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The Economics of Inequality, Poverty, and Health. Life After Deaton´s Report

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Abstract

The debate on the relationship between income, income inequality, and health of the last two decades has been based almost entirely on empirical considerations. The ideas prompting the debate are based on the concave relationship observed between health and income across countries, which suggests a negative relation between average health and income inequality. Angus Deaton's (2003) survey suggests that much of the relation between inequality and health comes from that nonlinearity and that inequality per se is not important for health other than through its effect on poverty. From this conclusion it follows that due to economic growth income and income inequality have ceased to be important determinants of population health in industrialized countries and soon they will be so in developing ones. We must notice, however, that: first, poverty is still widespread in developing countries, and that inequality is still important there; second, the poverty line income is not a constant; it depends on people's preferences, technology, and on average income and income inequality. To introduce the analysis of poverty in a theoretical account of the relation between income, inequality, and health we must move away from the simple concave model of income and health, and even beyond the more realistic albeit still ad-hoc formulations in the recent literature, and start studying economies with utility maximizing agents whose choices are guided by preferences for consumption and health and restricted by production and time. Not only a more precise analysis of the role of poverty and inequality in the determination of health will be gained, but also a better knowledge of how health inequalities affect economic behavior, such as labor supply. A model with micro-foundations will also allow us to use comparative-static analysis to identify which factors can breakdown a negative relationship between inequality and health operating through poverty, and thus help us better understand the most recent empirical findings. The purpose of this paper is to introduce such a model of inequality, poverty, and health.

JEL Classification: I12, D13, D31, H21, J22

Keywords: health, household production, inequality, poverty, disease environment.

Resumen

El debate en torno a la relación entre ingreso, desigualdad del ingreso y salud poblacional que lleva dos décadas ha estado basado casi enteramente en consideraciones empíricas. Las ideas que han motivado el debate han surgido de la curva cóncava que normalmente describe la relación entre salud e ingreso entre países, y que sugiere una relación negativa entre desigualdad y salud. La revisión crítica de la literatura realizada por Deaton (2003) sugiere que la relación observada entre desigualdad y salud proviene de esa nolinealidad y que la desigualdad no tiene por sí misma un impacto sobre la salud más allá de sus efectos a través de la pobreza. De esto se sigue que debido al crecimiento económico el ingreso y la desigualdad han dejado de ser determinantes importantes de la salud poblacional en los países industrializados y que pronto lo serán en los países en desarrollo. Debemos mencionar, sin embargo, que: primero, la pobreza es endémica en los países en desarrollo y que la desigualdad es aún importante allí; segundo, el ingreso de línea de pobreza no es una constante, depende de las preferencias de la gente, de la tecnología, del ingreso medio y de la desigualdad. Para introducir el análisis de la pobreza en una teoría de la relación entre ingreso, desigualdad y salud debemos dejar de lado el simple modelo de la relación cóncava y aun las formulaciones más realistas recientes pero todavía ad-hoc que se encuentran en la literatura; debemos empezar a estudiar estas relaciones en un marco teórico con agentes racionales cuyas decisiones estén guiadas por preferencias sobre unidades de consumo y estados de salud y restringidas por sus recursos materiales y temporales. No sólo lograremos comprender de manera más precisa la relación entre pobreza, desigualdad y salud poblacional, sino que entenderemos mejor el efecto de las desigualdades en salud sobre el comportamiento económico, como el de la oferta laboral. Un modelo con fundamentos microeconómicos nos permitirá utilizar el análisis estático-comparativo para identificar los factores que, de estar correlacionados con el ingreso o la desigualdad, eliminarían el impacto negativo de la desigualdad sobre la salud que opera a través de la pobreza, lo cual nos ayudaría a interpretar mejor los resultados obtenidos en las estimaciones antes mencionados. El propósito de este trabajo es presentar ese modelo de desigualdad, pobreza y salud.

Clasificación JEL: I12, D13, D31, H21, J22

Palabras clave: salud, producción del hogar, desigualdad, pobreza, ambiente de enfermedad.

