Aspirations, Health and the Cost of Inequality*

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Aug 2016

Abstract

How does inequality motivate people and at what cost? In a model of perpetual youth, people have heterogeneous upward-looking aspirations. They value their consumption relative to the conditional mean of those above them in the distribution; their survival depends on health capital produced from time investment and health goods. Higher fundamental inequality, working through the aspirations gap, motivates people to work and save more. Economic outcomes improve but income and consumption inequality worsen because the poor have less capacity to respond. By diverting resources from health production, aspirations also worsen mortality, especially for the poor. Though relative income has a strong negative effect on personal health, inequality has a weak effect on population health, explaining an empirical puzzle on the relative income and health gradient.

Keywords: Inequality, Aspirations, Consumption externality, Health, Grossman model, Relative income and health gradient, Heterogeneous agents
JEL Classification: D31, D91, I14, J20

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1 Introduction

We often care about inequality not for its functional consequences alone, but directly, because of what it means for our relative position in society. This may be due to rivalry with others who are doing economically better, ego rents from being perceived as more successful, or the information that relative position reveals about what it takes to succeed. Positional concerns, in turn, affect our well-being. If they motivate us to work harder or invest in the future, our economic lives improve. Conversely, personal health may decline if a loss of social status triggers a behavioral change or biochemical response from stress, feelings of inadequacy and failure.

This paper deals with how inequality motivates people and at what cost. The idea that inequality can be motivating is most widely associated with Friedman (1962) and underlies Okun's (1975) influential work on the equity-efficiency tradeoff. It has gained currency in policy circles yet received sparse systematic treatment in the academic literature. We show that if inequality motivates the rich as well as the poor, equilibrium inequality may well worsen.

The very different view, that inequality is costly because it directly and adversely affects health, originates with the work of Marmot (1986), Elstad (1998) and especially Wilkinson (1992, 1996) in the social epidemiology and public health literatures. This relative income gradient has been the subject of vigorous debate and conflicting evidence. We identify a behavioral channel through which relative position aggravates personal health and show how this explains the weak aggregate relationship between inequality and population health in the data.

Our framework is a life-cycle economy with heterogeneous ability and upward-looking aspirations. People pursue the consumption standards of those who are better off than them. In an effort to catch up, they work more (higher present consumption) and save more (higher future consumption). Their motivation to do so depends on how far they fall below their aspirations: the poor face a larger aspirations gap and respond more to relative position. Inequality, independently of absolute income, has a first-order welfare effect in this environment. Since the poor are already extended on the labor market, they have less room to raise labor supply. Despite perfect capital and insurance markets, this limited capacity worsens consumption and income inequality even as everyone is economically better off from aspirations.

Aspirations have health consequences too. The survival rate depends on health capital produced from time investment and complementary health goods, a synthesis of Blanchard (1985) and Yaari (1965) with Grossman (1972a). Stepping up labor supply comes at the cost of less discretionary time available for health production.[1] Likewise the greater emphasis on consumption and saving means a lower propensity to spend on health goods. Therefore, higher relative

[1] This response should be interpreted generally, not just working longer hours but taking on multiple jobs or branching into occupations that compensate better but have harsher work environments.

deprivation – equivalently higher aspirations gap – from higher fundamental inequality lowers life expectancy. Health production suffers across the distribution, more so among the poor who are worse off in relative terms.

This link between inequality and health marks the first contribution of our paper as it resolves an empirical puzzle – the conflicting micro- and macro-level evidence on health and inequality. Social epidemiologists often cite evidence on mortality and income inequality in the OECD to claim that, distinctly from the effect of absolute income, income inequality itself has a first-order negative effect on individual and population health. This and similar claims on the *relative income gradient* based on aggregate statistics are not robust to careful empirical analysis; the negative association between inequality and population health is weak at best. Disaggregated data, nonetheless, paint a clear and compelling picture: relative position in society and measures of relative deprivation consistently and negatively predict household health, controlling for absolute income.

In our model it is *because* households strongly respond to inequality under aspirations that the aggregate relationship between inequality and health is weak. Aspiration lowers the marginal propensity of health investment. Income gains are disproportionately allocated towards consumption spending and wealth accumulation, flattening the gradient between aggregate health and income. A mean preserving spread in household income – higher inequality – hence has a smaller negative effect on aggregate health. Other factors such as economic growth and medical innovations also weaken the aggregate relationship over time as they relax constraints on health investment in poorer households.[2] In other words, the absence of a strong relationship between inequality and population health should not be taken to imply that inequality has no direct and adverse health effects. If we care about the social cost of inequality, distributional measures such as the life expectancy gap or health Gini are more informative than an aggregate measure such as population life expectancy.

A second contribution of this paper is to further our understanding of aspirations and inequality beyond the naïve Friedman-Okun hypothesis. Much of the existing "Keeping Up with the Jones" (KUWJ) literature focuses on representative agents who aspire to a common standard of living, for instance, average consumption or wealth. Under this common aspiration there is no scope to identify differential effects across the distribution or to study the effect of aspirations on equilibrium inequality. In our model, not just the poor, the rich too are motivated by upward-looking aspirations. This introduces two additional margins. The ability of the rich to more strongly respond to aspirations through labor and capital supply tends to worsen

[2] The model deals with an observable behavioral response to aspirations and inequality. It does not formalize, in particular, the biochemical pathways that link loss of self-esteem and social status to ill health.

Nothing in our analysis suggests that relative income is a stronger determinant of health compared to absolute income. In fact it is because of the latter than economic growth undoes the adverse health effects of inequality.

economic inequality. Attenuating this is the superior good nature of health spending: the rich invest more of their marginal income on health rather than wealth.

A third contribution of this paper is methodological. To the best of our knowledge this is the first paper to analyze a Ramsey-type economy with endogenous and heterogeneous aspirations. The analytical complexity of this framework is resolved through quantitative work focused on the stationary distribution. We build on the consumption-based common-aspirations literature, including Abel (1990), Gali (1994), Alonso-Carrera *et al.* (2005, 2007), García-Peñalosa and Turnovksy (2008) and Barnett *et al.* (2010).[3] That aspirations are formed with respect to consumption implicitly assumes that some forms of spending like housing, cars, schools are informative about a household's living standards and generate envy among its neighbors and social circle.[4] Among more recent works, Genicot and Ray (2010) provide a helpful typology of social aspirations and show how common and stratified aspirations over a dynasty's future consumption lead to long-run polarization. Polarization does not occur in our model because the utility loss from aspirations failure is assumed to be concave instead of logistic. Finally this paper is related to the recent literatures on status-seeking and preference externality (e.g., Alvarez-Cuadrado and Long (2012), Corneo and Jeanne (1998), Kawamoto (2009), Lubik and Teo (2014), Suen (2014)),[5] and health production in an optimizing framework (e.g., Bhattacharya and Qiao (2007), Chakraborty *et al.* (2010), Goenka *et al.* (2014), Suen (2014)).

The next section discusses the evidence on relative income and health and analyzes a static model to illustrate how aspirations can explain the data. Section 3 studies the household's decision problem in a more general intertemporal model. Using quantitative work, section 4 digs deeper into aspirations, health and inequality at the individual level while section 5 studies the full equilibrium. Section 6 concludes.

2 Evidence and Theory

2.1 An Empirical Puzzle

A central theme in the literature on public health and epidemiology is the health effect of inequality – the relative income gradient – that operates independently of the absolute income

[3] García-Peñalosa and Turnovksy (2008) study heterogeneous aspirations in the Ramsey model to identify a preference specification for which the aggregate behavior does not depend on the distribution of aspirations. The aspirations, however, are posited to be exogenous individual-specific proportions of mean consumption.

[4] In the model distributional rank in and of itself is not valued by individuals for the simple reason that rank is hard to ascertain and value unless it leads to observable outcomes. In other words, people care about their relative position only to the extent that it reveals something about their relative standard of living, consumption being one measure. See also footnote 10.

[5] Some in this literature use relative wealth or income or a signaling good to model status seeking.

gradient that economists typically study. This focus owes much to the work of the social epidemiologist Richard G. Wilkinson who in a series of papers and monographs (Wilkinson, 1992, 1996, Wilkinson and Pickett, 2009) advanced the hypothesis that inequality has an adverse effect on individual and population health because of psycho-social causes, that inequality is, in and of itself, a health hazard (Deaton, 2001)

There is no correlation between life expectancy and GDP per capita across the OECD, for example, but a distinct negative relationship between life expectancy and inequality according to Wilkinson (1996) and a positive relationship between gains in life expectancy and gains in the income share of the poorest 60% according to Wilkinson (1992). The correlations are interpreted causally. Specifically, it is argued that social circumstances such as loss of self esteem, balance between work and home or loss of control over one's life in more unequal societies trigger behavioral and bio-chemical responses that heighten the risk of heart disease, cancers and other ailments. The particular psycho-social pathways are identified from other studies. Biologist Robert M. Sapolosky's work on primates is frequently cited as illustrating how social dominance, over time, causes physiological responses that can permanently elevate health hazard in humans (Wilkinson, 1996, ch 10). Similarly the Whitehall studies on British civil servants have found a strong inverse correlation between position in the administrative hierarchy and mortality rate. Mortality rate for men in the lowest administrative grade was three times higher than that for men in the highest grade, only a third of which is explained by the effect of income on health choices, the remainder presumably by the direct effect of relative position or inequality (Marmot, 1986, Smith *et al.*, 1990, Wilkinson and Pikett, 2009).[6]

The "Wilkinson hypothesis" has fundamentally influenced the public health debate on how to address health inequalities (Subramanian and Karachi, 2004). But barring notable exceptions such as Deaton (2001) and Eibner and Evans (2005), it has received little attention from economists researching health and inequality. A primary concern is surely identification, particularly when working with aggregate statistics. Setting that aside – for a compelling case would require a "natural experiment" that alters relative income while preserving own income – several other concerns have been voiced. First, Wilkinson's assertion of causality based on the aggregate data has been questioned right from the beginning. Suppose that the survival rate depends on household income through a positive and concave gradient. By Jensen's inequality, a mean-preserving increase in income dispersion would worsen a poorer household's health more than it improves a richer household's, that is, average or population health would worsen.

[6]Not all of the evidence Wilkinson cites neatly fit this mold. For example the negative effect of unemployment (Wilkinson, 1996, pp. 177-178) or natural disasters (p. 180) on subsequent mortality can be easily understood through the conventional income channel. Partly because of this, and partly because an economic model has little to say about automated biochemical responses to relative position, we focus exclusively on behavioral responses, the social half of Wilkinson's psycho-social hypothesis.

Gravelle (1998), therefore, questions whether a negative correlation between measures of inequality and aggregate health says anything about causality. More pointedly, a negative correlation is entirely consistent with the *absolute income* and health gradient.

A second problem is the robustness of the evidence. Judge (1995) reports that Wilkinson's original findings do not hold up to subsequent data and more careful methodology. While Kaplan *et al.* (1996) and Kennedy *et al.* (1996) find a similar negative relationship between health and inequality at the aggregate level for the US, it is sensitive to the southern States: the correlation weakens for white mortality alone (Deaton, 2003). The aggregate relationship has also weakened over time across the OECD. Table 1 reports – pooled over time and countries – correlations between inequality (Gini coefficient) and life expectancy (at birth).[7] The negative association is clearly weaker in the latter period and this pattern is robust to splitting the sample at 1985, 1990, 1995, 2000, and 2005.

