health-care expenditure, we find that the amount of health care inequality observed in the data is orders of magnitudes larger than what is implied by ex ante efficiency in our benchmark environment.

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1 Introduction

Health is perhaps the foremost contributor to ones happiness. It should not come at a surprise then, that societies have to confront themselves with two inevitable trade offs. First, how many resources should be allocated to health-care expenditures; second to whom allocate these resources. Policies that address these trade offs in one way or another have been at the forefront of policy debates for decades.[1] This paper contributes to this policy discussion by asking a simple question. How should society allocate resources for health expenditures across individuals?

This is without a doubt an ethically charged question with profound ethical implications. A possible approach in answering this question would be extending the approach of Rawls (1971) considering health care a *primary good*. The answer in this case would be simple, provide health resources as to maximize the welfare of the worse off individual. This answer - as noted by Arrow (1973) and Daniels (1985) - is however problematic. Using Arrow's language, it would condemn society to dealing with a "bottomless pit" in which an ever increasing amount of resources are diverted to the most ill individual. Daniels (1985) moves towards a characterization of a more desirable allocation of health-care. This is done by proposing an ad-hoc remedy to the Rawlsian-like approach: minimal levels of health expenditure. Our paper extends this approach by fully characterizing the allocation of health care across individuals both qualitatively and quantitatively. Our goal is to derive normative implications for health-care expenditure and compare this normative benchmark with what we observe in household level data in the United States.

We adopt the classical approach of welfare economics and consider how a central planner might allocate resources from an egalitarian (ex-ante) perspective. Without imposing additional restrictions the general normative implication of our model would be week: minimal positive levels of health expenditure for all individuals at all ages. We pursue instead a stark approach. We consider a formulation where health impacts the quality of life of an individual and reduces mortality risk as in Hall and Jones (2007). In our environment individuals are heterogeneous in their level of productivity and their ages. The central planner has complete information of individual's ability and age. In every period, conditional on such information he provides recommendation for amounts of work, consumption and health care. The amount of health-care received, besides affecting utility determines the probability of living until next period. The linkage between health-care and health status is provided by an age dependent function.

[1] For a recent example refer to Chairman Bernanke testimony before the committee on the budget, U.S. House of Representatives, on February 9, 2011. See: http://www.federalreserve.gov/newsevents/testimony/bernanke20110809a.htm

Our main theoretical result is that under all acceptable parameter configurations, society should devote more resources towards providing health care for individual with higher marginal productive value so long as they are not retired. The idea is simple, the planner allocates higher levels of health care to the highly productive since the opportunity cost of an hour of work from those types is higher to society.

Another result is that retired workers should receive the same amount of amount of health care independent of their productivity. Since at retirement the contribution of more productive and less productive to producing output is the same (namely they are both zero), there should not be any difference between them.

A key goal of the paper is to compare the normative implications with what is observed in US survey data. Our main data sources is the Medical Expenditure Panel Survey (MEPS) administered by the U.S. department of Health & Human Services. In the data we observe three main facts. First, inequality in health expenditure is large. In terms of log inequality it is roughly twice the inequality observed for income. Second, inequality in health expenditures decreases over the course of the working life. Third, consider the cross-section stratified by differences in observed productivity levels (quintiles of yearly income). In this case there are little aggregate differences in average health spending across groups. Only the very young -on average- appear to have a strong relation between income (this time yearly family income) and health expenditures.

We bring our model to the data estimating three key parameters. The flow utility value that any alive individual receives. The weight of health in the utility function and the degree of risk aversion on health expenditures. Levels of individuals productivity are determined directly from the population surveyed in MEPS. The estimation is conducted via method of moments using as targets the profile of average health expenditures and the aggregate levels of log-inequality over the course of the life-cycle. The model is capable of generating the decreasing pattern of inequality as in the data. Also, as in the data (and as expected from the theoretical result), more productive individuals receive higher level of health expenditure. However, this difference is significant only early in the life-cycle. The striking difference between data and model is in the level of inequality. It is possible for the model to replicate levels of inequality as we observe in the data, however these levels decrease at a much faster rate than what we observe in the data.

Our results have two main implications. First, reducing the large inequality we observe in the data can lead to a large welfare improvement. Our second implication speaks to the value that society assigns to the life of an individual. In Hall and Jones (2007) this value was taken from the department of transportation and was key in determining the growth rate of health expenditures over time.[2] Our estimated model provides an estimate for this value directly from the observed measure of inequality. The value observed is orders of magnitudes smaller than the ones commonly estimated by looking at individual actions.[3] Using current estimates of the *value of life* our model would generate almost no inequality in health expenditures.

Related papers

The paper closet to ours is Hall and Jones (2007). As in their paper the principle motivation for health care is to reduce mortality risk. Our paper can be seen as an extension of Hall and Jones (2007) in the cross-section. Hall and Jones (2007) focus on a representative agent formulation to derive normative implication for the overall spending on health care over time comparing with US aggregate data. We introduce heterogeneity and pursue the implication of the model comparing with household-level data.

Ozkan (2011) also looks at an environment similar to ours. The focus of the paper however, is in developing a positive description of household health care decisions. Health care expenditure pattern in his models are driven by wealth heterogeneity and moral-hazard-like market inefficiencies.

2 Data

Our main data source is the Household component of the Medical Expenditure Panel Survey (MEPS). Refer to Appendix A for details on this data set. Our data covers the years from 1996 to 2007. We drop individuals with total medical expenditures exceeding the 99.9 percentile (371 year-individual observations), with negative income (474 observation) and with not reported age (3603 observation). The following table summarizes the observation available for each year in our data

All variables are reported in 2005 dollars. All variables in the MEPS data set are deflated according to the recommended prices indices.[4]

3 Inequality in Health

We begin looking at measure of inequality. Our first look at the data is by looking at expenditure over age conditioning only on income quartile. In particular for each age group

[2] See http://ostpxweb.dot.gov/policy/reports/080205.htm.

[3] For a review refer to Viscusi and Aldy (2003) and Ashenfelter (2006).

[4] Refer to http://www.meps.ahrq.gov/mepswebabout_meps/Price_Index.shtml for additional information.

Year	Observations
1996	22,193
1997	33,767
1998	23,685
1999	24,359
2000	24,859
2001	33,218
2002	38,780
2003	33,891
2004	34,070
2005	33,578
2006	33,818
2007	30,681
Total	366,899

TABLE 1: Observations available per year in the MEPS data set after applying our sample selection.

we calculate the quartile ranges and assign each year observation in each category. The result are presented in Figures 1 and 2

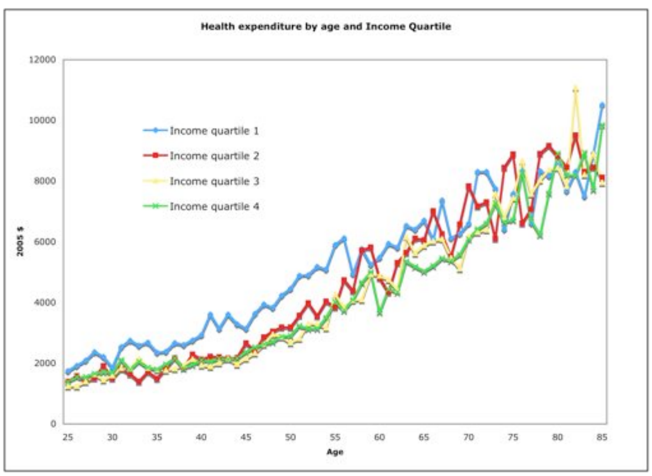

FIGURE 1: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual.

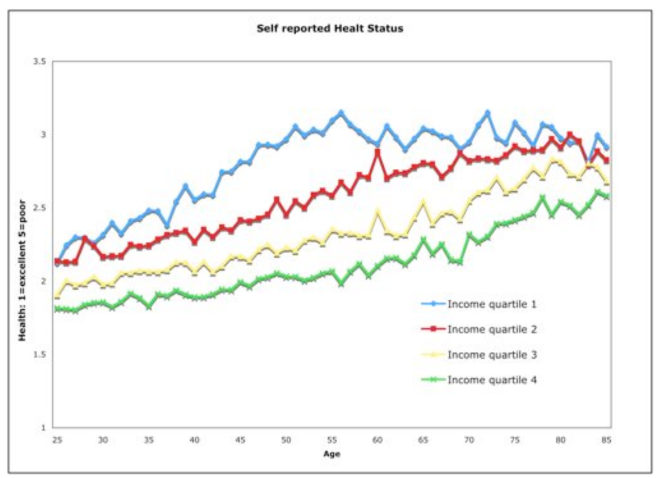

FIGURE 2: Self reported health status over age by income quartile. Lower income quartile number represent more income poor individual.

There is little difference in health expenditures between income groups. In addition it appears that the lowest income quartile spends more on health services early in life. However looking at this level of aggregation present an endogeneity problem. As we observe in Figure 2 the poorest income quartile is also the less healthy. The next set of figures conditions on health status together with income level. We look at 5 years intervals (average expenditures over 5 years) and we restrict our sample up to age 65. In the next section using RAND-HRS data we will focus on individual aged 50+. Results are in figures: 3, 4, 5, 6, 7.

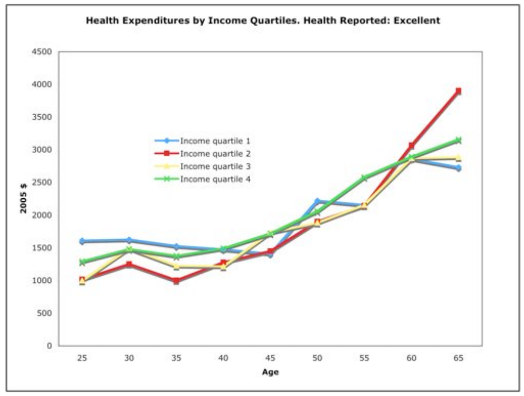

FIGURE 3: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: excellent.