Introduction

The existence and quality of the relationship between economic inequality and population health has been the subject of a vigorous debate in economics during the last two decades. Deaton's (2003) survey of the topic includes a critical review of the empirical literature, preceded by a discussion of the theoretical issues involved; this survey subsumes all the relevant work and it is our main point of departure. See also Li and Zhu (2006) for an updated bibliography and new evidence from China.

Deaton's theoretical discussion extends on the notion that a concave relationship between health and income within groups (in individual data) implies a negative relationship between average health and income inequality across groups (in aggregate data). Most of the evidence from aggregate data suggesting a link from inequality to health would then seem to be driven by this nonlinearity, and would not necessarily indicate a direct impact of inequality on average health.

Deaton starts from the very beginning, by asking whether it is even true that income has a causal impact on health; instead he emphasizes economists' idea of a reverse causality, from health to income, an idea that predicts wealth and education rather than income as factors determining health. He concedes, however, that empirically it is hard to disentangle these effects —for instance, the estimated relationship between income and health is reduced but not eliminated when controlling for risky behavior; that no one doubts that in poor countries, due to widespread malnutrition, income causes health; and finally that differences in health among adults in developed countries can be traced back to differences in income during childhood. These last considerations seem to convince him that assuming some causality from income to health is not an exageration.

He then proceeds to show theoretically how a concave relationship between income and health at the individual level produces a negative relationship between average health and income inequality in the aggregate, even when inequality *does not* have a direct impact on individual health. This is the so-called absolute income or poverty hypothesis.

Since the postulated concave relationship between income and health at the individual level is an ad-hoc formulation, Deaton also shows how more realistic theories of health determination end up producing the same effect as the simple concave hypothesis. Of particular interest for us is his discussion of a model in which individual health is linked to a latent variable, itself a function of income, in a way that bad health outcomes occur when the latent variable falls below some critical level. The model we introduce below to study inequality and health has many features in common with the latent variable model, but there are notable differences as well.

Deaton completes his theoretical discussion with an account of the implications of the relative income hypothesis, the idea that it is relative income and/or rank within a hierarchy which determines individual health. In this framework he discusses the so-called theory of mortality risk, and finally other channels through which inequality might affect health: credit constraints and underinvestment in human capital; the nutritional wage theory; and the relation between public goods and political inequality.

In the second part of his survey Deaton reviews the empirical literature and discusses the evidence. This session starts warning us that most measures of income inequality used in the literature are either of bad quality or not comparable across countries, or even over time for a given country. This reduces dramatically the number of studies to which Deaton gives any credibility.

The first category of studies reviewed is cross-country studies of income inequality and health. Preston (1975) and his followers were the first ones to estimate a concave relationship between income per capita and health across economies and postulate and estimate negative relationships between income inequality and health. These early contributors did not claim a direct impact of inequality on health and seemed to have been fully conscious that any such relationship was a result of the nonlinearity in the relationship between income and health.

A second generation of contributors led by Wilkinson (1992) reinterpreted the findings from cross-country studies as evidence that average income is the relevant determinant of health (say, of infant mortality) in poor countries and that income inequality is the relevant determinant in richer countries; and also as evidence of a negative association between income inequality and health (measured by life expectancy) within industrialized countries.

Later on —late 1990s and early 2000s— a third generation of researchers showed that i) with improved data sets, the findings of Wilkinson and his followers could not be replicated; and ii) the relationship between inequality and life expectancy across industrial countries vanished when researchers controlled for variables such as education and income per head.

Deaton therefore concludes that there is currently no evidence that income inequality affects life expectancy and all-cause mortality within industrialized countries. He does take for good the evidence from developing countries showing that, conditional on income, there is a negative relationship between inequality and infant mortality; which he interprets as merely showing the impact of high inequality on poverty levels, with poverty being the ultimate determinant of infant mortality.