	Full Sample	Before 2000	After 2000
Gini	-9.386^{**}	-13.167^{***}	-8.831^{**}
	(-2.486)	(-2.853)	(-1.993)

	Full Sample	Before 2000	After 2000
Gini	-9.234^{**}	-13.791^{***}	-7.302^{*}
	(-2.477)	(-3.0179)	(-1.735)
GDP Growth	-0.167	0.055	-0.391^{***}
	(-1.637)	(0.425)	(-3.555)

	Full Sample	Before 2000	After 2000
Gini	-7.370^{**}	-12.928^{***}	-8.393^{**}
	(-2.058)	(-2.862)	(-8.393)
Mean GDP Growth	-0.308^{*}	0.135	-0.662^{***}
	(-1.932)	(0.573)	(-4.012)

t-stat in Parentheses. Significance: ***: 1%, **:5%, *:10%

Table 1: Data: Life Expectancy and Inequality

Surveying the large body of research since Wilkinson's original work, Subramanian and Kawachi (2004) note that the literature has commonly used the Gini coefficient to measure inequality and "the published evidence so far is by no means conclusive about the relation between income distribution and population health" (p. 78). They call for further work, including a better integration of theory and empirics.

[7] Gini data come from the OECD, CIA World Fact Book and the Deininger and Squire Dataset. Life expectancy and income data covering 1974-2010 are from the OECD. "GDP growth" in Table 1 corresponds to the year the Gini is reported, "mean GDP growth" to average growth between observations.

Yet the disaggregated evidence is clearer: inequality – measured by relative position or deprivation, not the Gini coefficient – has a strong negative effect on individual and household-level health. Besides the studies on relative social position mentioned earlier (and the sources they cite), Deaton (2001) finds that an increase in Yitzhaki's (1979) measure of relative income deprivation within the US states results in worse reported health. Eibner and Evans (2005) confirm this finding for a larger range of health outcomes including mortality and alternative measures of the reference group used to construct the deprivation index. Relative deprivation has a particularly large impact on deaths related to smoking and coronary heart diseases which are known to be associated with long-term stress and excessive work. Both studies control for household income, that is, they identify a mechanism working separately from the direct effect household income has on health production (see also Subramanyam *et al.*, 2009). Studies have replicated the relative income effect for other populations, Dahl *et al.* (2006) for Norway and Kondo *et al.* (2008) for Japan, for instance.[8]

The seeming contradiction between aggregate and disaggregate data is puzzling. Understanding it is important not just for our grasp of health behavior and policy – is income growth alone enough to lift the poor out of poverty and ill health? should we redistribute income or directly tackle health inequality? – but also since much research has come to view aggregate measures of health such as life expectancy as good proxies for the social consequences of inequality, a topic that has emerged to the forefront of public and intellectual discourse in recent years.

2.2 A Resolution

What kind of theory do we need to explain the data? The one advanced in this paper relies on preference externality in the form of consumption-based aspirations.

Could a model without such an externality explain the evidence? Take the most obvious benchmark, a partial-equilibrium Grossman-Yaari-Blanchard longevity model where there is no consumption externality, markets are perfect and prices exogenous; this is nested by our specification. Since each household is autarkic, relative position in the distribution has an effect on household health only to the extent it is informative about the household's absolute income. Controlling for household income, we would expect relative position to have little, if any, effect on household health. As long as rich and poor households face the same prices,

[8]This is not to say that all studies find evidence in favor of the relative income gradient. In Miller and Paxson (2006), having wealthier neighbors does not aggravate mortality controlling for own income. It is unclear, though, if that necessarily negates the Wilkinson effect. If crime is lower in wealthier neighborhoods and the effect is strong, it may dominate the adverse relative income channel. Likewise it is hard to adequately control for selection, individuals choosing to locate in wealthier versus poorer neighborhoods.

endogenous factor prices do not negate this prediction. In other words, such a model would have a hard time explaining the strong micro-level evidence on the relative income gradient. At the macro level, on the other hand, the model would predict a non-causal negative (Jensen's inequality), possibly strong, association between population health and inequality. In other words, the model would not fit the macro evidence either.

Take a different alternative, one that departs from the neoclassical paradigm without introducing consumption externality and where relative position in the distribution has a direct bearing on health production. This may be due to, for example, credit frictions (Galor and Zeira, 1992), human capital externalities (Galor and Tsiddon, 1997), complementarity between survival and asset accumulation (Chakraborty and Das, 2005) or access to heath care (Gulati and Ray, 2016). Although not all these papers or related ones in the inequality literature directly study health, there are certain commonalities in why relative position matters: poorer households face different relative prices or expected returns (first three papers) or they face a different health production function (last paper). Whatever be the exact mechanism, inequality has a strongly negative causal effect on household *and* aggregate health in this literature. Here the drawback is the inability to match the macro evidence.[9]

How does preference externality help? In our model, households aspire to the average consumption level of everyone above them in the distribution. Since poorer households face a larger aspirations gap – a higher relative consumption deprivation – their marginal propensity to invest in health is considerably weaker than the health production function alone would suggest. Redistributing income towards them, through a mean preserving spread, does little to raise mean life expectancy. An advantage of this type of preference externality is that we can later use it to study the relationship between aspirations and inequality more broadly.

To gain some intuition consider the static decision-problem:

$$\max_{c,q,l} \quad V(c,H;\bar{C}) \equiv \psi_L(H)\,v(c,\bar{C}) \tag{1}$$

subject to

$$c + q = wl + \tilde{a} \tag{2}$$

$$H = f(q,l) \tag{3}$$

given assets $\tilde{a}$. This is a special case of the multi-period decision problem presented later. Here

[9]Some of these papers also feature income polarization that accentuates these margins. Note also that in Gulati and Ray (2016), the effect of inequality on the poor is non-monotonic at the neighborhood level: at low levels of inequality, increasing the proportion or income of the rich improves provision of local goods like health. This weakens the aggregate relationship but also predicts a positive effect of inequality on the health of the poor as long as initial inequality is low.

ψ_L represents average lifespan of the household, v the utility flow from consumption per year and V lifetime utility. Underlying the lifespan function is a survival function $\phi(H)$ that is increasing and concave in the household's health H. Sufficient concavity of the survival function is assumed so that the lifespan function is concave. It is because strong diminishing returns in the survival function does not imply strong diminishing returns in the lifespan function that health is a superior good (below).

Utility from personal consumption c depends on the individual's aspiration level $\bar{C}$. Suppose that $\partial(\partial v/\partial c)/\partial\bar{C} > 0$, that is, higher aspiration encourages personal consumption as the individual tries to catch up (Gali, 1994). It is through $\bar{C}$ that relative position will affect household health and this operates separately from the effect household income has on health production.

Two inputs go into the production of health, a health good q denominated in units of the consumption good and healthy time that depends inversely on market labor supply l, with $\partial f/\partial q > 0, \partial f/\partial l < 0$. Besides $\tilde{a}$, the household is endowed with a unit time endowment that is allocated towards labor supply and health production. Note the tradeoff: higher health investment raises quantity of life ψ_L at the expense of quality of life v.

To make further progress suppose that

$$\begin{aligned}
&\psi_L(H) = 1 + H \\
&v(c,\bar{C}) = \underline{v} + \frac{(c/\bar{C})^{1-\sigma}}{1-\sigma}, \ \sigma > 1, \ \underline{v} > 0 \\
&f(q,l) = Qq^{1-\alpha}(1-l)^{\alpha}, \ 0 < \alpha < 1.
\end{aligned}$$

The first identity follows from an underlying survival function $\phi(H) = H/(1+H) \in (0,1)$ with expected lifetime given by $\psi_L = 1/(1-\phi)$. For the marginal utility from consumption to be increasing in the aspirations level it is necessary that $\sigma > 1$. Implicitly we are normalizing utility from death to zero and a sufficiently high, positive, value of $\underline{v}$ ensures that utility from being alive is always positive. In addition $\tilde{a} > (1-\alpha)w/\alpha$ ensures that consumption is non-negative.

In an interior equilibrium – the only kind that we obtain in the dynamic model later – the response of longevity $\psi_L(H)$ to income and aspirations can be fully gauged from the behavior of health expenditure q. The proposition below summarizes this; proofs are available in the Appendix.

Proposition 1. *The solution to the household's optimization problem (1) subject to (2) and (3) consists of*

(i) A health investment function $q(w)$ that is increasing and convex in labor income, $q'(w) > 0, q''(w) > 0$;

(ii) *Health outcomes* $H(w) = Q[\alpha/(1-\alpha)]^{\alpha} w^{-\alpha} q(w)$ *and* $\psi_L(H(w)) = 1 + H(w)$, *both increasing and concave in labor income; and*

(iii) $\partial q'(w)/\partial \bar{C} < 0$.

The first result establishes that health expenditure is a superior good; a similar result holds with respect to household wealth $\tilde{a}$. Even so, the second result shows that health capital and longevity are both concave in labor income, that is, the marginal return to health is diminishing in income. The third result says that the marginal propensity to invest in health (MPIH) is decreasing in the aspirations level $\bar{C}$. At low income levels, that is low w, the marginal product of health investment is high. On the other hand, for a given $\bar{C}$, the aspirations gap $\bar{C}/c$ is larger and the marginal utility from personal consumption higher. Any income gain (higher w) is disproportionately allocated towards consumption spending over health investment. An increase in income therefore has a relatively small effect on a poorer household's health. Put differently the MPIH falls the poorer a household gets. This result is quite general and holds as long as aspirations are not directly based on health status.[10] Since the lifespan function remains concave in income, it is still the case that a mean preserving spread in income lowers average health. That effect gets weaker the more responsive the household becomes to aspirations (see later) and, not surprisingly, aggregate data may not systematically pick up a pronounced negative relationship between the two.

An additional channel is at work. The puzzlement about the lack of a strong connection between inequality and population health – causal or otherwise – stems from the premise that the aggregate health-income gradient is concave. As Hall and Jones (2007) have noted, and Proposition 1(i) shows, health spending is a superior good under standard preferences: it allows one to enjoy life at the extensive margin (longevity) compared to the intensive margin (consumption) that is subject to strong diminishing marginal utility. This property weakens the overall concavity between population health and income. It will become clearer later that this alone is not sufficiently strong to weaken the aggregate relationship; for the latter, upward-looking aspirations are essential. But it does influence how much health amplifies fundamental inequality.

[10] In other words, a direct preference over health as a consumption good can overturn these results if health itself is a social good. We see little evidence of it among the poor and lower middle-class. Even among the well-to-do, subgroups who socially signal their health and fitness goals are far from representative. Part of the problem may be that unlike certain health outcomes (death, illness) and health choices (gym membership, diet fads), an individual's intrinsic health is not observed by others. It is also unclear whether some of these choices – crash diets for example – actually improve health.

Alternatively, our results are overturned if consumption and health are *strongly* complementary; complementarity alone is not sufficient for this as equation (1) shows.

We model health through mortality mainly because much empirical work in this area uses mortality statistics.