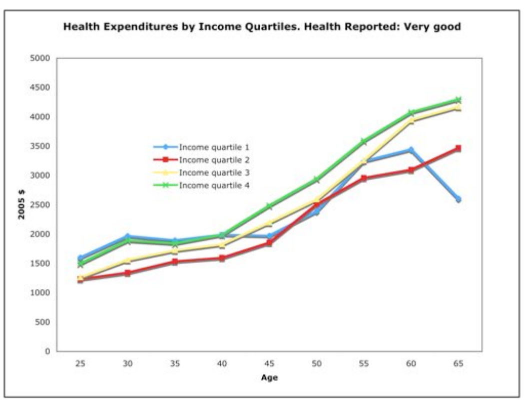

FIGURE 4: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: very good.

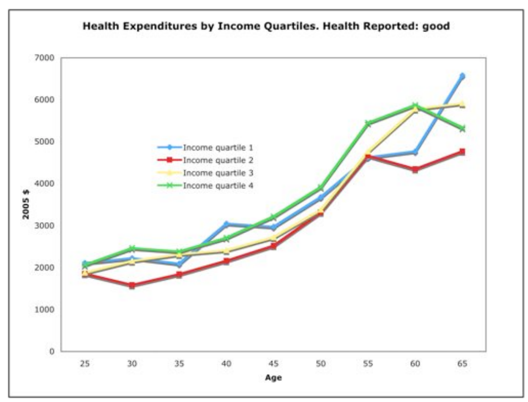

FIGURE 5: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: good.

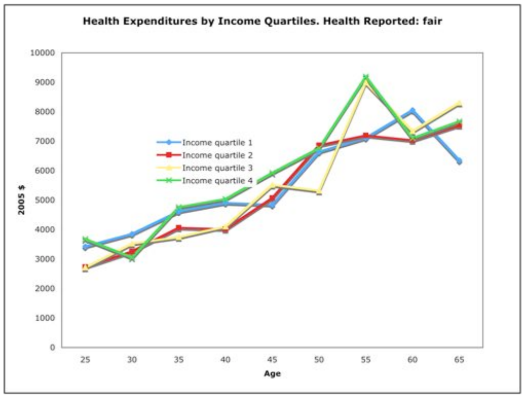

FIGURE 6: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: fair.

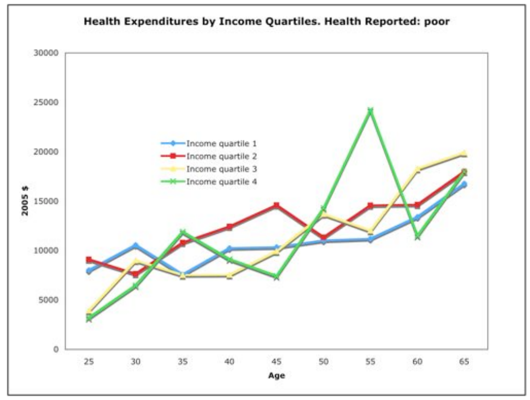

FIGURE 7: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: poor.

Once we condition on health we observe that on average individual on the highest income quartile spend more on health services than individual on the lowest Income quartile

3.1 The young and the retired

So far we have not displayed any information on health expenditures on individual aged 25 or younger. Since Income data of the individual is not available in most cases we next condition health expenditures by looking at family income. In particular using the MEPS family structure reported we construct income by family. We then divide the sample in family income quartiles. Results are in figures: 8, 9, 10, 11, 12.

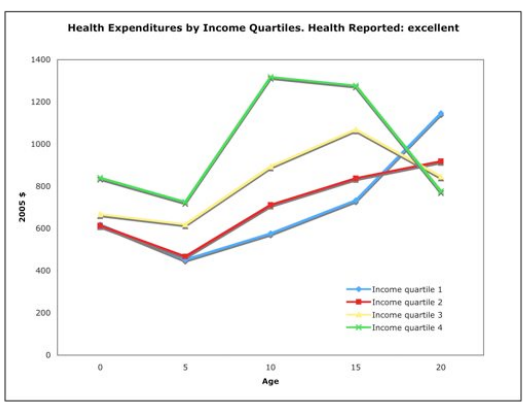

FIGURE 8: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: excellent.

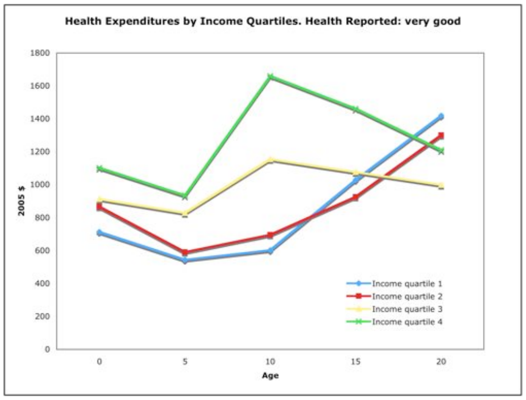

FIGURE 9: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: very good.

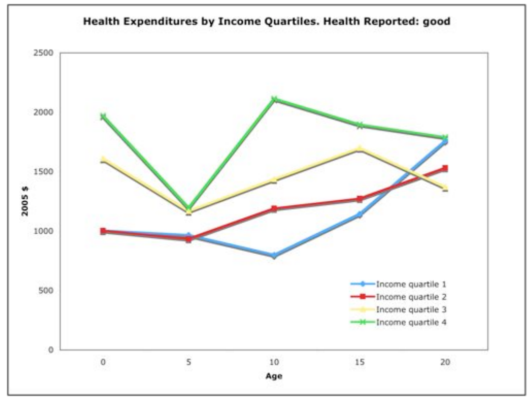

FIGURE 10: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: good.

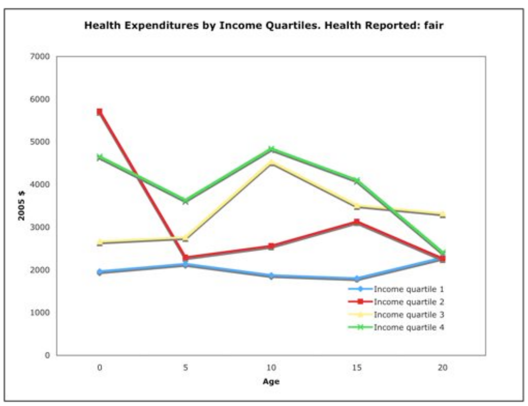

FIGURE 11: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: fair.

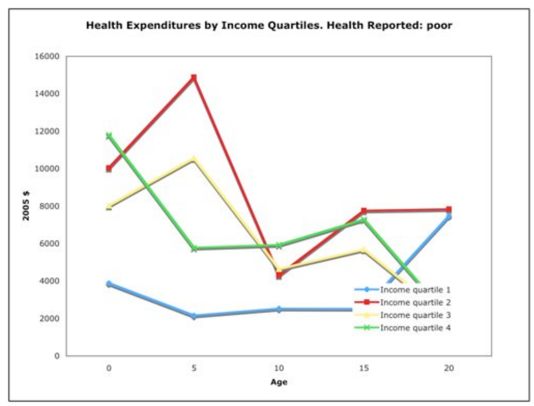

FIGURE 12: Health expenditure over age by income quartile. Lower income quartile number represent more income poor individual. Health reported: poor.

We now look at health expenditures as reported by the RAND-HRS data set. As before we group individuals into 5 years age groups. For these graphs we condition on total non housing wealth rather than income. Note also that information on health expenditures is not collected for all years in HRS interviews. We then restrict our time period from 1996 to 2002. We begin at looking at the entire cross section without conditioning on health. Note that as opposed to the previous graphs reported from MEPS the ones below are not weighted by populations weights. This is dues to the fact that HRS assigns a weight equal to 0 if the individual is in a nursing home.

The result is in Figure 13

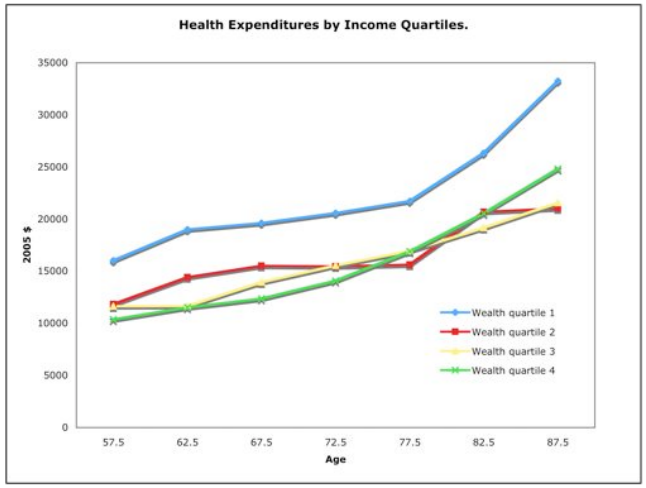

FIGURE 13: Health expenditure over age by wealth quartile. Lower wealth quartile number represent more income poor individual. Source: RAND-HRS

As we have done for the MEPS we now condition on health (the RAND-HRS uses the same descriptions for self reported health status.) Results are displayed in figures: 14, 15, 16, 17, 18.

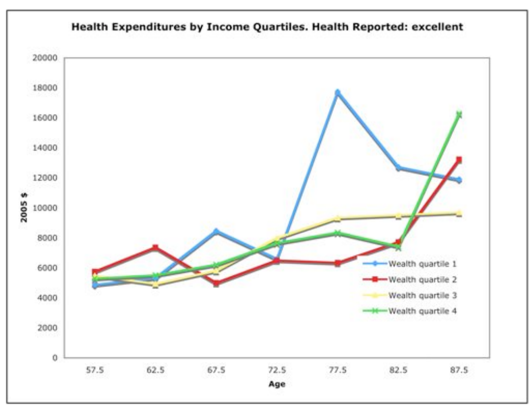

FIGURE 14: Health expenditure over age by wealth quartile. Source: RAND-HRS. Health reported: excellent.

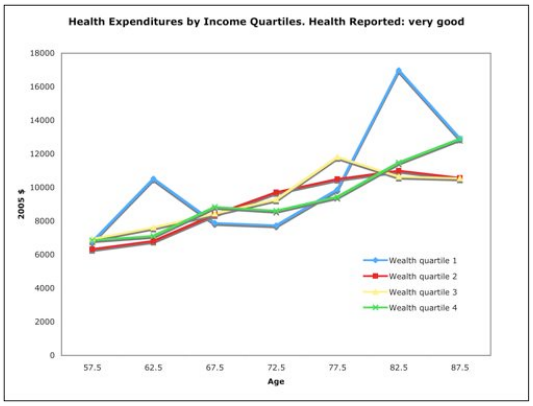

FIGURE 15: Health expenditure over age by wealth quartile. Source: RAND-HRS. Health reported: very good.