Given the rebuttal of the evidence from cross-country data, researchers have estimated the relationship across states of the United States. This line of research has found evidence of a strong negative relationship between inequality and many measures of health, particularly all-cause mortality.

While the quality of the data is indisputable, the results seem again to vanish whenever one controls for education, urbanization, and especially, by the share of blacks in the population. Coherently, no evidence supporting a link from inequality to health was found for Canadian or Australian provinces where race inequalities are seemingly less dramatic.

A third category of research, which seeks to isolate the effect of nonlinearity of income on health, are studies using individual data. These studies have had even less success in establishing a negative relation between income inequality and health.

Deaton's final conclusion is that inequality itself is not a major determinant of population health in industrialized countries; but that income inequality might still be important in developing countries.

Does Deaton's assessment leave any room for further inquiries into the relation between inequality and population health? We believe the answer is: yes, if we are willing to introduce a more prominent role for poverty into the theory. The chances of reaching a consensus on the relationship between inequality and health currently rely mainly on filling in the theoretical vacuum.

There remain many questions unanswered. Even when controlling for education income has, in Deaton's words, a protective effect on health at the individual level; the same is not always true in the aggregate data, the controlled effect of average income on health is sometimes negative. The contrast between the effects of income with individual and aggregate data is puzzling. We thus need to know more about the way income determines health at both the individual and aggregate level.

Another pressing question is why does the fraction of blacks in the population have a deleterious effect on population health in the United States? Let's recall that the evidence supporting a link from inequality to population health across US states and metropolitan city areas vanishes when researchers control for the fraction of blacks in the population.

The case for further inquiries into the relationship between inequality and health is maybe most strongly favored, however, by the causal effect of income on health found in poor countries, both in individual and aggregate data. Because poverty causes poor nutrition, inadequate sanitation, and low living standards, income inequality works through poverty to determine health. There might also be external effects of individual choices, and thus of individual income, on other people's health working through the disease environment, in a way similar to that postulated by the relative deprivation hypothesis.[1]

[1] Recent evidence supports the view of a link between average health and environmental conditions in developing and developed countries. Moreover, this link between quality of the environment and health seems to be stronger in economies with larger income inequality [Gaarder (2002)].

It is only within a model of rational agents that the effects of income inequality and poverty on health can be fully analyzed. In Deaton's ad-hoc formulations, the effects of changes in income and income inequality on health are analyzed as if the poverty line income was a constant. A more realistic account would make the poverty line depend not only on constant factors such as people's preferences but also on variable factors such as the cost of producing health at different levels of average income and income inequality.

Important marginal effects going from health to income are also left out of the discussion unless we model individuals' maximizing behavior. In particular, the effects of health on labor supply is usually not taken into account; differences in health status, given education, might lead to differences in the amount of labor supplied.

A promising way of modeling the relationship between income, income inequality, and health in a context of rational agents who maximize their utility from consumption and health status subject to income and time constraints, is closely related to the realistic but still ad-hoc formulation discussed by Deaton in which health is assumed to depend on a latent variable —itself a function of income— and that poor health occurs when the latent variable takes a value below a given threshold.

In section 2 we introduce a basic model along these lines to study inequality, poverty, and health. We use the model to analyze how individual and average health outcomes are determined by the interaction between income distribution, individuals' demand for health, and the disease environment.

In this model, individuals produce health at home with time and sanitation services. Sanitation services are shorthand for the broad category of health services derived from sanitary infrastructure such as potable water, sanitation itself, sewage, and refuse collection.

In the model, access to sanitation is achieved by settling down in a favorable location, such as a downtown area, where these services are available. To live in a favorable location individuals have to forego resources that would otherwise be consumed. Individuals without access to the sanitation services are those who settle down for free in a less favorable location, such as the outskirts of a city. So the location decision and the demand for sanitation services are actually the same decision in this model.

The marginal productivity of time and sanitation services allocated to the production of health is affected by the quality of the disease environment. In turn, the quality of disease environment is determined by the share of population with access to sanitation services.