3 An Intertemporal Model

To generalize the intuition from above, let $\bar{C}$ be heterogeneous and determined by the consumption distribution. Consider a discrete-time infinitely-lived economy populated by heterogeneous individuals (households) who potentially live forever. Time is indexed by $t = 0, 1, \ldots \infty$. Individuals are born with an idiosyncratic labor productivity draw θ, initial asset a_0 and health capital H_0. Every period that he is alive, each individual has a unit time endowment that he allocates between work and leisure.

3.1 Health Production

Much like the Grossman (1972a,b, 2000) model of health as an investment good, agents accumulate a stock of health through purposeful investment that determines their longevity. Unlike the Grossman model, they do not face a deterministic length of life that is dictated by a minimum health stock. Rather, the model builds on the perpetual youth framework from Yaari (1965) and Blanchard (1985) in that the agent's health capital at the beginning of any period positively affects his probability of surviving to the next period.

Health capital depreciates at the rate $\delta \in (0, 1)$. For individual i the stock of health at the beginning of $t+1$ depends on his undepreciated health capital and investment from period t:

$$H_{it+1} = (1-\delta) H_{it} + I_{it}. \tag{4}$$

Health investment, $I_{it} \geq 0$, is produced from the same two inputs as before. Healthy time allocation, without loss of generality, is taken to be leisure time $1 - l_{it}$, l_{it} being i's labor supply.[11] The second input in health production, q_{it}, is market-provided medical care or health goods such as visits to the doctor, drugs, vitamins, etc.. The relative price of this good is constant and normalized to unity, for example, if the final good can be converted one-for-one into q. Gross health investment depends on these inputs according to

$$I_{it} = I(l_{it}, q_{it}), \tag{5}$$

an increasing and concave function of leisure and health expenditure satisfying $I(1, q) = 0 =$

[11] This is a special case of Grossman's model where leisure time can be purely consumed or devoted to health production. Were people to invest healthy time into health production and separately value non-healthy time leisure, higher labor supply would lower both types of non-working time. Either way, the essential tradeoff is that higher consumption via higher labor supply entails a health cost. The non-rivalness of healthy time and leisure in our model does not fundamentally affect this tradeoff. And it is this tradeoff that underlies how higher inequality – higher aspiration gap – motivates people to work harder at the cost of poor health.

$I(l, 0)$. We use the same Cobb-Douglas specification as before, this time for health investment:

$$I(l_{it}, q_{it}) = Q(1 - l_{it})^{\alpha} q_{it}^{\rho}, \tag{6}$$

where $Q > 0$, $\alpha, \rho \in (0, 1)$ and $\alpha + \rho \leq 1$.

Health capital determines agent's i survival probability, ϕ_{it} through an increasing concave function

$$\phi_{it} = \phi(H_{it}) \tag{7}$$

that satisfies $\phi(\underline{H}) = 0$ for some $\underline{H} \geq 0$ and $\lim_{H \to \infty} \phi(H) = 1$ for $t \geq 1$. Numerical simulations below are based on

$$\phi(H_{it}) = \xi \left(1 - \frac{\nu}{H_{it}}\right)^{\tau}, \ t \geq 1 \tag{8}$$

whose curvature is determined by $\tau \in (0, 1)$, $\nu > 0$ is a scaling parameter and H is restricted to be above ν. To ensure that the agent is alive in the initial period $t = 0$, we assume that $\phi_{i0} = 1$. Since ϕ_{it+1} is the probability of being alive in $t+1$ conditional on being alive in t, the cumulative probability of being alive until period t is

$$\Phi_{it} = \prod_{n=0}^{t} \phi_{in}. \tag{9}$$

Health capital has no effect on i's decision problem except through the survival rate. In other words, health is not valued as a consumption good nor does it directly affect i's productivity.

3.2 Preferences

Utility in any period depends on personal consumption and leisure. As before, utility depends on relative position in the consumption distribution because people are aspirational. Specifically, people care about how deprived they are relative to those who are better off than themselves. In other words, their aspirational benchmark is the average consumption of all individuals who consume at least as much as they do. Even the highest-consumption agent is an aspirant, using his own consumption level to form that aspiration. Formally, individual i's aspirations level is given by

$$\bar{C}_{it} = \frac{\sum_{j=1}^{N} \mathbb{1}(c_{jt} \geq c_{it}) c_{jt}}{\sum_{j=1}^{N} \mathbb{1}(c_{jt} \geq c_{it})} \tag{10}$$

where $\mathbb{1}(c_{jt} \geq c_{it})$ is an indicator function that takes on the value 1 if true and 0 otherwise. It is important to note that unlike much of the literature on status-seeking, aspirations levels here are individual-specific.[12]

To understand how the aspirations gap, or relative deprivation, $\bar{C}_i/c_i$ varies across the population consider a hypothetical exogenous and continuous consumption distribution $\mathscr{F}(c)$ for which $\bar{C}_i = \int_{c_i}^{\infty} x d\mathscr{F}(x)/[1-\mathscr{F}(c_i)]$. In general it is not possible to sign $\partial\left(\bar{C}_i/c_i\right)/\partial c_i$ unambiguously. Consider two examples commonly used in the inequality literature, Log Normal and Pareto. Figure 1 illustrates that $\bar{C}_i/c_i$ is monotonically decreasing in consumption level for Log Normal (left panel). The fractal nature of the Pareto distribution (right panel) means both rich and poor face the same aspirations gap. In both cases, higher inequality implies a higher aspirations gap at all consumption levels. In the model, consumption inequality is the equilibrium

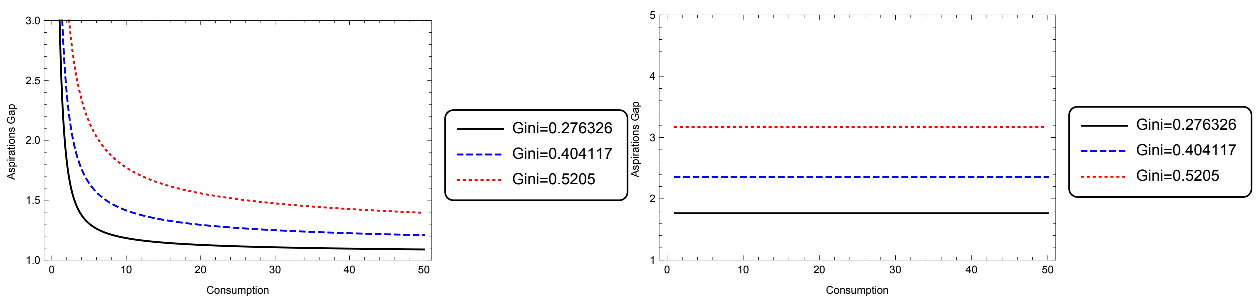


Figure 1: Consumption Deprivation for Log Normal (left) and Pareto (right) $\mathscr{F}(c)$

outcome of underlying ability inequality. Even for a Pareto ability distribution, the consumption distribution behaves similar to the Log Normal case in that the poor face a larger aspiration gap. This *amplifies* the labor supply and wealth accumulation margins from the static model in section 2.

Individual i's preferences over consumption and leisure in period t when he is alive are

$$u_{it} \equiv U(c_{it}, \bar{C}_{it}, l_{it}) = \frac{c_{it}^{1-\sigma}}{1-\sigma} \bar{C}_{it}^{\psi\sigma} + \gamma \frac{(1-l_{it})^{1-\sigma}}{1-\sigma} \tag{11}$$

where $\sigma > 0$ and $0 < \psi < 1$. This specification is similar to the macro KUWJ literature, particularly Gali (1994), though the consumption benchmark for all households is usually taken to be mean consumption. For $\psi = (\sigma-1)/\sigma$ with $\sigma > 1$, the first component of (11) becomes $\left(c_{it}/\bar{C}_{it}\right)^{1-\sigma}/(1-\sigma)$ similar to Abel (1990) where the aspirations level is mean consumption.

[12]The assumption that people's reference group comprises of the entire distribution above them is informed by the empirical literature discussed in section 2.1. If the reference group is more restricted – people with consumption levels only within a certain range of an individual's, or more generally, higher subjective weight attached to people whose consumption levels are closer – then relative income would matter less for household behavior both theoretically and empirically.

Alpizar *et al.*'s (2005) survey-experimental evidence shows that relative consumption of non-positional goods matters as much as positional goods; no distinction is made here between the two. We do allow $\psi \neq (\sigma-1)/\sigma$ which means $\sigma > 1$ is not necessary for an increase in $\bar{C}_{it}$ to increase the marginal utility of consumption as long as $\psi > 0$. The quantitative results do, however, use a value of σ above unity to be consistent with the macro evidence.[13]

A final point about the utility function. Note that when $\sigma > 1$, $u_{it} < 0$. To ensure that utility from being alive always exceeds that from death, we normalize the latter to a large negative number such that $(1-\beta)\underline{U} < \inf\{U(c_{it}, \bar{C}_{it}, l_{it})\}_{t=0,i=1}^{\infty,N}$. A complete specification of individual preferences is then

$$U(c_{it}, \bar{C}_{it}, l_{it}) = \begin{cases} \frac{c_{it}^{1-\sigma}}{1-\sigma}\bar{C}_{it}^{\psi\sigma} + \gamma\frac{(1-l_{it})^{1-\sigma}}{1-\sigma}, & \text{if agent } i \text{ is alive} \\ (1-\beta)\underline{U}, & \text{otherwise.} \end{cases}$$

3.3 Decision Problem

Individual i's labor productivity θ_i is time invariant, drawn at the beginning of his life from the distribution $\Gamma(\theta)$ with finite support. We assume that the wage rate per efficiency unit of labor w is constant and exogenous. The return on investment $\tilde{R}_{it}$ is individual-specific. Since individuals die over time, to ensure their assets are accounted for we assume a perfect annuities market (Yaari, 1965). Under a perfectly competitive market, the zero profit condition implies equilibrium annuitized investment return of $\tilde{R}_{it} = R/\phi_{it}$, R being the constant return on investment. Implicitly this assumes access to an international capital market where the borrowing and lending rates are $R-1$. This in turn implies a constant aggregate capital-labor ratio from a CRS technology, and constant wage per efficiency unit of labor.

Individual i's period t budget constraint is

$$c_{it} + q_{it} + a_{it+1} = w\theta_i l_{it} + \tilde{R}_{it}a_{it}, \tag{12}$$

where a denotes his financial assets.[14] He maximizes expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\Phi_{it} \left\{ \frac{c_{it}^{1-\sigma}}{1-\sigma}\bar{C}_{it}^{\psi\sigma} + \gamma\frac{(1-l_{it})^{1-\sigma}}{1-\sigma} \right\} + (1-\Phi_{it})\underline{U} \right], \tag{13}$$

[13] Yet another alternative for socially-minded behavior is for agents to directly care about inequality measures such as the Gini coefficient or the Kuznet's ratio. Those measures capture the whole distribution; it is unclear that people care about those who are worse off than themselves in the same way they care about those who are doing better.