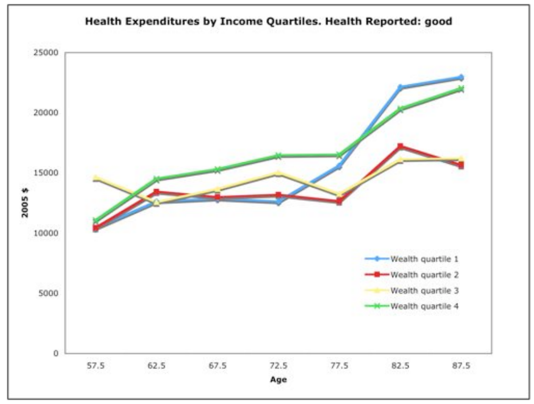

FIGURE 16: Health expenditure over age by wealth quartile. Source: RAND-HRS. Health reported: good.

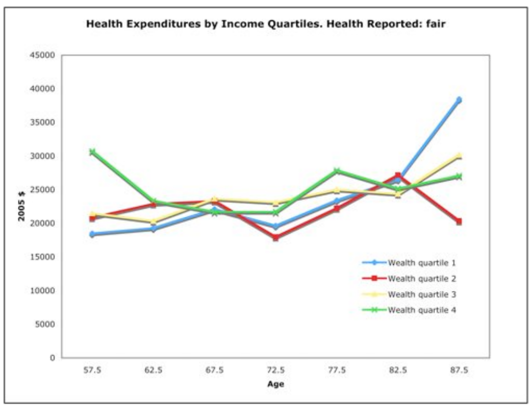

FIGURE 17: Health expenditure over age by wealth quartile. Source: RAND-HRS. Health reported: fair.

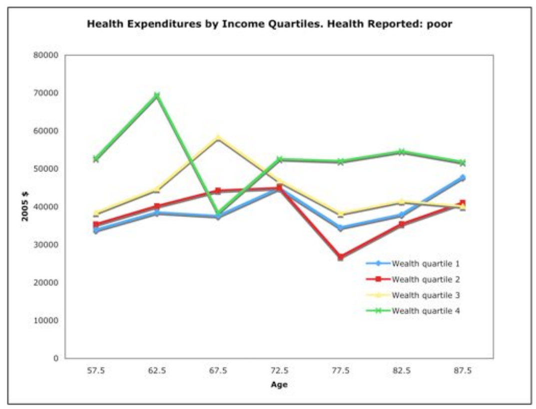

FIGURE 18: Health expenditure over age by wealth quartile. Source: RAND-HRS. Health reported: poor.

3.2 Total Inequality

Finally we look at the profile of inequality over the life-cycle focusing on log-expenditure in health services. Figure 19 displays the result for individuals with self reported health either excellent or very good:

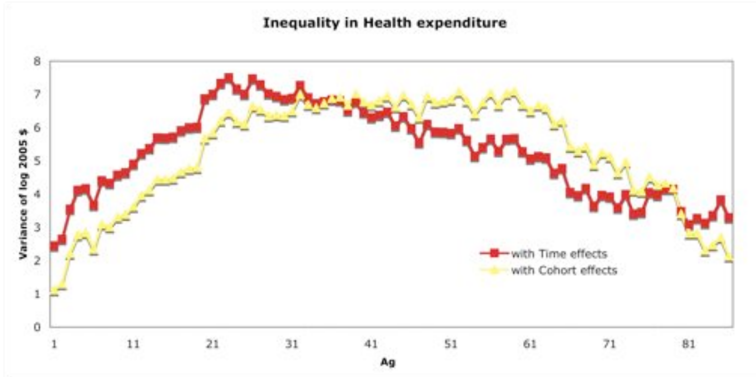

FIGURE 19: Age profile for inequality for log health expenditure. Cohort and time effects profiles. Data restricted for health above very good.

Both view on inequality: with either time or cohort effects feature a hump shape over the life-cycle. However within the time effects view, inequality reaches it's maximum and decreases at the beginning of the working life: 25 years. While in the cohort view, inequality reaches the maximum at the beginning of the working life but decreases only at the retirement age: 62 years.

4 A Dynamic Model of Health and Mortality

4.1 Environment

The environment we study is similar to Hall and Jones (2007). We depart from their setup in that we assume individuals are heterogeneous in their productivity and labor supply is endogenous. We also limit our attention to study the problem of one cohort. Next, We describe the details of the environment.

The economy is populated by a continuum of finitely lived workers divided into a finite number of types $\theta \in \Theta = \{\theta_1, ..., \theta_I\}$ of relative size $\pi(\theta_i)$. All workers are born at date zero and face the probability of death at the end of each age a. Following Hall and Jones (2007) we assume that survival rate depends on health status $x_a(\theta)$ at each age a for worker of type θ. The fraction of type θ workers who survive to age a is denoted by $N_a(\theta)$ and given by

$$\begin{aligned} N_{a+1}(\theta) &= P(x_a(\theta))N_a(\theta) \\ N_0(\theta) &= 1 \quad \text{for all } \theta \end{aligned}$$

$P(\cdot)$ is an strictly increasing and strictly concave function. The economy lasts for maximum of A periods and all workers die at the end of age A. Workers of type θ who are alive at age

a enjoy consumption $c_a(\theta)$ and work for $h_a(\theta)$ hours.

Definition 1 *An allocation-for workers who are alive- is the collection of maps*

$$c_a : \Theta \to \mathbb{R}_+ \quad 0 \leq a \leq A$$

$$h_a : \Theta \to [0,1] \quad 0 \leq a \leq A$$

$$x_a : \Theta \to \mathbb{R}_+ \quad 0 \leq a \leq A$$

$$N_a : \Theta \to [0,1] \quad 0 \leq a \leq A$$

Given an allocation $(c_a(\theta), h_a(\theta), x_a(\theta), N_a(\theta))$, preferences of worker of type θ is given by

$$\sum_{a=0}^{A} \beta^a N_a(\theta) u(c_a(\theta), x_a(\theta), h_a(\theta)).$$

Worker's type θ determines his productivity $y_a(\theta)$ at all ages. We assume there is an exogenous age of retirement a_{ret} such that $y_a(\theta) = 0$ for all age a_{ret}. Productivity is increasing in θ at all pre-retirement ages, i.e.

$$y_a(\theta') > y_a(\theta) \qquad \text{for all } a < a_{ret} \text{ and all } \theta', \theta \text{ such that } \theta' > \theta$$

A worker of type θ at age a who supplies h_a hours of work produces $y_a(\theta)h_a(\theta)$ units of output. Without loss of generality we assume Θ is ordered such that $\theta_{i+1} > \theta_i$ for all $i = 1, \ldots, I$.

There is a storage technology with fixed rate of return $R = 1/\beta$. The heath status $x_a(\theta)$ is produced by spending on health care. The health care spending required to achieve health status $x_a(\theta)$ is given by $g_a(x_a(\theta))$ where $g_a(\cdot)$ is strictly increasing and strictly convex and can potentially depend on age.

Definition 2 *An allocation* $(c_a(\theta), h_a(\theta), x_a(\theta), N_a(\theta))$ *feasible if*

$$\sum_{\theta} \pi(\theta) \sum_{a=0}^{A} \frac{1}{R^a} N_a(\theta) \left[c_a(\theta) + g_a(x_a(\theta)) - y_a(\theta)h_a(\theta)\right] \leq 0$$

$$\begin{aligned} N_{a+1}(\theta) &= P(x_a(\theta))N_a(\theta) \\ N_0(\theta) &= 1 \quad \textit{for all } \theta \end{aligned}$$

4.2 Full information ex ante efficient allocation

In this section we study the problem of a social planner who maximizes the ex ante welfare of individuals subject to a feasibility constraint. We will derive the properties of ex-ante efficient allocation. In particular we are interested to know how does the provision of health care and health status vary across different productivity types.

The planning problem can be written as the following

$$\max_{c_a(\theta),h_a(\theta),x_a(\theta),N_a(\theta)} \sum_{\theta} \pi(\theta) \sum_{a=0}^{A} \beta^a N_a(\theta) u(c_a(\theta), x_a(\theta), h_a(\theta))$$

subject to

$$\sum_{\theta} \pi(\theta) \sum_{a=0}^{A} \frac{1}{R^a} N_a(\theta) \left[c_a(\theta) + g_a(x_a(\theta)) - y_a(\theta) h_a(\theta)\right] \leq 0$$

$$\begin{aligned} N_{a+1}(\theta) &= P(x_a(\theta)) N_a(\theta) \\ N_0(\theta) &= 1 \quad \text{for all } \theta. \end{aligned}$$

Let the allocation $(c_a^*(\theta), x_a^*(\theta), h_a(\theta), N_a^*(\theta))$ be the solution to the planner's problem. In order to be able to derive analytical results on properties of the efficient allocation we make the following assumptions.

Assumption 1 *The per period utility function is always positive*

$$u(c, x, h) > 0 \quad \textit{for all } c, x, h.$$

Assumption 2 *The per period utility function does not depend of health status and is additive separable in consumption and leisure*

$$u(c, x, h) = u(c) + v(1 - h)$$

where $u', -u'', v', -v'' > 0$.

It immediately follows from assumption 2 that

$$\begin{aligned} x_A^*(\theta) &= 0 \quad \text{for all } \theta \\ c_a^*(\theta) &= c^* \quad \text{for all } \theta \text{ and all } a. \end{aligned}$$

Also, since $y_a(\theta) = 0$ for $a \geq a_{ret}$, we must have

$$h^*_a(\theta) = 0 \quad \text{for all } \theta \text{ and all } a \geq a_{ret}.$$

Furthermore, since there is no distortion in consumption-hours margin, we must have

$$\theta u'(c^*) = v'(1 - h^*_a(\theta)) \quad \text{for all } \theta \text{ and all } a < a_{ret}$$

which implies

$$h^*_a(\theta') > h^*_a(\theta) \quad \text{for all } \theta' > \theta \text{ and all } a < a_{ret}.$$

In the first proposition we show that after retirement all workers must have the same health status. The idea here simple. After retirement all workers enjoy the same amount of leisure and the do not contribute to production. The additive separability also implies that everyone receives the same consumption. Therefore, utility of each living retired person is the same at each age. There is no gain to planner from having more numbers of certain type survive to higher ages. On the other hand, the cost of producing health status is convex and its return in terms of increasing survival rate is concave. Therefore, it is preferred to the planner to have everyone survive to higher ages at the same rate. This means everyone should have the same health status.