Individual utility depends on both consumption and health; as mentioned above, individuals buy sanitation services and combine them with nonmarket time to produce health; consumption goods are bought directly from the market. Purchases of consumption goods and sanitation services must satisfy the budget constraint of the individual, while time in home production plus time in the market exhaust the endowment of time.

Individuals' choices regarding location, consumption, and time allocation are rational. Individuals do not take into account, however, the impact on the disease environment of their location choice. The presence of this externality renders the equilibrium allocation inefficient in this model. In the Appendix 2, and under more restrictive assumptions regarding preferences and technologies, we find the optimal allocations and derive the Pigouvian scheme of taxes and subsidies that would implement it.

In section 3 we use the model to study the relation between inequality and average health. We first show in section 3.1 that if the utility function is quasilinear average health is affected neither by the degree of income inequality nor by the level of median income in the economy, and average health is entirely determined by preferences and technology. This restrictive assumption is then dropped in section 3.2 where we assume a more standard, convex, specification for the individual preferences. It is under this specification that the model yields a negative relationship between inequality and average health.

Section 4 discusses the way the model allows us to interpret the main empirical findings in the literature. In particular, we use the model to establish the conditions under which the negative relationship between inequality and population health vanishes; we focus on two reasonable explanations: The first is that the cost of sanitation services might itself be associated with inequality; the second is that median income and income inequality might be related in the fashion of a Kuznets' Curve across economies, or over time for a given economy. We study the predictions of the model under these assumptions and find that they are successful in breaking down the negative relation between inequality and average health. We also analyze in this section the way in which the interaction between income distribution, preferences, technology, and the cost of sanitation jointly determine the poverty line, and we show that the effects of income and income inequality on poverty and thus on population health might not disappear with economic development as fast as we might thought when the poverty line is variable rather than constant.

Section 5 discusses the limitations of the model and concludes. In this version all graphs and figures are confined to the end of the paper, after the references and the two appendices.

2. The Model

2.1. Individual Preferences

We think of an economy populated by individuals who derive utility from the consumption of a market good c and a home produced commodity q; thus utility can be represented by a function $u = u(c,q)$ which the individual will seek to maximize. In general, we shall assume that the marginal utility of both objects of choice is positive and decreasing. In order to focus on the topic of the paper we will associate c with the traditional notion of pure consumption units and q with the "health status" of the individual.

2.2. Home Production Technology

Health status q is determined by the interaction between the individual production of health, h, and the quality of the disease environment, denoted by H.[2] This home production technology can be represented by the production function $q = q(h,H)$. Individual production h is determined by the function $h = h(1-l,s)$. Let l, with $0 < l \leq 1$, be the proportion of the individual's time endowment devoted to the production of market goods so that $1-l$ is time in home production. And let s be an indicator of the individual's access to a market good, the second input in the home production: $s = 1$ if the individual has got access to this good, and $s = 0$ otherwise. This input is thus an indivisible good. Although there are many examples of indivisible inputs in the home production of health, in this paper we think of this good as providing sanitation services.

2.3. Location and Sanitation Services

The indivisible nature of the good providing sanitation services can be motivated by thinking of its provision as geographically limited. We assume that in order to have access to sanitation individuals must choose one of two locations in a circular city; we can think of these two locations as "the center" and "the outskirts". Sanitation services are only available in the city center, and to secure a location there the individual must pay an amount $\kappa > 0$ of the numeraire good. Location in the outskirts is for free (no consumption must be foregone) but no sanitation services are provided there. We assume that there are no congestion effects resulting from the location choices of individuals.

[2] See Gary S. Becker (1993), and A. Cigno (1991), chapter 2.

2.4. Disease Environment

The quality of the disease environment in the city, denoted by H, is assumed to depend directly on the share of population with access to sanitation services. For simplicity we assume that H is equal to the percentage of the population with access to the sanitation services.