[14] Annuity firms are owned by households. Since they do not make profits, we do not explicitly include (zero) dividends from their ownership on the income side.

where $\beta \in (0,1)$ is the subjective discount rate, subject to the health transition equation (4), health production function (5), survival function (7), budget constraint (12), and the usual no-Ponzi game condition, given θ_i and initial conditions (a_{i0}, H_{i0}). To conserve notation we do not explicitly distinguish between calendar time and age of the individual even though not all individuals will be alive every period.[15]

Differently from the Ramsey model with homogeneous KUWJ preferences, the entire consumption and wealth distributions, not just their means, matter for household choices here. Since individuals face idiosyncratic productivity and aspirations levels, two simplifying assumptions are made to reduce computational time and impose a recursive structure. First, we assume that the individual takes into account how his health choices affect the annuity return $\tilde{R}$ that he receives. The rationale for this is that people often purchase insurance based on actuarial tables.[16] Secondly, we solve the household's decision problem assuming the economy has reached the stationary distributions of health, wealth and consumption. Specifically we impose stationarity of the consumption distribution, derive health and wealth dynamics consistent with that assumption and then focus exclusively on the steady-state relationship between health, wealth and aspirations.

For the state vector $(\theta_i, a_i, H_i, \bar{C}_i)$ and vector of controls (a_i', l_i, q_i), the dynamic programming problem for individual i is

$$V(\theta_i, a_i, H_i, \bar{C}_i) = \max_{l_i, a_i', q_i} \left\{ u\left(c_i, \bar{C}_i, l_i\right) + \beta\phi\left(H_i'\right) V\left(\theta_i', a_i', H_i', \bar{C}_i'\right) + \beta\left(1 - \phi\left(H_i'\right)\right) \underline{U} \right\} \tag{14}$$

subject to

$$\begin{aligned} a_i' &= w_t \theta_i l_i + \frac{R}{\phi(H_i)} a_i - q_i - c_i, \\ H_i' &= (1-\delta) H_i + Q(1-l_i)^{\alpha} q_i^{\rho}, \\ \bar{C}_i' &= \Gamma(\theta_i, a_i, H_i, \bar{C}_i, \Xi), \\ \theta_i' &= \theta_i, \end{aligned} \tag{15}$$

where V is the value of being alive, a_{i0}, H_{i0} and $\phi_{i0} = 1$ are given, Γ is a belief function that determines how i perceives its aspiration to evolve, and Ξ is the joint distribution of θ, a and H in the population. In the quantitative work below we focus on a stationary distribution where

[15] Note how the static model of section 2 was a special case of this dynamic setup under $\psi = (\sigma-1)/\sigma$, $\beta = 1$, $\xi = \tau = \nu = 1$, $\rho = 1-\alpha$, $\delta = 1$ and exogenous $\bar{C}$. The health scale was redefined there to start at zero and each household was initially endowed with $(1-\phi)\tilde{a}/\phi$ assets to simplify the algebra. Finally utility from death was normalized to zero which, for optimal decisions, is isomorphic to the assumption $\underline{v} = -\underline{U}$.

[16] It has the computational advantage of reducing the state space since the annuity return is not part of it. In any case, computational results using a coarser grid are similar under price-taking behavior.

$\bar{C}_i' = \bar{C}_i$. Hence the belief function does not have to be specified for our purpose.

3.4 Optimal Behavior

Consider the optimal choices of a_i', l_i, and q_i. First take the consumption Euler equation:

$$\frac{c_i'}{c_i} = \left(\beta R\right)^{\frac{1}{\sigma}} \left(\frac{\bar{C}_i'}{\bar{C}_i}\right)^{\psi}. \tag{16}$$

Since the interest rate is exogenous, to ensure a stable invariant distribution we impose the restriction

$$\beta R = 1 \tag{A1}$$

under which the Euler equation simplifies to

$$\frac{c_i'}{c_i} = \left(\frac{\bar{C}_i'}{\bar{C}_i}\right)^{\psi}. \tag{17}$$

This immediately implies that each individual's consumption reaches steady state whenever the aggregate consumption distribution is stationary. The perfect annuities market assumption ensures that this is independent of the individual's mortality rate.

Optimal choices for labor supply and health expenditure, l_{it} and q_{it}, are

$$\begin{aligned} w\theta_i c_i^{-\sigma} \bar{C}_i^{\psi\sigma} - \gamma(1-l_i)^{-\sigma} + \beta \frac{\partial H_i'}{\partial l_i} \big[\phi'(H_i')\{V(\theta_i', a_i', H_i', \bar{C}_i') - \underline{U}\} \\ + \phi(H_i') V_3(\theta_i', a_i', H_i', \bar{C}_i')\big] \leq 0, \end{aligned} \tag{18}$$

and

$$-c_i^{-\sigma} \bar{C}_i^{\psi\sigma} + \beta \frac{\partial H_i'}{\partial q_i} \big[\phi'(H_i)\{V(\theta_i', a_i', H_i', \bar{C}_i') - \underline{U}\} + \phi(H_i') V_3(\theta_i', a_i', H_i', \bar{C}_i')\big] \leq 0. \tag{19}$$

respectively. Define

$$\Omega_i' \equiv \phi'(H_i')[V(\theta_i', a_i', H_i', \bar{C}_i') - \underline{U}] + \phi(H_i') V_3(\theta_i', a_i', H_i', \bar{C}_i'),$$

the common term in equations (18) and (19), using which it follows from (19) that

$$\Omega_i' = \frac{c_i^{-\sigma} \bar{C}_i^{\psi\sigma}}{\beta\left[\partial H_i' / \partial q_i\right]}. \tag{20}$$

Substituting (20) into (18) yields:

$$\left(\frac{\bar{C}_i^{\psi}}{c_i}\right)^{\sigma}\left(w\theta_i+\frac{\partial H_i'/\partial l_i}{\partial H_i'/\partial q_i}\right)=\gamma(1-l_i)^{-\sigma}. \tag{21}$$

To make further progress, take the parametric example from (6) using which equation (21) becomes:

$$\left(\frac{\bar{C}_i^{\psi}}{c_i}\right)^{\sigma}(1-l_i)^{\sigma-1}\left(w\theta_i(1-l_i)-\frac{\alpha}{\rho}q_i\right)=\gamma. \tag{22}$$

To understand how aspirations affect the individual's health consider a simple comparative statics exercise. Suppose at the optimum governed by (22), individual i experiences an exogenous increase in his aspiration level $\bar{C}_i$. How do healthy time investment and health expenditure respond? Through the budget constraint, personal consumption is positively related to labor supply, negatively to health expenditure. The remaining terms on the left-hand-side of (22), on the other hand, depend negatively on labor supply and health expenditure. That is, the left-hand-side of the equation is unambiguously decreasing in labor supply. When $\bar{C}_i$ increases, an increase in labor supply can restore equality to the first order condition. This means health time investment, all else constant, will fall from an increase in aspirations.

The effect on health expenditure, on the other hand, is ambiguous. It could either rise or fall depending on the strength of the response through consumption (denominator) versus returns to health expenditure (numerator). Recall, though, that health time and expenditure are complementary inputs. Since health time investment falls unambiguously, there is another effect to consider in the overall response to $\bar{C}_i$ – returns to health expenditure fall. Indeed, for the special case of $\gamma = 0$, equation (22) says that labor supply and health expenditure are inversely related and the latter falls for sure. We conclude based on this, that a rise in aspirations lowers time investment in health for sure and, possibly, health expenditures. In the computational work below, the latter is always true in the parameter space chosen. This is only a partial equilibrium response since $\bar{C}_i$ depends on the consumption distribution. It is important to understand how the distribution responds in turn and affects equilibrium health and wealth outcomes. The definition below specifies this equilibrium which is then analyzed numerically in the following section.

Definition 2. *The* ***dynamic equilibrium*** *of this economy consists of a finite set of individuals* $\mathscr{I}_t$ *with* $\#\mathscr{I}_t = N > 1$ *who are alive at* $t = 0, 1, \ldots, \infty$, *a consumption distribution* $\{C_{it}\}_{i\in\mathscr{I}_t}$, *controls* $\{l_{it}, a_{it+1}, q_{it}\}$ *and state variables* $\{\theta_i, a_{it}, H_{it}, \bar{C}_{it}\}$ *for* $i \in \mathscr{I}_t$ *such that*

(i) The controls $\{l_{it}, a_{it+1}, q_{it}\}$ *represent the optimal solution to* (14) *subject to* (15), *given*

$\{\theta_i, a_{it}, H_{it}, \bar{C}_{it}\}$,

(ii) *The health stock evolves according to* (6) *for a given set of optimal controls* $\{l_{it}, a_{it+1}, q_{it}\}$ *and* H_{it}, *and*

(iii) *Aspirations are in equilibrium, that is, the distribution of aspirations* $\{\bar{C}_{it}\}$ *taken as given for the solution to* (14) *subject to* (15) *generates the distribution of optimal consumption* $\{C_{it}\}_{i\in\mathscr{I}_t}$ *that is consistent with those aspirations according to* (10),

given constant prices $\{w, R\}$ *and the initial distribution of* $\{H_0, a_0\}$ *in the population.*

The evolution of $\mathscr{I}_t$ follows the replacement assumption discussed in section 5. Briefly, a deceased individual is replaced by another who has different labor productivity and initial conditions. Hence N is independent of time.

4 Aspirations, Health and Inequality

To establish equilibrium relationships between aspirations and health behavior and between inequality and aggregate health using quantitative methods, parameter values are assigned with an empirical counterpart in mind.

4.1 Parameterization

These values are reported in Table 2. Individuals are assumed to start their planning horizon at age 20 which means all life expectancy numbers reported below are conditional on age 20. The length of a period is chosen to be a year, so the discount rate is set to 0.96, similar to the business cycle literature. The implied return on saving is 4.17% consistent with long-run US data. The weight on preference for leisure in the utility function, γ, is set to 0.5. The implied average share of working hours is 0.35, close to the 0.36 implied by McGrattan and Rogerson's (2004, Table 1) estimate for 2000 assuming discretionary hours per day to be 16. We follow Carroll *et al.* (1997) in choosing $\sigma = 2$. The aspirations parameter ψ is is set to $(\sigma-1)/\sigma = 0.5$, the value in Carroll *et al.* (1997). This implies utility from consumption depends on the ratio $c_i/\bar{C}_i$. Alternative values of ψ are also considered for robustness.

Since capital markets are perfect and complete and there are no non-convexities, long-run inequality depends on labor productivity inequality that we refer to as *fundamental inequality.* The state space Θ for this productivity is discretized and agents are endowed with productivities ranging from 1 to 20 in increments of $\kappa = 0.01$. The probability/population weights corresponding to the θ's are chosen from a Pareto distribution. Since we are interested in tracing the effect

Parameter	Value	Description	Source
β	0.96	Discount rate	
σ	2	Elasticity of substitution	Carroll *et al.* (1997)
α	0.91	Leisure share in health production	1 - ρ
ρ	0.09	Health good share in health production	Health expenditure share of GDP in 2000
Q	0.195	Health investment productivity	Scale
ξ	0.9857	Scale parameter for survival probability	Population Life Expectancy at 20 in 2000.
τ	0.15875	Shape parameter for survival probability	Life Expectancy at 20 Gap in 2000
ν	0.1	Scale parameter for survival probability	Scale
w	20	Wages	Scale
H_{i0}	Varies	Initial stock of health	
γ	0.5	Weight on leisure	Average share of working hours
ψ	0.5	Responsiveness to reference consumption	Carroll *et al.* (1997)
δ	0.03	Depreciation of health capital	Rockwood and Mitnitski (2007)
N	500	Population size	Scale
R	$1/\beta$	Rate of return on savings	

Table 2: Parameter Values

of inequality on economic and health outcomes, we use several combinations of the minimum and shift parameters of the Pareto distribution.[17]

Initial population and the (exogenous) wage rate are scaling parameters; their values are set arbitrarily. Each individual is endowed with an initial health close to his steady state and initial asset holding of zero. The former is arrived at by solving the health transition equation (4) for a given set of policy rules. It ensures that the simulations are local to the stationary distribution. In particular, since individuals die and new individuals are introduced every period to replace them, it is possible that a non-trivial measure of the agents never get close to their steady-state health and wealth levels; starting them close to their steady-state health ensures faster convergence. The zero initial assets assumption, on the other hand, is in keeping with a perfect annuities market where assets of the deceased are seized by competitive risk-neutral firms that sell annuities and do not make any profits.