Proposition 1 *Suppose per period utility function satisfies the assumptions 12. Let $x^*_a(\theta)$ be the solution to the planer's problem. Then*

$$x^*_a(\theta) = x^*_a(\theta')$$

for all θ and θ' and all $a \geq a_{ret} - 1$

Proof. We first show the claim must hold for $a = A - 1$. Suppose there are some type θ and θ' such that $x^*_{A-1}(\theta') > x^*_{A-1}(\theta)$. Then, $x^*_{A-1}(\theta)$ and $x^*_{A-1}(\theta')$ must be the solution to the following maximization problem

$$\max_{\hat{x}_{A-1}(\theta), \hat{x}_{A-1}(\theta')} \pi(\theta')N^*_{A-1}(\theta')P(\hat{x}_{A-1}(\theta')) + \pi(\theta)N^*_{A-1}(\theta)P(\hat{x}_{A-1}(\theta))$$

subject to

$$\pi(\theta)N^*_{A-1}(\theta)(g(\hat{x}_{A-1}(\theta)) - g(x^*_{A-1}(\theta)) + \pi(\theta')N^*_{A-1}(\theta')(g(\hat{x}_{A-1}(\theta')) - g(x^*_{A-1}(\theta')) = 0$$

Otherwise, they can be replaced by the solution of this problem. The resulting allocation will use the same amount of resources and increases the ex ante welfare (recall that consumption is the same for all types and workers do not work after retirement). The first order condition for this problem imply

$$\frac{P'(x^*_{A-1}(\theta))}{g'_{A-1}(x^*_{A-1}(\theta))} = \frac{P'(x^*_{A-1}(\theta'))}{g'_{A-1}(x^*_{A-1}(\theta'))}$$

but concavity of $P(\cdot)$ and convexity of $g_{A-1}(\cdot)$ imply

$$P'(x^*_{A-1}(\theta)) > P'(x^*_{A-1}(\theta'))$$

$$g'_{A-1}(x^*_{A-1}(\theta)) < g'_{A-1}(x^*_{A-1}(\theta'))$$

That is a contradiction.

Next suppose the claim is true for all ages $a+1, a+2, \dots, A$. We will show it must be true at age a. Again, suppose there are some type θ and θ' such that $x^*_a(\theta') > x^*_a(\theta)$. Note that the claim is true for all ages above a, therefore

$$\frac{N^*_{a'}(\theta)}{N^*_{a+1}(\theta)} = \frac{N^*_{a'}(\theta')}{N^*_{a+1}(\theta')} \qquad \text{for all } a' > a+1$$

$x^*_{A-1}(\theta)$ and $x^*_{A-1}(\theta')$ must be the solution to the following maximization problem

$$\max_{\hat{x}_a(\theta),\hat{x}_a(\theta')} \pi(\theta')N^*_a(\theta')P(\hat{x}_a(\theta')) \sum_{a'=a+1}^{A} \beta^a \left(\frac{N^*_{a'}(\theta')}{N^*_{a+1}(\theta')}\right) + \pi(\theta)N^*_a(\theta)P(\hat{x}_a(\theta)) \sum_{a'=a+1}^{A} \beta^a \left(\frac{N^*_{a'}(\theta)}{N^*_{a+1}(\theta)}\right)$$

subject to

$$\begin{aligned}
&\pi(\theta)\frac{1}{R^a}N^*_a(\theta)g_a(\hat{x}_a(\theta)) + \pi(\theta)N^*_a(\theta)P(\hat{x}_a(\theta)) \sum_{a'=a+1}^{A} \frac{1}{R^{a+1}} \left(\frac{N^*_{a'}(\theta)}{N^*_{a+1}(\theta)} g_{a+1}(x^*_{a+1}(\theta))\right) \\
&+\pi(\theta')\frac{1}{R^a}N^*_a(\theta')g_a(\hat{x}_a(\theta')) + \pi(\theta')N^*_a(\theta')P(\hat{x}_a(\theta')) \sum_{a'=a+1}^{A} \frac{1}{R^{a+1}} \left(\frac{N^*_{a'}(\theta')}{N^*_{a+1}(\theta')} g_{a+1}(x^*_{a+1}(\theta'))\right) \quad = \\
&\pi(\theta)\frac{1}{R^a}N^*_a(\theta)g_a(x^*_a(\theta)) + \pi(\theta)N^*_a(\theta)P(x^*_a(\theta)) \sum_{a'=a+1}^{A} \frac{1}{R^{a+1}} \left(\frac{N^*_{a'}(\theta)}{N^*_{a+1}(\theta)} g_{a+1}(x^*_{a+1}(\theta))\right) \\
&+\pi(\theta')\frac{1}{R^a}N^*_a(\theta')g_a(x^*_a(\theta')) + \pi(\theta')N^*_a(\theta')P(x^*_a(\theta')) \sum_{a'=a+1}^{A} \frac{1}{R^{a+1}} \left(\frac{N^*_{a'}(\theta')}{N^*_{a+1}(\theta')} g_{a+1}(x^*_{a+1}(\theta'))\right)
\end{aligned}$$

First order conditions imply

$$\frac{P'(x^*_a(\theta))}{g'_a(x^*_a(\theta)) + P'(x^*_a(\theta))} = \frac{P'(x^*_a(\theta'))}{g'_a(x^*_a(\theta')) + P'(x^*_a(\theta'))}$$

Or

$$\frac{1}{\frac{g_a'(x_a^*(\theta))}{P'(x_a^*(\theta))}+1}=\frac{1}{\frac{g_a'(x_a^*(\theta'))}{P'(x_a^*(\theta'))}+1}$$

and therefore

$$\frac{P'(x_a^*(\theta))}{g_{A-1}'(x_a^*(\theta))}=\frac{P'(x_a^*(\theta'))}{g_a'(x_a^*(\theta'))}$$

which again, is a contradiction.

■

Our next proposition establishes that more productive workers must have higher health status at all pre-retirement ages. Before we state and prove the result we write the planner's problem recursively.

Let k_a be the total (net) saving in the economy up to age a. Define the function $V_a(N_a(\theta_1), N_a(\theta_2), ..., N_a(\theta_I); k_a)$ as

$$V_a(N_a(\theta_1), N_a(\theta_2), ..., N_a(\theta_I); k_a) = \max \sum_{\theta} \pi(\theta) \sum_{a'=a}^{A} \beta^{a'-a} N_{a'}(\theta) \left[u(c_{a'}(\theta)) + v(1 - h_{a'}(\theta))\right]$$

subject to

$$\sum_{\theta} \pi(\theta) \sum_{a=0}^{A} \frac{1}{R^a} N_a(\theta) \left[c_a(\theta) + g_a(x_a(\theta)) - y_a(\theta) h_a(\theta)\right] \leq k_a$$

$$\begin{aligned} N_{a+1}(\theta) &= P(x_a(\theta)) N_a(\theta) \\ N_a(\theta) &\quad \text{given for all } \theta \end{aligned}$$

We can write the planner's problem as the following Bellman's equation

$$\begin{aligned} &V_a(N_a(\theta_1), N_a(\theta_2), ..., N_a(\theta_I); k_a) = \\ &\max \sum_{\theta} \pi(\theta) N_a(\theta) \left[u(c_a(\theta)) + v(1 - h_a(\theta))\right] + \beta V_{a+1}(N_{a+1}(\theta_1), N_{a+1}(\theta_2), ..., N_{a+1}(\theta_I); k_{a+1}) \end{aligned}$$

subject to

$$\sum_{\theta} \pi(\theta) N_a(\theta) \left[c_a(\theta) + g_a(x_a(\theta))\right] + k_{a+1} \leq R k_a + \sum_{\theta} \pi(\theta) N_a(\theta) y_a(\theta) h_a(\theta)$$

$$\begin{aligned} N_{a+1}(\theta) &= P(x_a(\theta)) N_a(\theta) \\ N_a(\theta) &\quad \text{given for all } \theta \end{aligned}$$

with $k_0 = 0$.

During the pre-retirement ages, more productive workers work more and produce more output. Therefore, there is an efficiency motive for planner to increase the number of more productive workers at each age. There is also an efficiency motive that counter act with that. Less productive workers enjoy more leisure. Everything else equal, planner prefers more of the less productive people around. However, the planner can always compensate loss of utils from having fewer of the less productive workers. In the next proposition, we show that planner always prefers to have fewer number of less productive worker and higher number of more productive worker. Since more productive workers produce more output. The planner can afford to have every works less and enjoys more leisure. This will compensate the loss of utils from having fewer of less productive workers.

Given that the higher number of more productive workers is desired, it is clear that the planner wants them to be healthier so that they survive to higher ages with higher probability.

The following proposition formalizes this argument.

Proposition 2 *Suppose per period utility function satisfies assumptions 1 and 2. Then*

1. *For all ages $a < a_{ret}$ and for all $\varepsilon > 0$, $(N_a(\theta_1), N_a(\theta_2), ..., N_a(\theta_I))$,*

$$V_a(N_a(\theta_1), ..., , N_a(\theta_i) - \varepsilon, ..., N_a(\theta_{i'}) + \tfrac{\pi(\theta_i)}{\pi(\theta_{i'})}\varepsilon, \ldots, N_a(\theta_I); k_a) >$$
$$V_a(N_a(\theta_1), ..., , N_a(\theta_i), ..., N_a(\theta_{i'}), \ldots, N_a(\theta_I); k_a)$$

   for all $\theta_{i'} > \theta_i$.

2. *For all ages $a < a_{ret} - 1$, and all all $\theta_{i'} > \theta_i$, $x_a(\theta_{i'}) > x_A(\theta_i)$.*

Proof.

We break the proof in two steps. In step 1, we establish the first part of the claim for $a = a_{ret-1}$. Then, in step 2 we show that if the claim is true in period $a + 1$, it must be true in period a and the second part of the claim must also hold.