2.5. Individual Budget Constraint

We assume individuals are producer-consumers with different labor productivity levels, ω. Since individuals allocate l units of time to the production of the numeraire good y, then $y = \omega l$. The numeraire good can be used either for consumption or in exchange for sanitation services. Since the model is static, there is neither a storage technology nor a market for borrowing and lending and thus no physical capital. The budget constraint of an individual with labor productivity ω who chooses to live in the city center is therefore given by $c + \kappa = y$, while for an individual who chooses a location in the outskirts the budget constraint is $c = y$.

2.6. Population and Income Distribution

Individuals are distributed over levels of labor productivity according to the density function $n(\omega)$. The cumulative distribution function is given by $N(\underline{\omega}) = \int_0^{\omega} n(\omega) d\omega$. We further assume that ω ranges from 0 to ∞, so that total population of the economy is given by $N = \int_0^{\infty} n(\omega) d\omega$. For simplicity, we normalize $N = 1$. Figure 1 shows one possible cumulative distribution function.

2.7. Individual Optimization Problem

For the moment let's set $l = \ell$, $0 < \ell < 1$, for all individuals; then the production of the numeraire good depends only on the level of productivity of each individual. This simplification allows us to concentrate in the trade-off between consumption and health facing the individuals. We relax this assumption in section 3.2 below.

With a constant l, the only remaining determinant of individual health production is location, i.e. access to sanitation. Individuals therefore maximize their utility by choosing consumption and location. While consumption is a continuous variable, location is a discrete one: either $s = 1$ and the individual chooses a location in the city center with access to sanitation services, or $s = 0$ and the individual chooses a location in the outskirts of the city with no access to sanitation services.

In order to solve this optimization problem, it is useful to think of the individuals' decision making process as taking place in two stages.

In the first stage, the individual chooses the level of consumption c_s^*, for a given income *and a* given location s, with $s = 0,1$. The solution is trivial; let $c_0^* = \omega\ell$ and $c_1^* = \omega\ell - \kappa$ be optimal consumption without and with access to sanitation services, respectively, for a labor productivity ω. Location also determines health; for an equilibrium H , H^*, let $q_1^* = q_1\left[(1-\ell,1), H^*\right]$ be the health status achieved if $s = 1$, and let $q_0^* = q_0\left[(1-\ell,0), H^*\right]$ be the health achieved if $s = 0$.

Then, in the second stage the individual chooses the location s which yields the larger utility. At this stage the problem of the individual is to

$$\underset{s\in\{0,1\}}{Max}\left\{u\left(c_s^*, q_s^*\right)\right\}$$

As we shall see below, this choice depends on the individual's productivity level, on the location cost, and on the parameters of the distribution of the population over the levels of labor productivity.

2.8. The Equilibrium Allocation

The equilibrium in this economy is described by the share of the population with access to sanitation services, and the consumption and health status of all individuals.

To find the equilibrium allocation we conjecture that there must be a threshold value of labor productivity, denoted $\overline{\omega}$, for which individuals are indifferent between choosing a location in the city center —and thus having access to sanitation services— and choosing a location in the outskirts —and having no access to sanitation.

Notice that q_s^* will depend on $\overline{\omega}$: when choosing s individuals take H^*, the equilibrium quality of the disease environment, as given; equilibrium H must itself be consistent with individuals' choices since H is the share of population choosing a location with access to sanitation services. In equilibrium it must be true that

$$H^* = 1 - N\left(\overline{\omega}\right) = 1 - \int_0^{\overline{\omega}} n(\omega)\, d\omega ,$$

where $N\left(\overline{\omega}\right)$ is the share of individuals without access to sanitation services.

Then the threshold productivity level $\overline{\omega}$ solves the equation

$$u\left(\overline{\omega}\ell, q_0^*\left(h(1-\ell,0),1-N\left(\overline{\omega}\right)\right)\right) = u\left(\overline{\omega}\ell - \kappa, q_1^*\left(h(1-\ell,1),1-N\left(\overline{\omega}\right)\right)\right) \tag{1}$$

Labor productivity $\overline{\omega}$ is a threshold in the sense that all individuals with $\omega < \overline{\omega}$ will end up choosing $s = 0$, while all individuals with $\omega \geq \overline{\omega}$ shall choose $s = 1$. We show below that under standard assumptions regarding the form of the utility function there is a unique solution to this equation.