The health parameters Q and ν are also scale parameters. Q pins down steady-state health

[17] Most figures on aggregate inequality use the parameter combination $\{1.01, 1.01\}$. Since we truncate the upper tail of the Pareto distribution at 20, we redistribute the remaining weight ω (for $\theta > 20$) over $[1,20]$. Let x be the rank of θ in the grid (Θ) over $[1,20]$. Then x gets assigned a new population weight of $G(x) + \omega.(x^4/L)$, where $L = \sum_1^{20/\kappa} x^4$ is a normalizing constant, κ is the step size of the Θ grid, and $G(x)$ is the probability of drawing productivity $\theta(x)$ from the untruncated Pareto distribution. The exponent on the re-weighting function and the mean of Θ are chosen to generate levels of inequality that are consistent with observed data across a wide range of OECD countries. The resulting distribution still "looks" Pareto – for all of the distributions used in the simulations, the highest weight added to any $\theta \in [1,20]$ is 0.00013.

and ν dictates the range of values health can take. To economize on computational time, they are chosen so that the state-space for health capital is relatively small and contains steady-state health (note from (4) that the latter does not directly depend on ν). The depreciation rate of health capital is taken to be 3% (Rockwood and Mitnitski, 2007). Utility from death is normalized to -5000 so that all households strictly prefer being alive.[18]

The remaining health parameters $(\alpha, \rho, \tau, \xi)$ are targeted to specific moments in the data. There is little guidance in the empirical literature on α and ρ since their estimates vary a lot and have a large variance (e.g. Grossman, 1972b). We impose CRS $\rho = 1 - \alpha$, then pick ρ in order that the share share of health expenditure in GDP is 15.4% as in the US in 2000 (Hall and Jones, 2007).

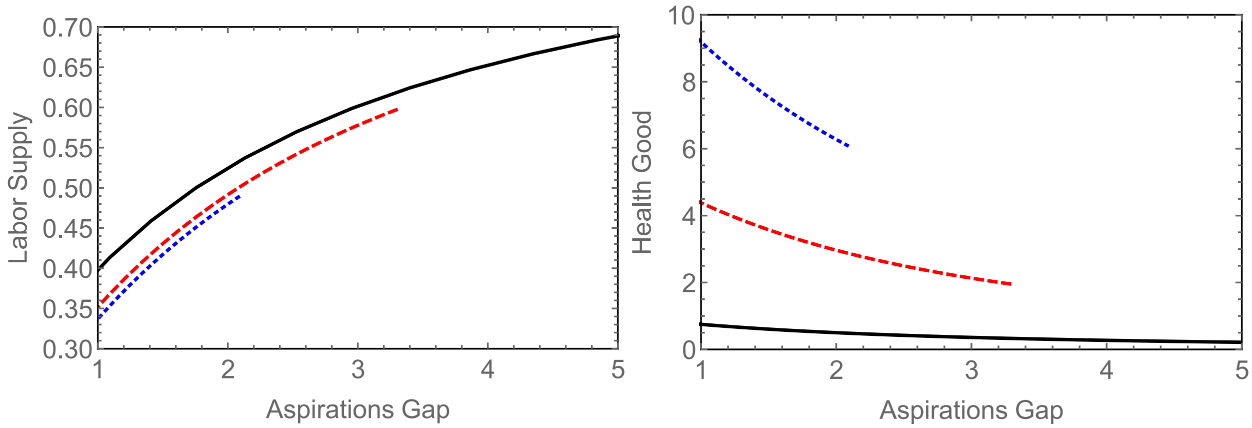
The parameter ξ is chosen to reproduce population life expectancy of 56.64, same as that in the US in 2000 (World Development Indicators) taking into account that model agents start at age twenty. Life expectancy differs substantially between the rich and the poor in the US, the gap widening in recent decades (Meara *et al.*, 2008, Olshanksy *et al.*, 2012). Singh and Siahpush (2006) construct a relative deprivation index that is close to the spirit of our model. The index is based on a number of indicators like education, occupation, wealth and unemployment, all of which are closely related with relative income. They report that life expectancy at birth for the highest socio-economic group was 79.2 and for the lowest socio-economic group 74.7 in 1998-2000, a gap of 4.5 years; τ is chosen to match this for the top and bottom deciles in the model.

4.2 Policy Functions

Central to the relationship between health and inequality is the effect of relative deprivation at the micro level. This is best understood through policy rules that depend on the state vector $(\theta_i, a_i, H_i, \bar{C}_i)$. Figure 2 shows labor supply and health expenditure by exogenously varying $\bar{C}_i$ with the aspirations gap defined as $\bar{C}_i / c_i$. Health capital is set to 8 and assets to zero; results are qualitatively similar for alternative values.

Recall from section 3 that agents with a larger aspirations gap, $\bar{C}_{it}/c_{it}$, will unambiguously supply more labor and likely spend less on the health good. Confirming that, labor supply in the figure rises and health time investment falls with the aspirations gap. Could individuals be substituting towards the health good? Not so: the second panel shows that those with larger aspiration gaps also spend less on the health good. Doing so frees up resources for personal consumption as these individuals attempt to close their aspirations gaps while the discounted

[18] As $\underline{U}$ becomes more negative, people acquire a greater distaste for death and invest more in health. The approach we followed is to set $\underline{U}$ sufficiently low so that people prefer to be alive, then set other parameter values to match the data.



(a) Labor Supply

(b) Health Expenditure

Figure 2: Health inputs vs Aspirations Gap
Solid: $\theta = 1$, Dashed: $\theta = 5$, Dotted: $\theta = 15$

cost, in the form of worse survival, comes in the future.[19]

To what extent are these effects due to the conventional absolute income effect versus socially-minded behavior? The best way to gauge that is to contrast two cases: the baseline model ($\psi = 0.5$) and a version without aspirations ($\psi = 0$). Figure 3 shows how health changes as the aspirations gap widens. Labor supply, health expenditure and health outcomes strongly re-

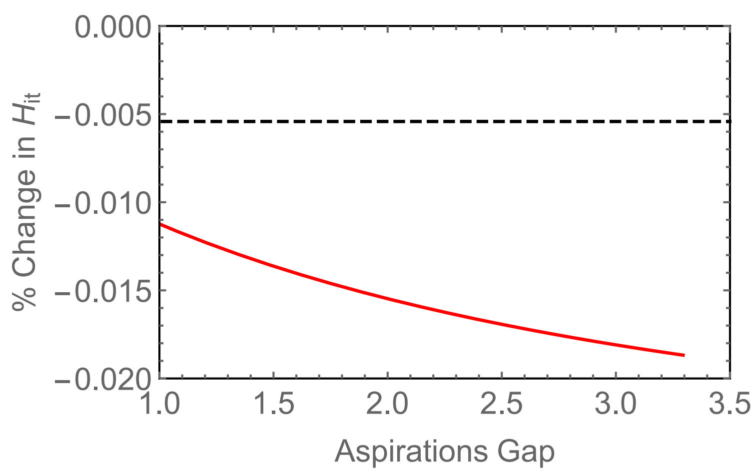


Figure 3: Aspirations and Health Production
Solid: Baseline, Dashed: No Aspirations

spond to relative consumption when individuals care about their relative position. When they do not, relative consumption has no health effect, only absolute income matters. The overall effect of aspirations is thus to lower health production, an effect that worsens as one moves

[19]Some of the policy functions are not reported for the entire range of the aspirations gap because the gap does not extend as far for higher productivity individuals who are also higher up in the consumption distribution.

down the consumption distribution (higher $\bar{C}_i/c_i$).[20]

Since those with the largest aspiration gap invest the least in health, we obviously expect them to have lower life expectancy. Figure 4 confirms this by contrasting the baseline case of aspirations ($\psi = 0.5$) with one without ($\psi = 0$) for the same productivity distribution. Ability

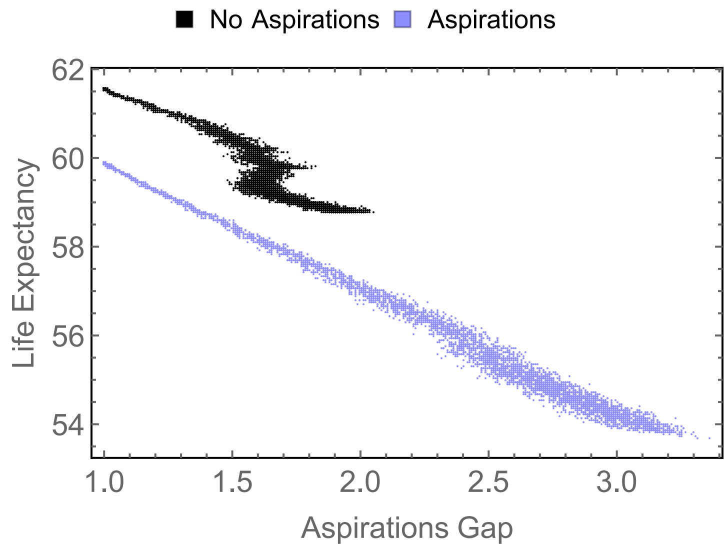


Figure 4: Life Expectancy at Age 20 vs Aspirations Gap

Gini in the aspirations and no-aspirations scenarios are same, about 0.49. Figure 4 shows that being aspirational has a health cost. The highest $\bar{C}_i/c_i$ – the maximum aspirations gap in the figure – differs between the aspirational and non-aspirational societies; the latter is smaller. In both scenarios, however, this maximum corresponds to the same least productive individual since the distribution of productivities is identical. Contrasting this individual's life expectancy between the two scenarios – a gap of about 2 years – clearly shows the adverse effect aspirations has on health. Another way this is evident is in the population life expectancy gap. The gap between the lowest and highest deciles of the consumption ratio $\bar{C}_i/c_i$ (that is, between the most and least productive individuals) is 5.467 with aspirations in Figure 4, significantly lower at 2.526 years without.

In summary, these results establish that relative position or consumption deprivation – as measured by $\bar{C}_i/c_i$ – has a negative effect on an individual's health because the greater marginal valuation placed on personal consumption is met through less investment in health production. That higher values of fundamental inequality imply greater aspirations gap in the population means that higher inequality could lead to higher life expectancy gaps in the population

[20]The truncated Pareto distribution of productivity induces a consumption distribution for which $\bar{C}_i/c_i$ falls with c_i. The response of savings to aspirations is intuitive and omitted for brevity: as the aspirations gap increases, the agent chooses to hold less assets.

and, possibly, lower average life expectancy. A fuller appreciation of these results requires us to consider the aggregate picture.