Step1

Without loss of generality and in order to make notation easier to follow we present the proof for θ_1 and θ_I. Let $(c^*_a(\theta), h^*_a(\theta), x^*_a(\theta), N^*_a(\theta))$ and k^*_a be the solution to the planner's problem.

Consider the following perturbation in the distribution of types alive at age $a_{ret} - 1$.

$$\begin{aligned}
\tilde{N}_{a_{ret}-1}(\theta_1) &= N^*_{a_{ret}-1}(\theta_1) - \epsilon \\
\tilde{N}_{a_{ret}-1}(\theta_I) &= N^*_{a_{ret}-1}(\theta_I) + \frac{\pi(\theta_1)}{\pi(\theta_I)}\epsilon \\
\tilde{N}_{a_{ret}-1}(\theta) &= N^*_{a_{ret}-1}(\theta) \quad \text{for all other } \theta
\end{aligned}$$

Consider the alternative allocation $(\tilde{c}_{a_{ret}-1}(\theta), \tilde{h}_{a_{ret}-1}(\theta))$ such that

$$\begin{aligned}
\tilde{c}_{a_{ret}-1}(\theta) &= c^*_{a_{ret}-1}(\theta) \\
\tilde{h}_{a_{ret}-1}(\theta) &= h^*_A(\theta) \quad \theta = \theta_1, \dots, \theta_{I-1} \\
\tilde{h}_{a_{ret}-1}(\theta_I) &= \frac{N^*_{a_{ret}-1}(\theta_I)\pi(\theta_I)y_{a_{ret}-1}(\theta_I)h^*_{a_{ret}-1}(\theta_I) + \epsilon\pi(\theta_1)y_{a_{ret}-1}(\theta_1)h^*_{a_{ret}-1}(\theta_1)}{\left(N^*_{a_{ret}-1}(\theta_I)\pi(\theta_I) + \epsilon\pi(\theta_1)\right)y_{a_{ret}-1}(\theta_I)}
\end{aligned}$$

Note that $\sum_\theta \pi(\theta)\tilde{N}_{a_{ret}-1}(\theta)u(\tilde{c}_{a_{ret}-1}(\theta)) = \sum_\theta \pi(\theta)N^*_{a_{ret}-1}(\theta)u(c^*_{a_{ret}-1}(\theta))$. So we need to show $\sum_\theta \pi(\theta)\tilde{N}_{a_{ret}-1}(\theta)v(1-\tilde{h}_{a_{ret}-1}(\theta)) > \sum_\theta \pi(\theta)N^*_{a_{ret}-1}(\theta)v(1-h^*_{a_{ret}-1}(\theta))$ to establish the claim.

Note that

$$\begin{aligned}
\tilde{h}_{a_{ret}-1}(\theta_I) &= \frac{N^*_{a_{ret}-1}(\theta_I)\pi(\theta_I)y_{a_{ret}-1}(\theta_I)h^*_{a_{ret}-1}(\theta_I) + \epsilon\pi(\theta_1)y_{a_{ret}-1}(\theta_1)h^*_{a_{ret}-1}(\theta_1)}{\left(N^*_{a_{ret}-1}(\theta_I)\pi(\theta_I) + \epsilon\pi(\theta_1)\right)y_{a_{ret}-1}(\theta_I)} \\
&< \frac{N^*_{a_{ret}-1}(\theta_I)\pi(\theta_I)h^*_{a_{ret}-1}(\theta_I) + \epsilon\pi(\theta_1)h^*_{a_{ret}-1}(\theta_1)}{\left(N^*_{a_{ret}-1}(\theta_I)\pi(\theta_I) + \epsilon\pi(\theta_1)\right)} = \hat{h}_{a_{ret}-1}(\theta_I).
\end{aligned}$$

where $\hat{h}_{a_{ret}-1}(\theta_I)$ is the weighted average of $h^*_{a_{ret}-1}(\theta_1)$ and $h^*_{a_{ret}-1}(\theta_I)$.

Then,

$$\begin{aligned}
& \sum_\theta \pi(\theta)\tilde{N}_{a_{ret}-1}(\theta)v(1-\tilde{h}_{a_{ret}-1}(\theta)) > \sum_\theta \pi(\theta)N^*_{a_{ret}-1}(\theta)v(1-h^*_{a_{ret}-1}(\theta)) \\
= {} & (N^*(\theta_I)\pi(\theta_I) + \epsilon\pi(\theta_1))v(1-\tilde{h}_{a_{ret}-1}(\theta_I)) - \\
& N(\theta_I)\pi(\theta_I)v(1-h^*_{a_{ret}-1}(\theta_I)) - \epsilon\pi(\theta_1)v(1-h^*_{a_{ret}-1}(\theta_I)) \\
> {} & (N(\theta_I)\pi(\theta_I) + \epsilon\pi(\theta_1))v(1-\hat{h}_{a_{ret}-1}(\theta_I)) - \\
& N(\theta_I)\pi(\theta_I)v(1-h^*_{a_{ret}-1}(\theta_I)) - \epsilon\pi(\theta_1)v(1-h^*_{a_{ret}-1}(\theta_I)) \\
> {} & 0.
\end{aligned}$$

The last inequality follows from strict concavity of $v(.)$.

Step 2

Suppose for all $\varepsilon > 0$, $(N_{a+1}(\theta_1), N_{a+1}(\theta_2), ..., N_{a+1}(\theta_I))$,

$$V_{a+1}(N_{a+1}(\theta_1) - \varepsilon, ..., N_{a+1}(\theta_I) + \tfrac{\pi(\theta_1)}{\pi(\theta_I)}\varepsilon; k_{a+1}) >$$
$$V_{a+1}(N_{a+1}(\theta_1), ..., N_{a+1}(\theta_I); k_{a+1})$$

First we show that $x_a^*(\theta_1) < x_a^*(\theta_I)$. Let $(N_{a+1}^*(\theta_1), N_{a+1}^*(\theta_2), \ldots, N_{a+1}^*(\theta_I))$ and $(x_a^*(\theta_1), \ldots, x_a^*(\theta_I))$ be the solution given $(N_a(\theta_1), N_a(\theta_2), \ldots, N_a(\theta_I))$. Suppose $x_a^*(\theta_1) \geq x_a^*(\theta_I)$.

Consider the following alternative allocations

$$\begin{aligned}
\tilde{c}_a(\theta) &= c_a^*(\theta) \\
\tilde{h}_a(\theta) &= h_a^*(\theta)
\end{aligned}$$

$$\begin{aligned}
\tilde{N}_{a+1}(\theta_1) &= N_{a+1}^*(\theta_1) - \epsilon \\
\tilde{N}_{a+1}(\theta_I) &= N_{a+1}^*(\theta_I) + \frac{\pi(\theta_i)}{\pi(\theta_I)} \\
\tilde{N}_{a+1}(\theta) &= N_{a+1}^*(\theta) \quad \text{ for all other } \theta
\end{aligned}$$

$$\tilde{x}_a(\theta) = x_a^*(\theta) \quad \theta = \theta_1, \ldots, \theta_{I-1}$$

and $\tilde{x}_a(\theta_1)$ and $\tilde{x}_a(\theta_I)$ such that

$$\begin{aligned}
P(\tilde{x}_a(\theta_1) &= \frac{\tilde{N}_{a+1}(\theta_1)}{N_a(\theta_1)} = \frac{N_{a+1}^*(\theta_1)}{N_a(\theta_1)} - \frac{\epsilon}{N_a(\theta_1)} \\
P(\tilde{x}_a(\theta_I) &= \frac{\tilde{N}_{a+1}(\theta_I)}{N_a(\theta_I)} = \frac{N_{a+1}^*(\theta_I)}{N_a(\theta_I)} - \frac{\pi(\theta_1)}{\pi(\theta_I)}\frac{\epsilon}{N_a(\theta_I)}
\end{aligned}$$

Note that because $P(\cdot)$ is concave, we have

$$\begin{aligned}
P(\tilde{x}_a(\theta_1)) - P(x_a^*(\theta_1)) &= -\frac{\epsilon}{N_a(\theta_1)} > P'(x_a^*(\theta_1))(\tilde{x}_a(\theta_1) - x_a^*(\theta_1)) \\
P(\tilde{x}_a(\theta_I)) - P(x_a^*(\theta_I)) &= \frac{\pi(\theta_1)}{\pi(\theta_I)}\frac{\epsilon}{N_a(\theta_I)} > P'(x_a^*(\theta_I))(\tilde{x}_a(\theta_I) - x_a^*(\theta_I))
\end{aligned}$$

and therefore

$$\begin{aligned}
\tilde{x}_a(\theta_1) - x_a^*(\theta_1) &< -\frac{\epsilon}{N_a(\theta_1)P'(x_a^*(\theta_1))} \\
\tilde{x}_a(\theta_I) - x_a^*(\theta_I) &< \frac{\pi(\theta_1)}{\pi(\theta_I)}\frac{\epsilon}{N_a(\theta_I)P'(x_a^*(\theta_I))}
\end{aligned}$$

Next, we will show that $\sum_\theta \pi(\theta)N_a(\theta)g_a(\tilde{x}_a(\theta)) - \sum_\theta \pi(\theta)N_a(\theta)g_a(x_a^*(\theta)) < 0$. Note that

$$\begin{aligned}
& \sum_\theta \pi(\theta)N_a(\theta)g_a(\tilde{x}_a(\theta)) - \sum_\theta \pi(\theta)N_a(\theta)g_a(x_a^*(\theta)) \\
= \;& N_a(\theta_1)\pi(\theta_1)(g_a(\tilde{x}_a(\theta_1)) - g_a(x_a^*(\theta_1)) + \\
& N_a(\theta_I)\pi(\theta_I)(g_a(\tilde{x}_a(\theta_I)) - g_a(x_a^*(\theta_I)) \\
< \;& N_a(\theta_1)\pi(\theta_1)g'(x_a^*(\theta_1))(\tilde{x}_a(\theta_1) - x_a^*(\theta_1)) + \\
& N_a(\theta_I)\pi(\theta_I)g'(x_a^*(\theta_I))(\tilde{x}_a(\theta_I) - x_a^*(\theta_1)) \\
< \;& \epsilon\pi(\theta_1)\left(\frac{g'(x_a^*(\theta_I))}{P'(x_a^*(\theta_I))} - \frac{g'(x_a^*(\theta_1))}{P'(x_a^*(\theta_1))}\right) \\
\leq \;& 0
\end{aligned}$$

The first inequality follows from convexity of $g(\cdot)$, the second inequality comes from what we derived above (by replacing for $\tilde{x}_a(\theta_1) - x_a^*(\theta_1)$) and the last inequality follows from convexity of $g(\cdot)$, concavity of $P(\cdot)$ and our assumption that $x_a^*(\theta_1) \geq x_a^*(\theta_I)$.