The equilibrium is thus fully described by $\overline{\omega}$. Once we know $\overline{\omega}$, we also know how many individuals have access to sanitation services; the quality of the disease environment; and the levels of consumption and health achieved by each individual.

3. Inequality and Health

In this section we use the model to derive the relation between income, inequality, and health. Before we proceed with the analysis we must first show how to compute the average level of health of the population, and then we must parameterize the functions for the preferences and technologies.

Notice that with a constant time allocation, having or not access to sanitation services fully determines the individuals' level of health; then the average health status of the population can be computed from the formula

$$\overline{q} = N\left(\overline{\omega}\right)\, q_0\left(h(1-\ell,0),1-N\left(\overline{\omega}\right)\right) + \left[1-N\left(\overline{\omega}\right)\right]\, q_1\left(h(1-\ell,1),1-N\left(\overline{\omega}\right)\right),$$

where $\overline{q}$ denotes the average level of health achieved by the population.

It is straightforward to show that $\overline{q}$ is negatively related to $N\left(\overline{\omega}\right)$. The larger the share of population without access to the sanitation services, the lower the average level of health achieved.

We assume that the health production function takes the form of a CES function with $q_s(h,H) = \left[\beta h^{\varphi} + (1-\beta)H^{\varphi}\right]^{\frac{1}{\varphi}}$, for $s = 0,1$, $0 < \beta < 1$ and $0 < \varphi < 1$; we further assume that h is a linear function of time and sanitation services $h = (1-\ell) + \delta s$, with $s = 0,1$, and where $\delta > 0$ is the impact of sanitation services on health.

Regarding preferences, we consider two forms for the utility function. In section 3.1 we assume that the utility function is quasilinear, linear in consumption and concave in health; in section 3.2 we assume utility is concave in both consumption and health; in both cases we assume separability between consumption and health.

3.1. Quasilinear Preferences

If the utility function takes the quasilinear form $u(c,q)=c+\ln q$, then $\overline{\omega}$ solves the equation

$$\ln q_1(\overline{\omega})-\ln q_o(\overline{\omega})=\kappa\ , \tag{2}$$

to be compared with the general equilibrium condition (1) above. This equilibrium condition has a very clear interpretation. For an individual with productivity $\overline{\omega}$ the left-hand side (LHS) of the equation is the gain, and the right-hand side (RHS) is the cost, of choosing a location in the city center with access to sanitation services. The level of labor productivity $\overline{\omega}$ is the one for which individuals are indifferent between locating in the city center or in the outskirts.

Again, individuals with $\omega<\overline{\omega}$ find that LHS < RHS and they achieve a larger utility by choosing to live in the outskirts ($s=0$). Alternatively for individuals with $\omega>\overline{\omega}$, LHS > RHS and they maximized utility by choosing $s=1$. It can be shown that this value is uniquely determined. Write (2) as

$$\frac{q_1(\overline{\omega})}{q_0(\overline{\omega})}=e^{\kappa}\ ;$$

after substituting $q_1(\overline{\omega})$ and $q_o(\overline{\omega})$ from their functional forms and rearranging the terms, equation (2) can be rewritten as

$$\frac{\beta(1-\ell+\delta)^{\varphi}+(1-\beta)[1-N(\overline{\omega})]^{\varphi}}{\beta(1-\ell)^{\varphi}+(1-\beta)[1-N(\overline{\omega})]^{\varphi}}=e^{\varphi\kappa}\ .$$

There is only one $\overline{\omega}$ that solves this equation: the LHS increases monotonically with ω and the RHS is a constant. We can even solve analytically for the equilibrium value. The size of the population without access to sanitation services is given by the formula

$$N(\overline{\omega})=1-\left[\frac{\beta\left((1-\ell+\delta)^{\varphi}-(1-\ell)^{\varphi}e^{\varphi\kappa}\right)}{(1-\beta)(e^{\varphi\kappa}-1)}\right]^{\frac{1}{\varphi}}. \tag{3}$$

Since the cumulative distribution function $N(\cdot)$ is known, we can readily find $\overline{\omega}$ by inverting the function.[3] Graphically, the solution is shown in Figure 2.