5 Aggregate Implications

5.1 From Household Behavior to the Full Equilibrium

To construct the aggregate equilibrium of this economy requires two things. Though factor prices are exogenous (for computational convenience), in the aggregate, there is a feedback loop from the consumption distribution to household behavior and back to the consumption distribution. Equilibrium requires that households' aspirations be consistent with the consumption distribution (Definition 2(iii) above).

Secondly, the evolution of $\mathscr{I}_t$ has to be specified. A positive measure of households die every period. We assume these households are replaced by an equal number of new households each with its own productivity draw and initial conditions $a_{i0} = 0$ and $H_{i0} = X(\theta_i)$, where X is a function that produces the steady-state level of health for a given productivity. We check convergence to the stationary distribution by looking at the time paths of average consumption, labor, and the Gini coefficient. Typically these three variables reach stationary values after 100 simulation periods. In what follows each of the simulations were run for 500 periods with a "burn-in" period of 500 that was dropped from the sample.[21]

In the closed-economy Ramsey model with heterogeneous households, the steady-state wealth distribution requires a well-defined demand for capital that is introduced through a diminishing returns production function (e.g. García-Peñalosa and Turnovksy, 2014). Here, as in many open economy models, the interest rate is exogenous. To ensure a steady state, open economy models often assume an endogenous discount rate, for example β as a function of consumption or income. Though the effective discount rate for any individual i, $\beta\Phi_i$, is endogenous in the model, under perfect annuities market, the expected return on saving is independent of Φ_i. It is possible then for i to accumulate unlimited assets over time. Since the numerical solution method discretizes the state space for assets over a finite grid, i's assets can converge to the upper bound of that state space in finite time. Were that to happen, eventually the asset distribution would become degenerate and all income heterogeneity would come from labor income. In the simulations, only a tiny minority of high productivity individuals face this issue. This is because mortality risk ensures that most individuals die well before reaching the upper bound of the asset space. Moreover, when an individual dies, he is replaced by one

[21] A stationary distribution always exists in the parameter space we study. Though convergence and uniqueness are not analytically established, neither has been an issue in the simulations for a range of parameter values near those used in Table 2 and initial conditions reported above.

with no initial assets. Mortality and the replacement assumption together ensure that the vast majority of agents are in the interior of the state space and the steady-state asset distribution is non-degenerate.

5.2 Is Inequality Motivating?

Friedman's (1962) spirited defense of capitalism argues that the inevitable inequality that results from private enterprise is desirable because, among other factors, it motivates people to strive for something better. Presumably doing so puts them in a better place in life, either economically or in a broader sense.

Our model can test this conjecture since inequality, through the aspirations gap, incentivizes work and asset accumulation and may attenuate fundamental inequality if the poor respond more strongly. We first eliminate health by setting $\tau = 0$ and study how the presence of aspirations alters the income distribution. Figure 5 contrasts (solid lines correspond to best non-linear fits) steady-state household income at different productivity levels with and without aspirations: all households are clearly economically better off when they are aspirational. But Figure 5 also hints at a differential effect: more productive (richer) households may be relatively better off under aspirations.

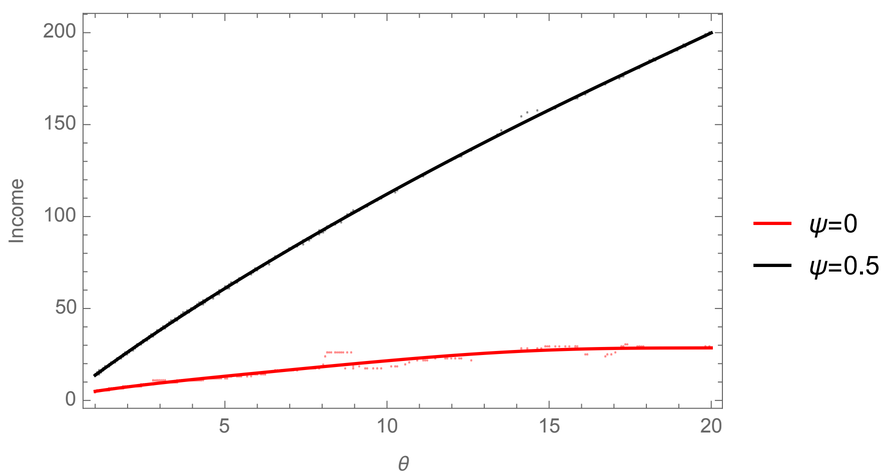
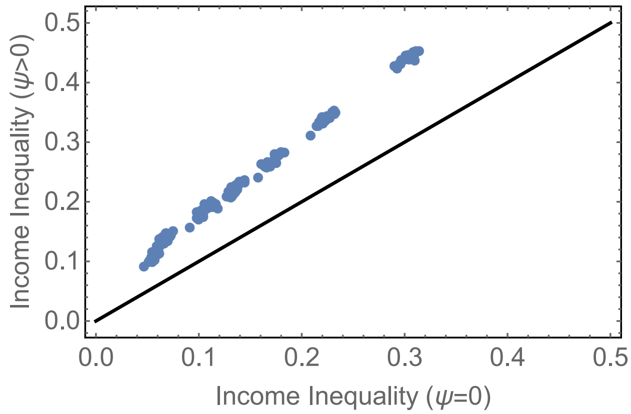
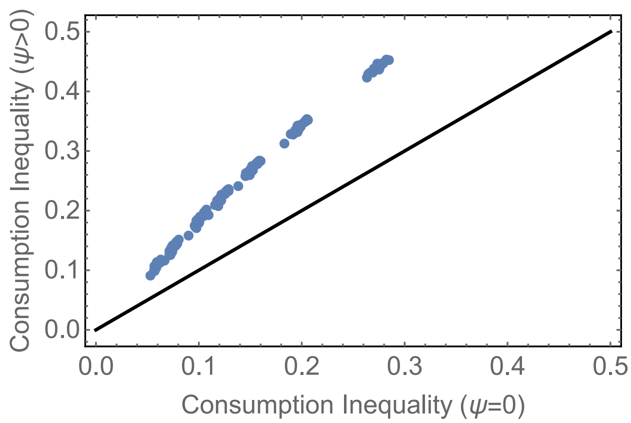


Figure 5: Effect of Aspirations on Household Income

To see this clearly, compare consumption and income inequality with and without aspirations. Figure 6 is produced by exogenously varying inequality in the underlying productivity distribution through *mean preserving spreads.* The solid black line is the 45^o line. Despite the same underlying productivity distribution, consumption and income inequality are, contrary to Friedman's conjecture, consistently higher under social aspirations.



(a) Income Inequality



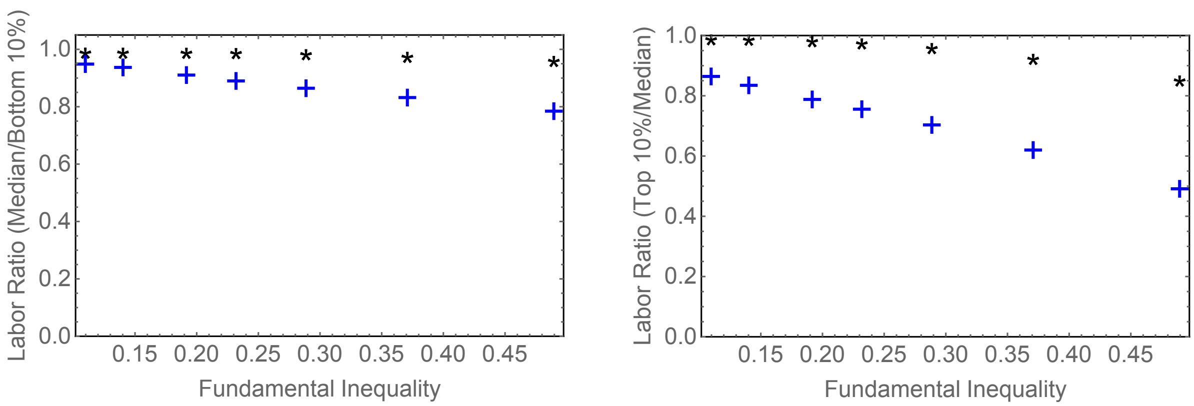
(b) Consumption Inequality

Figure 6: Aspirations and Inequality
Solid: 45° Line, Markers: Simulations

This must mean aspiration affects rich and poor households differently. All differences in steady-state income from labor and capital arise purely from lifetime labor supply (recall that individuals start without financial assets). So if aspiration prompts highly productive (richer) individuals to respond more on the labor market than less productive (poorer) ones, fundamental inequality would be aggravated, not alleviated. Figure 7 studies this possibility by plotting two labor supply ratios against fundamental inequality: median labor supply relative to the bottom decile's labor supply (panel a) and the top decile's labor supply relative to median labor supply (panel b).[22]

We know from before that aspiration motivates all households to raise their labor supply. What Figure 7 shows is that this response systematically differs across the productivity distribution. Without aspirations (plus), there is a greater dispersion in labor supply – richer in-

[22]These are based on the labor supply, not consumption, distribution. The top 10% of the labor supply distribution (Figure 7b) corresponds to the bottom 10% of the consumption distribution.



(a) Median/Bottom 10% Labor Supply

(b) Top 10%/Median Labor Supply

Figure 7: Relative Labor Supply and Fundamental Inequality
This figure plots the ratio of labor supply of the median and the bottom decile and the top decile and median against fundamental inequality with and without aspirations
Blue/Plus: No Aspirations, Black/Star: Aspirations

dividuals supply considerably less at any level of fundamental inequality. Under aspirations (asterisk), these individuals increase their labor supply more than poorer ones. In the simulations labor supply of the bottom 10% actually fell relative to the median as inequality increased. Though richer individuals always supply less labor than poorer ones, their higher productivity and lifetime wealth accumulation are sufficient to raise their relative income and consumption levels.

That less productive (poorer) individuals supply more labor than more productive (richer) ones is a testable prediction of the model. For simulations that produce an empirically reasonable value of Gini of 0.357 (compared to 0.36 in the US in 2000 as per OECD database), the bottom half of the income distribution supplies on average 36.2% of their labor endowment while the top half supplies 33.3%, a gap of about 8%. Among the employed in the US, those with less than high school education worked for 7.96 hours per “average day” in 2013 compared to 7.44 hours for those with bachelor’s degree and higher, a gap of about 7% (Bureau of Labor Statistics, American Time Use Survey, Table 4).[23]

We conclude that since richer households have more capacity to respond on the labor market, equilibrium inequality rises under aspirations. Notably this occurs without credit frictions that distort investment behavior across the income distribution or any (health) cost to being aspirational. Credit frictions would only exacerbate matters if they were to affect the poor dis-

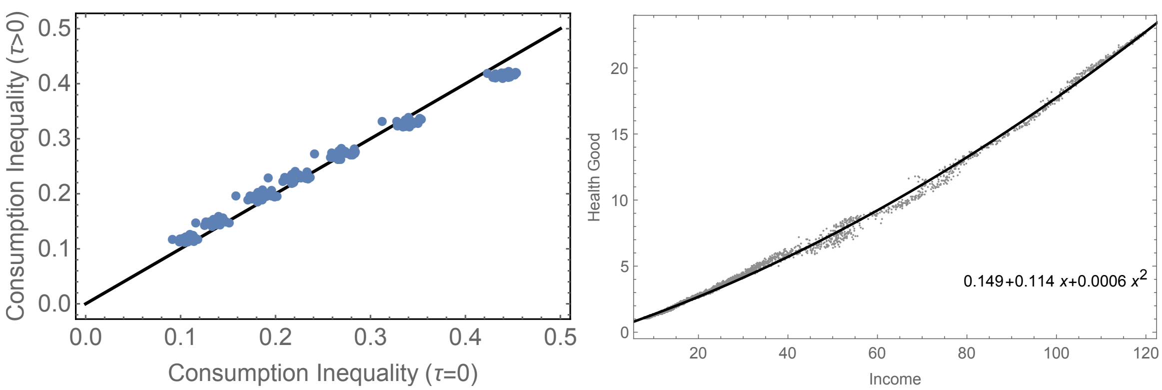
[23]The comparison by labor earnings is less clear cut for obvious reasons (Table 5). Interestingly, a recent study by the Center for Disease Control (Morbidity and Mortality Weekly Report, April 3, 2015) notes a systematic discrepancy even in sleep time, something usually taken to be non-discretionary in macro-models. In particular, more than 35% of adults below the poverty line enjoyed less than six hours of sleep per night in 2013. Among those earning more than four times the poverty line, 27.7% did.

proportionately. And introducing health costs, as we show next, worsens absolute *and* relative health of the poor, amplifying the effect aspirations has on overall welfare.