This is a contradiction, because the alternative allocation uses less resources and gives higher utility to planner (because $V_{a+1}(N_{a+1}^*(\theta_1), \ldots, N_{a+1}^*(\theta_I); k_{a+1}^*) < V_{a+1}(N_{a+1}^*(\theta_1) - \epsilon, \ldots, N_{a+1}^*(\theta_I) + \frac{\pi(\theta_1)}{\pi(\theta_I)}\epsilon; k_{a+1}^*))$. Hence it must be true that $x_a^*(\theta_1) < x_a^*(\theta_I)$.

Now consider the following allocation

$$\begin{aligned}
\tilde{N}_a(\theta_1) &= N_a(\theta_1) - \epsilon \\
\tilde{N}_a(\theta_I) &= N_a(\theta_I) + \frac{\pi(\theta_1)}{\pi(\theta_I)}\epsilon \\
\tilde{N}_a(\theta) &= N_a(\theta) \quad \text{for all other } \theta
\end{aligned}$$

$$\begin{aligned}
\tilde{c}_a(\theta) &= c_a^* \quad \text{for all other } \theta \\
\tilde{x}_a(\theta) &= x_a^*(\theta) \quad \text{for all other } \theta \\
\tilde{h}_a(\theta) &= h_a^*(\theta) \quad \theta = \theta_1, \ldots, \theta_{I-1} \\
\tilde{h}_a(\theta_I) &= \frac{N(\theta_I)\pi(\theta_I)y_a(\theta_I)h_a^*(\theta_I) + \epsilon\pi(\theta_1)y_a(\theta_1)h_a^*(\theta_1)}{(N(\theta_I)\pi(\theta_I) + \epsilon\pi(\theta_1))\, y_a(\theta_I)}
\end{aligned}$$

Note that

$$\begin{aligned}\tilde{N}_{a+1}(\theta_1) &= P(x_a^*(\theta_1))(N_a(\theta_1)-\epsilon) = N_{a+1}(\theta_1) - P(x_a^*(\theta_1))\epsilon \\ \tilde{N}_{a+1}(\theta_I) &= P(x_a^*(\theta_I))(N_a(\theta_I) + \frac{\pi(\theta_1)}{\pi(\theta_I)}) = N_{a+1}(\theta_I) + P(x_a^*(\theta_I))\frac{\pi(\theta_1)}{\pi(\theta_I)}\epsilon\end{aligned}$$

From our assumption we know

$$\begin{aligned}& V_{a+1}(N_{a+1}^*(\theta_1),\ldots,N_{a+1}^*(\theta_I);k_{a+1}^*) \\ < \;& V_{a+1}(N_{a+1}^*(\theta_1) - P(x_a^*(\theta_1))\epsilon,\ldots,N_{a+1}^*(\theta_I) + \tfrac{\pi(\theta_i)}{\pi(\theta_I)}P(x_a^*(\theta_1))\epsilon;k_{a+1}^*) \\ < \;& V_{a+1}(N_{a+1}^*(\theta_1) - P(x_a^*(\theta_1))\epsilon,\ldots,N_{a+1}^*(\theta_I) + \tfrac{\pi(\theta_i)}{\pi(\theta_I)}P(x_a^*(\theta_I))\epsilon;k_{a+1}^*)\end{aligned}$$

since $x_a^*(\theta_I) > x_a^*(\theta_1)$.

Using similar argument that we used for problem in age $a_{ret}-1$ we can show that $\sum_\theta \pi(\theta)\tilde{N}_a(\theta)v(1-\tilde{h}_a(\theta)) < \sum_\theta \pi(\theta)N_a(\theta)v(1-h_a^*(\theta))$. Therefore the proof is complete.

■

So far we have established that the ex ante efficient amount of inequality is health is not zero. The society must treat more productive worker different that less productive workers while they are active. We also showed that all workers must enjoy the same health during their retirement age.

4.3 Adding private information

To be completed.

5 Estimation

To limit the effect of heterogeneity on inequality we drop the following observations.

Moments used in estimation

1. Variance of log health expenditure over the ages of 25 to 85.

2. Mean of log health expenditures over the ages of 25 to 85.

Parameters estimated: b flow of utility. α weight of health in utility function. γ curvature of health in utility function. Additional moments looked at

1. Mean of log income over the ages of 25 to 85.

Table 2: Observations dropped.

Criterion	Sampling selection
Missing health status	4062
Working more than 140 per week	28
Income less or equal zero	14945
Income above the 99.5 percentile	1010
Health expenditures less than \$50	36192
Final observations	165229

2. Variance of log income over the ages of 25 to 85.

5.1 Results

For these two cases below, discount factor and returns on capital are ($\beta = 0.983, R = 1.06$).

6 Hall and Jones (2007) benchmarks

In this case a period in the model is one year and everybody dies at 85. Productivity levels are matched to the observed income level in MEPS. Probability for each of the 7 types considered are determined to match inequality in income at age 25. The result for this case is shown in figure 6. No much difference with respect to the previous case. Provides a better match (almost by construction) for the income side.[5] For this case the value of life is equal to 339.143 \$. Hence in magnitude we are closer to the Hall and Jones (2007) values (3 million dollars)

6.1 Estimated Utility Function

In this section I let the parameters for flow utility (b), weight of health in utility function (α) and curvature of health in utility function (γ) be determined by matching aggregate moments. Key observation is that as b is too big in Hall and Jones. This also has drastic effects for the value of life.

[5] Inequality of income is not pinned down. For example if there is a very high mortality rate for unproductive individuals we observe average values increasing and inequality increasing.

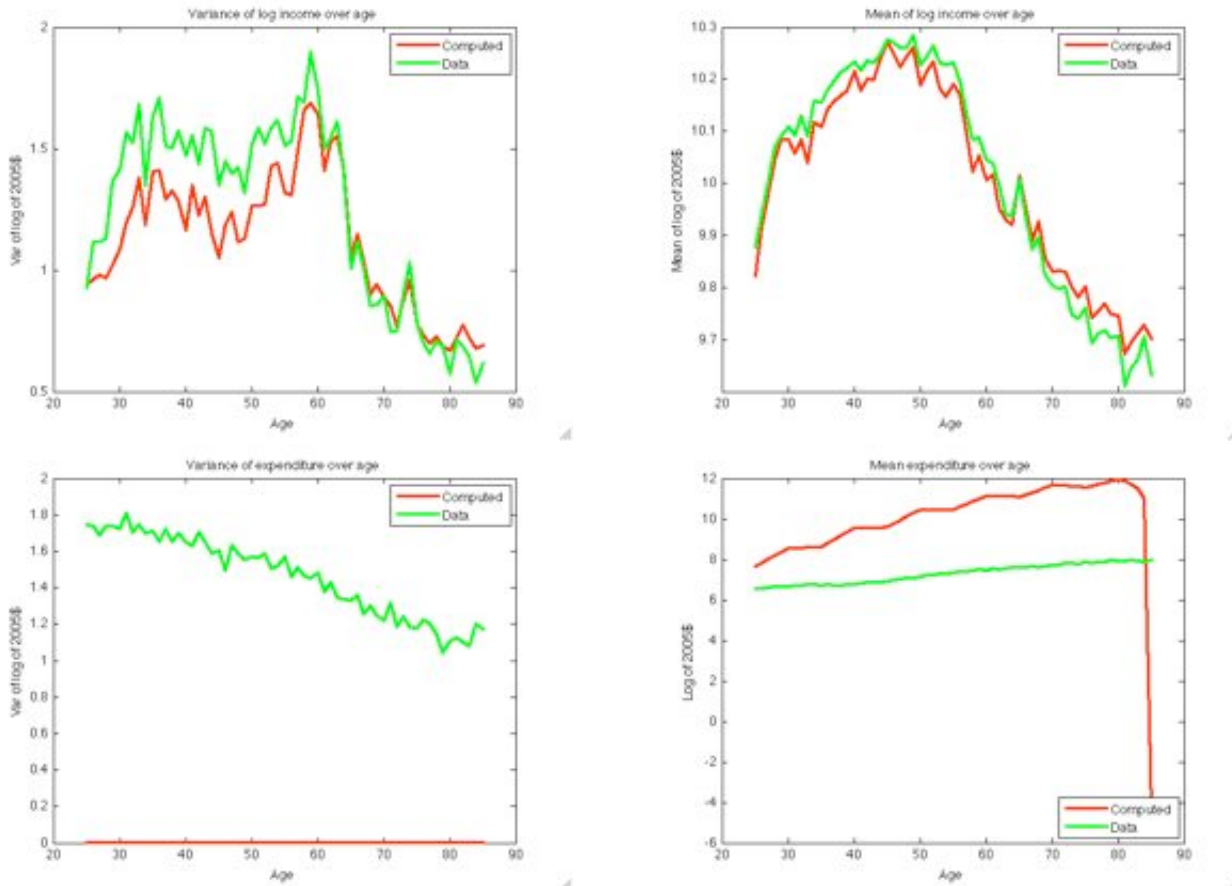

FIGURE 20: Benchmark calculation using Hall and Jones (2007) parameters ($b = 26, \alpha = 0, \sigma = 2$). And MEPS productivity values.