5.3 Inequality as Health Hazard

Economic inequality under health production

Lower health production lowers expected lifetime and, hence, wealth accumulation. Since this effect ought to be stronger for the poor, one would expect consumption inequality to worsen under health production. Interestingly that happens only at low and moderate levels of inequality as Figure 8(a) shows (similarly for income inequality). An opposing effect is at work. The rich, already consuming a lot, face sharper diminishing returns from consumption than from health. They spend disproportionately more on health (Figure 8(b)). Their lower saving and consumption propensity tends to lower consumption inequality. This effect is pronounced at higher levels of inequality where the rich enjoy high consumption levels. The poor, on the other hand, face a larger aspirations gap and step up their consumption.[24]



(a) Consumption Inequality with and without Health

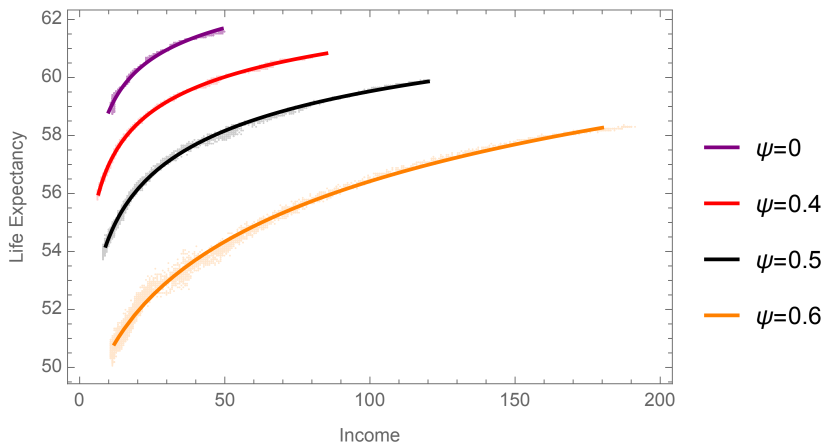
(b) Health Spending is a Superior Good

Figure 8: The Effect of Health on Equilibrium Inequality under Aspirations

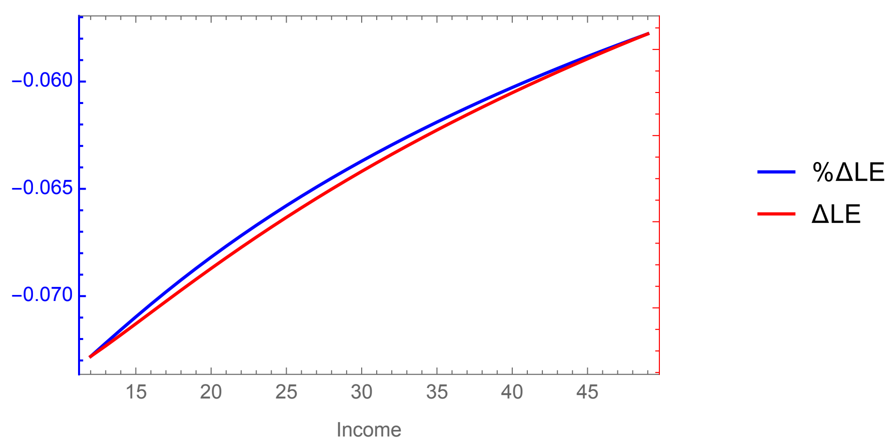
Health inequality

What about health? Figure 9(a) plots simulated data for household steady-state life expectancy (calculated as $1/(1-\phi(H))$) and income corresponding to the four parameter values $\psi \in \{0, 0.5, 0.5, 0.6\}$. Each solid line in the figure corresponds to a nonlinear fit to the data. As with the partial equi-

[24]For a mean preserving spread in productivity, the aspirations gap rises more for the lower than the upper tail; see Figure 1.



(a) Life Expectancy at Age 20 and Income, with and without Aspirations



(b) Percentage and Absolute Deviation in Life Expectancy relative to No-Aspirations

Figure 9: Household Income and Health with and without Aspirations

librium model of section 2, regardless of how socially minded households are, aspirations adversely affect health production. As social aspiration increases, for instance ψ going from 0 to 0.4 versus 0.50 to 0.6, health production and life expectancy worsen for any income level. The equilibrium relationship between health and income gets flatter too: the marginal propensity to invest in health is weakened at lower income levels since poorer households face a larger aspirations gap which raises their marginal utility from consumption. This result is similar to the effect on saving of conspicuous consumption in youth in Corneo and Jeanne (1998) and consumption-based common aspirations in Alonso-Carrera *et al.* (2005). Figure 9(b) presents the absolute and relative change in life expectancy going from $\psi = 0$ to $\psi = 0.5$ (baseline) at different values of household income. The rich suffer the least in both absolute and relative terms, though at sufficiently high income levels the loss is trivial.[25]

The health cost of inequality

A simple though admittedly limited way to gauge the cost of inequality is to consider "compensating variation" with respect to aspirations. For example we can ask how much additional consumption does an aspirational household need to have the same expected utility were it to be non-aspirational? Or, alternatively, how many additional years of life expectancy does the household need to be indifferent between being aspirational and non-aspirational behavior? The first question cannot be answered because expected lifetime utility under aspirations is always lower than without aspirations for a given health stock. So we turn to the second one. Holding consumption, labor supply, and aspirations gap constant, Figure 10 shows how many more years of life expectancy aspirational households require to be indifferent between having and not having aspirations. across productivities. The black line is the value of Gini that the model was calibrated to, the red and blue lines show 10% increases and decreases of this value. Not surprisingly, the health cost is substantial for poorer households: 6.1 life years lost by the least productive decile compared to 3.4 life years for the most productive decile. In other words, inequality disproportionately penalizes the health of the poor.

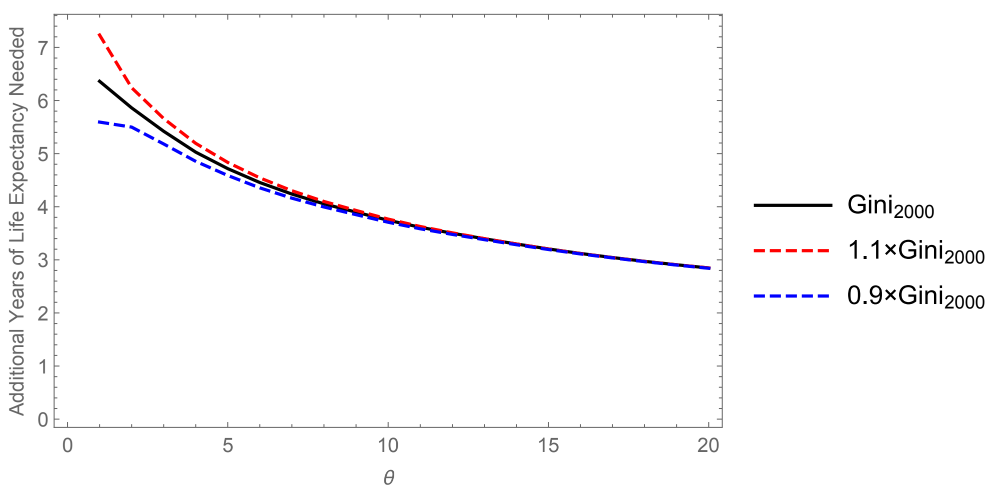


Figure 10: The Health Cost of Aspirations

[25]This cannot be seen from the figure directly. Because aspirations induce agents to pursue higher income and consumption, the equilibrium distributions of income can differ between $\psi = 0$ and $\psi = 0.5$. Specifically the baseline case will exhibit a wider range of incomes for the same underlying distribution of productivity.

5.4 The Relative Income Gradient

Weak Aggregate Relationship

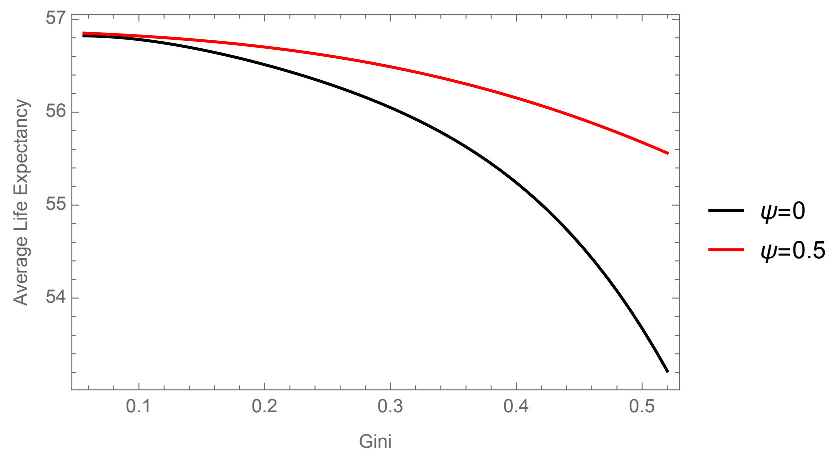
We return to our prior discussion on how this explains the empirical puzzle on inequality and health. Note, first of all, the strong concavity of the no-aspirations case in Figure 9. Clearly mean preserving spreads of the underlying productivity distribution would generate a relatively strong effect on population life expectancy as we conjectured in section 2. Moreover, as Figure 3 showed, health investment does not respond to relative position under no-aspirations. That means, the no-aspirations model would not explain the strong micro-level evidence on the relative income gradient either.

Under aspirations, though the production of health is subject to strong diminishing returns – health time investment has a natural upper bound of unity in (6) effectively making it a constraint on health accumulation even if income were to grow without bounds – the overall relationship between household health and income is weakened by relative position. In Figure 9, a marginal decrease in household income decreases its health by a relatively small magnitude if its aspirational motives are strong. This weakening of the effect of income is entirely consistent with the same household responding strongly to relative deprivation as measured by the consumption gap $c_i/\bar{C}_i$ in partial equilibrium (recall Figure 2).