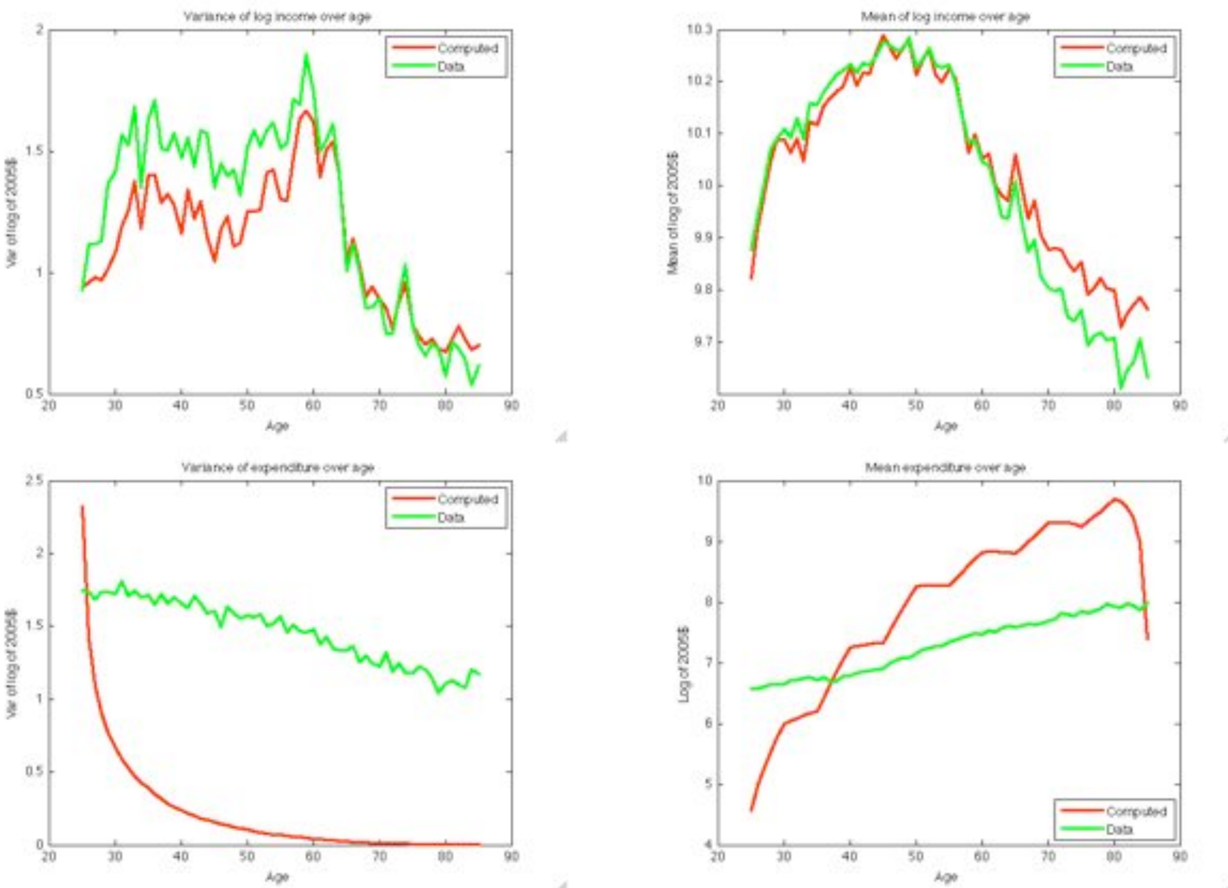

FIGURE 21: Estimated version ($b = 1.4433; \alpha = 1.8818; \sigma = 4.0133$) using MEPS productivity values.

In this case the discount factor as in Hall and Jones ($\beta = 0.983$). The estimation procedure is done by simplex search. The minimum was found for the following parameter values

$$b = 1.4433; \quad \alpha = 1.8818; \quad \sigma = 4.0133$$

As mentioned b must be way lower to generate inequality. Results are in figure 6.1. Inequality early in life can be matched quantitatively. Also inequality is decreasing over age as in the data. However inequality drops way faster that what we observe in the data. Clearly finite horizon problems are present. Large inequality in health expenditures causes unproductive agents to drop from the data hence average productivity is larger when old and overall inequality in income is lower over the life-cycle. In this case the value of life is -8.635 \$.

Conclusion

To be completed.

Appendix

A The MEPS Data set

The Medical Expenditure Panel Survey (MEPS) is a large-scale panel administered by the U.S. department of Health & Human Services since 1996. The panel is designed to be representative of the united states non institutionalized population. The data set collects information on what health services are used, how frequently are used, what is the expense incurred in using these services. The MEPS data is one of the main source for the National Health Expenditure Accounts (NHEA).

Our main source is the household component of the data set (MEPS-HC) this component is designed with an overlapping structure. Each household is interviewed 5 times over the course of 2 years. Roughly each wave contains roughly 30.000 individuals for a total of around 12.000 families. In each interview data is collected on demographic variables, income variables, hours worked, various measures of self reported health and specific questions on health conditions. In addition detailed information on health services usage charges incurred and expenditures (including out of pocket) on these services.[6] This data is complemented with information obtained by the individual's medical providers. In particular the following payment sources are included in the MEPS

1. Out of pocket by patient or patient's family;
2. Medicare;
3. Medicaid;
4. Private Insurance;
5. Veterans' administration;
6. TRICARE;
7. Other federal sources;
8. Other state and local sources;
9. Workers compensation;
10. Other unclassified sources (automobile, homeowner's,liability insurances)

[6] Note that information on over the counter medicines is not included in the MEPS definition of expenditures.

Each interviewed member is asked to self report it's health status (mental health status is collected separately) according to the following categories: excellent, very good, good, fair and poor. For each family in the sample frequency weights are provided. These weights are designed to make the MEPS consistent with the Current Population Survey.

B Comparison with Aggregate Data

We now determined how the the MEPS data set is aligned with the overall US population. We aggregate the variables in the data and compare with the NIPA aggregate data. Variable from aggregate US data are deflating using the correspective price index reported in Table 2.5.4 of the NIPA tables.[7] Figure 22 shows over time the relation between the total income in the MEPS data set and total compensation to employees as reported by NIPA Table 2.1 line 2. We observe that income in the MEPS overestimates aggregate income slightly.

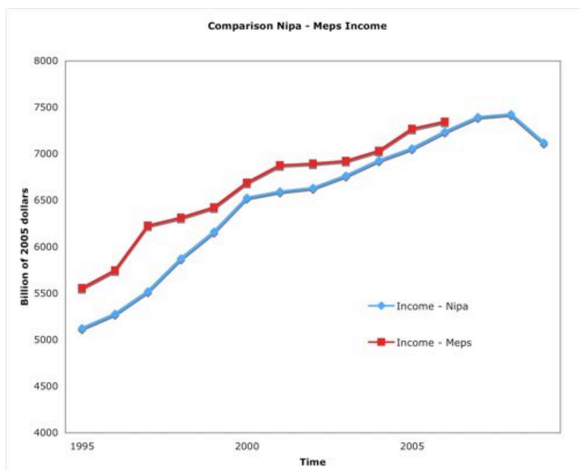

FIGURE 22: Relation between the total income in the MEPS data set and total compensation to employees from NIPA data.

Figures 23 and 24 focus on comparison on health expenditures. In particular Figure 23 compares total charges, expenditure reported in MEPS with aggregate data reported in NIPA table 2.3.4 line 16. Figure 24 compares expenditures in dental services and prescription medicines with aggregates reported by the NHEA.[8]

A striking feature of figure 23 is how the growth rate of charges for medical services is much higher than the growth rate of aggregate expenditures and expenditures reported in MEPS. The main observation is that MEPS data underestimates the levels of aggregate

[7]Refer to http://www.bea.gov/national/nipaweb/index.asp Table 2.5.4.
[8]Refer to https://www3.cms.gov/NationalHealthExpendData/.

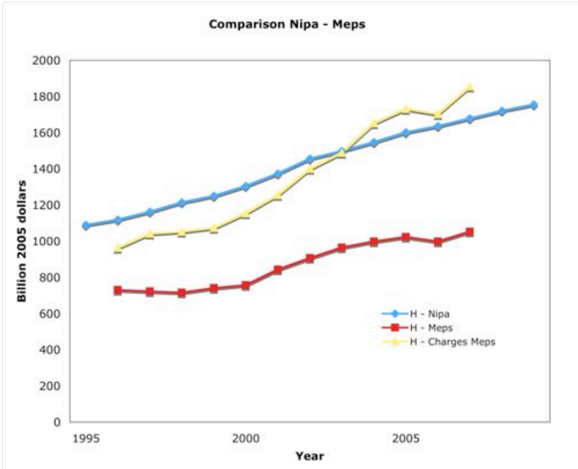

FIGURE 23: Relation between MEPS aggregated data on expenditures and charges and aggregate NIPA data.

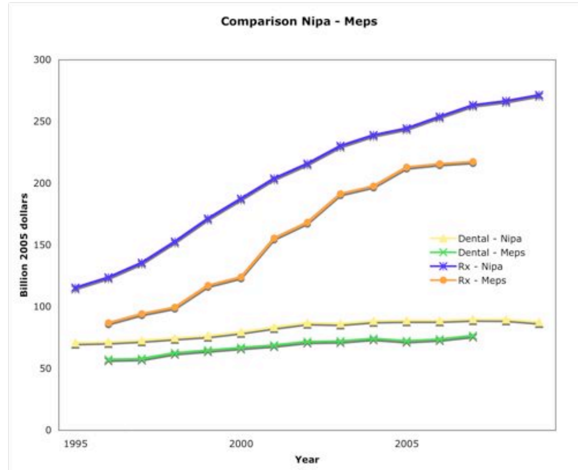

FIGURE 24: Relation between MEPS aggregated data on expenditures on dental services and prescription medicines and aggregate NHEA data.

data systematically. This is less severe in some service categories as shown in figure 24. This discrepancy is beyond usual discrepancy expected in survey data (due to under reporting and oversampling). Additional reason for lack of alignment between the two data sources is reported in in Selden, Levit, Cohen, Zuvekas, Moeller, McKusick, and Arnett (2001). The authors find that the discrepancy is due to the fact that MEPS does not report expenditure information relative to:

1. Construction and research;
2. Nursing homes;
3. Non-community, non-Federal Hospitals;
4. Government spending on health care not administered in hospitals (schools);
5. Alternative care;
6. Institutionalized population;
7. Expenditures of active duty military personnel;
8. Long term care in VA hospitals;
9. Foreign visitors to the United States;

In this paper we focus in inequality across ages and income levels of health care expenditures. Most of the above expenditure categories are beyond the scope of our model. However, the main source of bias in comparing expenditure between individuals is the lack of information from Nursing home. The next section looks at detail information on nursing home expenditures.