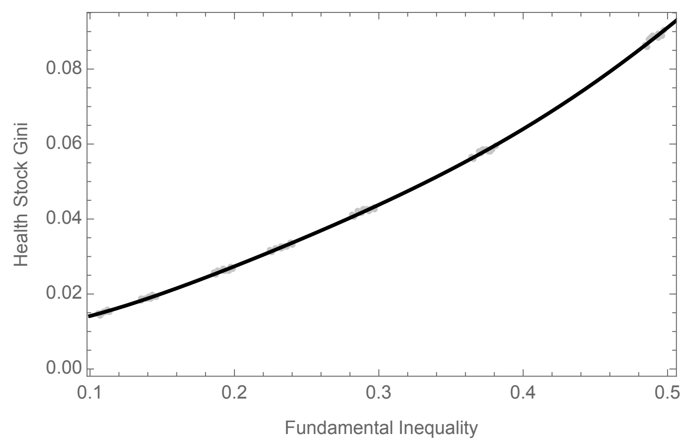
A clearer view of how aspiration weakens Jensen's inequality emerges from Figure 11(a). It plots model-generated population life expectancy against different values of income inequality with and without aspirations. It is produced from the estimated relationships in Figure 9 after ensuring that the curves for $\psi = 0$ and $\psi = 0.5$ yield the same life expectancy at the mean steady-state income level; this is to control for the level difference in Fig 9 since the model is not being recalibrated for $\psi = 0$. Higher inequality has a modest negative relationship with average life expectancy; the association weakens with aspirations. We erred on the side of being conservative in picking $\psi = 0.5$ for the baseline case since we do not have direct estimates of it. A sufficiently high value can weaken the negative relationship to insignificance. Hence, if households are aspirational, it may be hard to consistently observe the negative consequences of inequality from aggregate health statistics. Measures of health inequality, on the other hand, are more informative about the consequences of income inequality. In Figure 11(b), higher fundamental inequality strongly raises inequality of health (or longevity).

Weakening Aggregate Relationship

The model also explains why the aggregate relationship between health and inequality has weakened in recent decades. Two obvious explanations are economic growth and medical improvements. Looking again at Table 1, the sub-sample shows that after 2000 income growth had



(a) Life Expectancy at Age 20 and Inequality



(b) Health Inequality versus Fundamental Inequality

Figure 11: Health and Inequality

a significant effect on life expectancy, so it could be that increases income are causing the weakening relationship. We simulate the model economy by varying the wage rate to 10 and 30 from the baseline value of 20.[26] We find that increasing income decreases the gradient between life expectancy and inequality. This is obvious from the regression results produced from the simulated data and reported in Table 3: an increase in the wage rate weakens the negativity of the inequality-life expectancy gradient. One would, of course, expect higher income to raise health expenditure and healthy time investment. There is, however, a biological constraint on how much that can raise life expectancy (upper bound on ϕ). Therefore the impact of a uniform increase income will be weaker in those economies with already high life expectancy/low in-

[26]In comparison to the baseline, a wage of 30 represents an 52% increase in GDP, while a wage of 10 represents a 54% reduction. Though the wage rate w and aggregate return to capital r are constant in this model, this approach is similar to what one would do in a closed-economy under a Cobb-Douglas technology like $K^{\varepsilon}(BL)^{1-\varepsilon}$. In steady state, an increase in TFP B would increase the wage rate leaving unchanged the return to capital.

equality than those with low life expectancy/high inequality. The negative effect of GDP growth post-2000 in Table 3 could have to do with how widely those income gains have been shared; in practice, labor earnings have stagnated suggesting that GDP growth was associated with a worsening of the aspirations gap for the lower tail of the distribution.

		Inequality (Gini)
$w = 10$	Income	-5.981^{***}
		(-7.361)
	Consumption	-6.232^{***}
		(-7.337)
$w = 20$	Income	-5.364^{***}
		(-6.75)
	Consumption	-5.763^{***}
		(-6.735)
$w = 30$	Income	-5.164^{***}
		(-6.32)
	Consumption	-5.504^{***}
		(-6.345)

t-stats in parentheses, significance levels: ***: 1%, **:5%, *:10%

Table 3: Model: Life Expectancy and Inequality

A second possibility for the weakening correlation is changes in health production. For instance, improvement in medicine or access to medical care can yield better health from a given set of inputs. A simple way to test this is to exogenously increase health productivity Q; we consider outcomes under $Q = 0.195$ (baseline) relative to $Q = 0.2925$ for the same baseline wage of 20. The higher value of Q raises life expectancy to be sure, but also weakens the correlation between income and health. The slope coefficient goes from -5.763 to -5.011 for consumption inequality, from -5.264 to -4.625 for income inequality as Q increases. This makes intuitive sense: a higher Q increases the marginal benefits of healthy time investment and health expenditure for those with lower life expectancy (income) who are already supplying labor close to their maximum potential. The differential effect on poorer households relative to richer ones can lessen the erosive effects of inequality.

5.5 Remarks

These household-level results on the aspirations gap and health outcomes and aggregate-level results on inequality and overall life expectancy or life expectancy inequality may also arise under income-based aspirations. For example, if people cared about relative income because of upward-looking aspirations, then given his financial wealth, the only way an individual can raise his present income is by supplying more labor. That comes at the cost of less time in health production. This is also true in our model except that those income gains are valued only to the extent they helped raise relative consumption and, as we saw in the simulations, health spending also fell. If people cared about relative income, on the other hand, their higher earnings would be valued directly as well as functionally. Health spending would rise as long as health is a normal good and that would tend to substitute for the missing health time investment. As long as time and health expenditure are not too substitutable, overall health production would suffer. Similar results can be obtained under wealth-based aspirations. The important point is that as long as aspirations are formed on the basis of non-health goods or outcomes, there is a trade-off between being aspirational and being healthy.

It should be noted that not all our results require heterogeneous aspirations. Take common aspirations with respect to mean consumption. Households below the mean have a positive aspirations gap, the gap increasing the poorer a household is. The qualitative response to the aspirations gap among these households would be similar: higher labor supply, higher income, lower health production than without aspirations. Households above the mean, on the other hand, have a negative aspirations gap. Deriving “pride” from their relative success, they would supply less labor, earn less income and realize better health than otherwise. In this world, aspiration has the effect of attenuating, not amplifying, fundamental inequality. How motivating aspirations is thus depends on how it differs across the distribution.

Upward-looking aspirations seem a more plausible description of human behavior than common aspirations. The idea that the poor and the rich both desire the same standard of living contradicts what we observe, more so in light of recent media reports on attitudes towards rising inequality (Rampall, 2011 and Wood, 2011 for example). Despite spectacular income growth among the top 1-5% of households in the US over the last thirty years, researchers have observed among them a lingering feeling of not being rich, of being “middle class”. One explanation is that the sharp divergence of incomes within this group itself has caused status anxiety as the rich and the super-rich constantly compare their lives with those doing even better. Of course, pursing upward-looking aspirations in our model (negligibly) worsens the health of the rich which, depending on one’s perspective, may seem counterfactual. In reality, the rich are better equipped to redress this through better healthcare and production technologies.

6 Conclusion

We developed a model of upward-looking aspirations and demand for health to study the effect of inequality. The model showed that relative deprivation within a reference group is an important determinant of mortality. In addition, it showed that even though social aspirations can be motivating, income and consumption inequality are worsened since poorer households are limited by how much they can respond to those aspirations. When households invest in health, this worsening inequality is accompanied by another welfare cost, worsening absolute and relative health for poorer households. Finally, we provided an explanation for why the correlation between inequality and life expectancy at the aggregate level is weak and possibly declining over time.

In analyzing the effect of aspirations on household behavior, we assumed for tractability that all households are aspirational. Since not meeting one's aspirations, "aspirations failure", lowers utility, not everyone may choose to be aspirational. Typically we would see this among the poorest households who psychologically opt out of the rat race (Barnett *et al.*, 2010) or may choose not to make investments that raise their relative income (Genicot and Ray, 2010). Non-aspirational behavior would obviously neutralize the effect that aspirations has on health production. Since lack of aspirations lowers household income, their health would suffer still because of the conventional absolute income gradient. How inequality affects the decision to be aspirational and how adversely health is affected by that decision are topics for further research. Another useful extension to this paper would be to explore the role of policy. Redistributive taxation or health investment subsidies can improve health outcomes by making individuals feel relatively less deprived. Similarly public health provision, by lowering the shadow price of health for poorer households, would be a way to contain the social cost of inequality and aspirations failure.

Appendix

In an interior optimum the household equates the marginal cost and benefit from the two types of health investment, q and $1-l$, respectively:

$$\begin{aligned}(1-\alpha)Qq^{-\alpha}(1-l)^{\alpha}\left[\underline{v}+\frac{(c/\bar{C})^{1-\sigma}}{1-\sigma}\right] &= (1+H)\frac{c^{-\sigma}}{\bar{C}^{1-\sigma}},\\ \alpha Qq^{1-\alpha}(1-l)^{\alpha-1}\left[\underline{v}+\frac{(c/\bar{C})^{1-\sigma}}{1-\sigma}\right] &= w(1+H)\frac{c^{-\sigma}}{\bar{C}^{1-\sigma}}.\end{aligned}$$

It follows that healthy time and health good investment are linearly related, $1-l=[\alpha/(1-\alpha)]q/w$. Using this, rewrite the budget constraint as $c = wl+\tilde{a}-q = w+\tilde{a}-q/(1-\alpha)$. Optimal health expenditure is then the implicit solution to

$$\alpha^{\alpha}(1-\alpha)^{1-\alpha}Qc^{\sigma}\left[\underline{v}\bar{C}^{1-\sigma}+\frac{c^{1-\sigma}}{1-\sigma}\right]=(1+H)w^{\alpha}$$

with c given by the equation above and $H = Q[\alpha/(1-\alpha)]^{\alpha} w^{-\alpha} q$. Straightforward differentiation shows that

$$\frac{\partial q}{\partial w} = \frac{(1-\alpha)\left(-\underline{v}Q(\sigma-1)\sigma\left(\frac{\bar{C}}{c}\right)^{1-\sigma} + Q + \left(\frac{\alpha}{1-\alpha}\right)^{1-\alpha}(\sigma-1)\,w^{\alpha-1}\right)}{Q\left(-\underline{v}(\sigma-1)\sigma\left(\frac{\bar{C}}{c}\right)^{1-\sigma} - \sigma + 2\right)} > 0$$

$$\frac{\partial}{\partial \bar{C}}\left(\frac{\partial q}{\partial w}\right) \propto -\frac{\underline{v}(\sigma-1)^{3}\sigma\left(\frac{c}{\bar{C}}\right)^{1-\sigma}\left((1-\alpha)Qw + \alpha\left(\frac{\alpha}{1-\alpha}\right)^{-\alpha} w^{\alpha}\right)\left((\sigma-2)\left(\frac{c}{\bar{C}}\right)^{1-\sigma} + \underline{v}(\sigma-1)\right)}{Qw\bar{C}\left((\sigma-2)\left(\frac{c}{\bar{C}}\right)^{1-\sigma} + \underline{v}(\sigma-1)\sigma\right)^{3}} < 0$$

It is tedious but straightforward to show that (details available upon request) $q(w)$ is convex, that is, $q''(w) > 0$. That is, as in Hall and Jones (2007), health spending is a superior good. Straightforward differentiation also shows that $H(w)$ and $\Psi(w)$ are both increasing and concave functions (details available upon request).

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