B.1 Nursing homes

To see the effect of lack of nursing home expenditures I look at expenditures over age. Figures 25 and 26 report data over age for years 1996 and 2004. The three lines reported are: aggregate NH EA data for total expenditures (the top line), aggregate expenditures from the MEPS (the bottom line). In addition I correct the MEPS data by adding the expenditures on nursing home over age reported by the NH EA. The result is the middle line. We observe how the discrepancy between NH EA and MEPS becomes significant after age 64. The main source of this discrepancy is due by the lack of nursing home data as shown by the middle line in both figures.

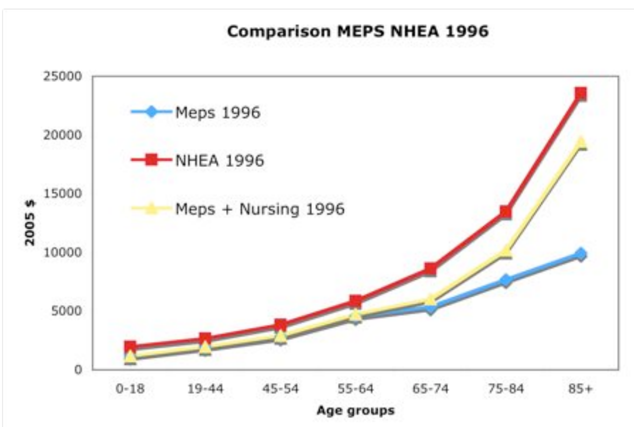

FIGURE 25: Aggregate data over age from NH EA and MEPS for year 1996.

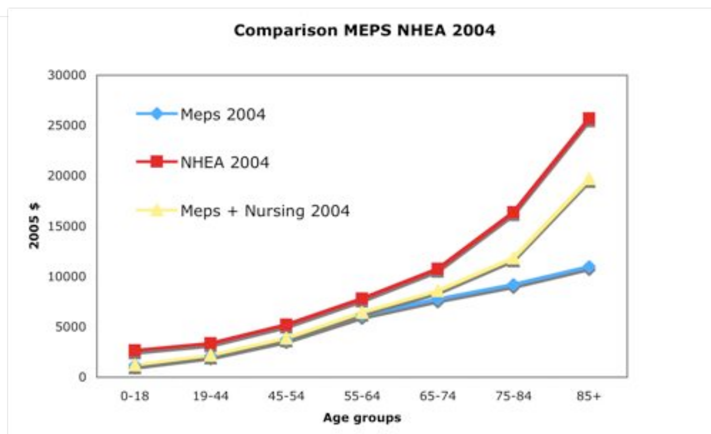

FIGURE 26: Aggregate data over age from NH EA and MEPS for year 2004.

The Health and retirement study reports data on health expenditures for individuals of age 50 an over (limited information on younger individual is due to spouses of younger age). We use the Health and retirement studies data formatted by the RAND corporation.[9] We use the same price indices as in the MEPS data and perform the same sample selection. Total observation are reported in Table 3.[10]

In Figure 27 we report what fraction of the population used nursing home facilities in

[9]Refer to http://www.rand.org/labor/aging/data prod/ for information. Also look at Yogo (2009) for an accurate description.

[10]Note that the HRS interviews households every two years asking information on the previous two years (not for the first wave).

Year	Observations
1992	12,652
1994	19,642
1996	17,991
1998	21,384
2000	19,579
2002	18,167
2004	20,129
2006	18,469
2008	17,217
Total	165,230

TABLE 3: Observations available per year in the RAND-HRS data set after applying our sample selection.

the previous 12 months. The figure is also reported by condition on 4 wealth quartiles for every age group. The measure of wealth used is non housing wealth.

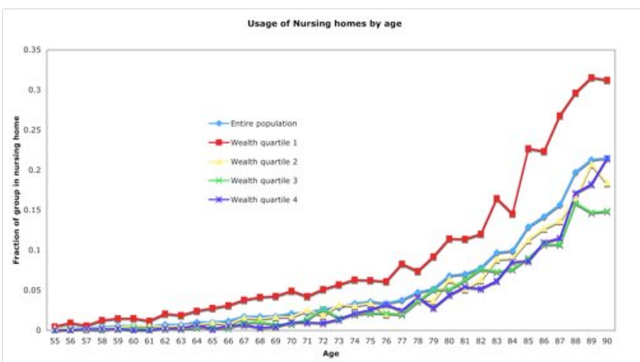

FIGURE 27: Percent of the population using nursing homes in the previous 12 months. Total and by wealth quartiles. Source: RAND-HRS

C Comparison with other expenditure data

As a final comparison for the MEPS we look at other sources that report comparable health expenditure measures. The consumer expenditure survey reports out of pocket expenditures incurred by households. Out of pocket expenditures do not include health insurance premiums. We use the CEX data set prepared by **?**.[11]. In table C and 5 we report comparisons between the calculation by Duetsch (2008), the MEPS and our calculation on the CEX.

[11]We use Sample A from http://www.economicdynamics.org/RED-cross-sectional-facts.htm

	Duetsch (2008)	MEPS	CEX
Income before taxes	$64,156	$58,707	$69,777
Age of reference person	59.3	59.1	58.3
Persons in reporting unit	2.1	2.15	2.26
Out of pocket	$1,825.64	$1,949.08	$2,213.32
Out of pocket on drugs	$712.73	$931.6	NA
Total expenditures	NA	$10,804.91	NA
Total charges	NA	$17,866.7	NA

TABLE 4: Comparison MEPS - CEX. Year 2005, age of reference person 55 to 64. For the MEPS we discard individual with negative reported family income, for the CEX, we discard individual that complete less than 4 interviews.

	Duetsch (2008)	MEPS	CEX
Income before taxes	$45,202	$45,953	$44,467
Age of reference person	69.1	69.2	69.1
Persons in reporting unit	1.9	1.85	1.7
Out of pocket[12]	$1,823.64	$2,158.4	$2,387.82
Out of pocket on drugs	$956.26	$1,225.9	NA
Total expenditures	NA	$12,553.39	NA
Total charges	NA	$24,094.83	NA

TABLE 5: Comparison MEPS - CEX. Year 2005, age of reference person 65 to 74.

C.1 Year and Cohort Effects

In this subsection we look at what are the aggregates effects on health expenditure due to the year of birth and year of interview. How the year of birth impact a moment will be called a Cohort effect. How the year of interview impacts a moment will be called Time effect. We follow the procedure described in Heathcote, Storesletten, and Violante (2005). The basic assumption is that moments calculated on the data are affected log-linearly by the year of birth or year of interview. Hence to determine the age profile of a moment free of Cohort effects (denoted in the graphs as "with Cohort effects") we will run a linear regression on the moment using a complete set of dummies on age and year of birth. The moment itself will be calculated on the logged value of the data. The graphs will display the coefficients on age of this linear regression.[13]

[13] As in Heathcote, Storesletten, and Violante (2005), we normalize the coefficients to match the unconditional average of the corresponding cross sectional moment.

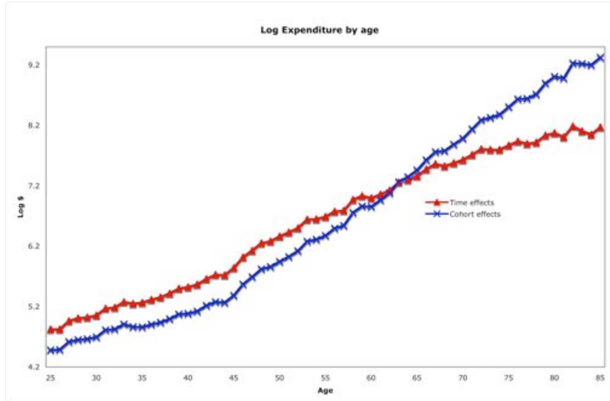

FIGURE 28: Age profile for log health expenditure. Cohort and time effects profiles.

In figure 28 we report the average expenditure over age looking at both cohort and time effects. The profile with cohort effects displays a larger growth rate versus the profile with time effects. The profile with time effects displays no significant difference with the unconditional moment. We next look at the effect of cohort and time effect on inequality.

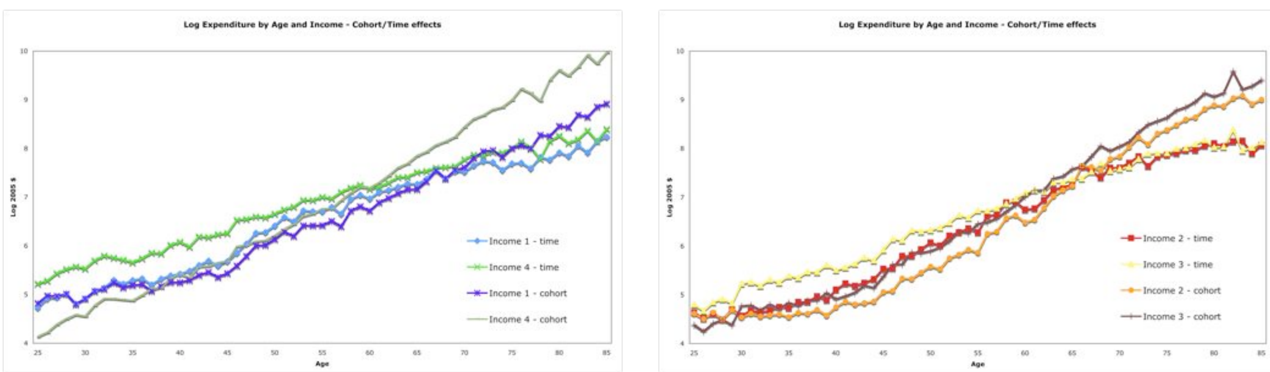

FIGURE 29: Inequality in log expenditure over age by income quartile. Lower wealth quartile number represent more income poor individual. Cohort and time effects profiles.

Figure 29 displays inequality in health expenditure as in figure 1: without conditioning on self reported health status. As in the previous picture case effects do not impact significantly relative to the unconditional moment. A key observation is that taking the average log-expenditure versus directly the average expenditure –as in figure 1– makes clear that more income rich individual spend more across the life cycle. This is due to the non linear log-transformation that puts less weigh on the right hand side of the expenditure distribution. In addition cohort effects increase the growth rate of expenditures versus time effects. This might cause more income poor individual to spend more in health services early in life.

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