[3] This equilibrium is suboptimal. We solve for the Pareto optimal allocation in Appendix 2.

Notice, interestingly, that $N(\overline{\omega})$ depends only on the parameters determining preferences and technology, and is independent from the parameters of the income distribution. For example, two income distributions with equal median but differing degrees of dispersion will have the same $N(\overline{\omega})$.

To see this, consider the two cumulative distribution functions displayed in Figure 3. Both cumulative distribution functions correspond to income distribution functions with median m_ω but with different levels of inequality; the solid line is the cumulative distribution function of a more unequal income distribution. Since $N(\overline{\omega})$ is independent of the parameters of the income distribution function, $\overline{\omega}$ is smaller in the economy with higher inequality, but the share of population with access to sanitation services is the same in both economies, and so is the level of average health.

Average health is also independent of changes in the median income, for a given degree of income inequality. Figure 4 depicts the cumulative distribution functions of two income distribution densities which differ in median income labor productivity, but have similar degrees of labor productivity dispersion. The solid line represents the cumulative income distribution of the richer economy, i.e. the one with higher median income.

Again, $N(\overline{\omega})$ is the same regardless the parameters of the income distribution function; it is $\overline{\omega}$ which adjusts to the difference in the median incomes: it is larger in the economy with larger median income. So under this parameterization "rich" economies do not achieve higher levels of average health than poor economies. The share of population with access to sanitation services is the same in both economies, and so is the level of average health.

With quasilinear utility, average health achieved by the population is independent of the income distribution.[4] Although this result is consistent with the claim —supported by the empirical evidence— that health and inequality are unrelated, it is clearly inconsistent with the evidence that richer economies have a larger proportion of population with access to sanitation services and thus with better average health.

A more standard formulation is therefore adopted in section 3.2: utility is assumed concave in both consumption and health, but we keep the separability assumption. In this more general setting inequality will affect health negatively and richer economies will have higher shares of population with access to sanitation services.

[4] See Mas-Colell *et al.* (1995), sections 10.C and 10.G., for a general discussion of the relation between endowments' distribution and equilibrium allocations in quasilinear economies.

3.2. Convex Preferences and the Time Allocation

In this section we derive the relation between inequality and average health in a more standard setting regarding preferences and the use of time. In particular we assume convex separable preferences over consumption and health, and we relax the assumption made before regarding the invariability of time devoted to the production of goods and health. Assume that the utility function now takes the form $u(c,q)=v(c)+f(q)$; where $v(c)$ is an increasing and concave function of c, i.e. $v'(c)>0$, $v''(c)<0$; and $f(q)=\ln q$ as before. Also assume that time devoted to goods production, l, is a choice variable. The share of time which is not devoted to market activities is used, as before, in the production of h.

3.2.1. Labor Supply

The allocation of time to the production of goods and to the home production of health will differ across individuals according to the degree of access to sanitation services. In what follows we show that individuals with access will be able to produce more h with the same home production time; these individuals will prefer, in the margin, to supply less labor to home production and allocate more time to the production of consumption goods, and will therefore be better off.

Let $l(\omega,s)$ be the time devoted to the production of consumption goods as a function of labor productivity and the access to sanitation services. Let's keep in mind that $s=1$ for individuals with access to sanitation, and $s=0$ for those without access to sanitation services.

The optimal $l(\omega,0)$ solves the following problem:

$$\underset{l}{Max}\ \{v(c_0)+\ln q_0\}$$

subject to

$$c_0=\omega l$$

and

$$q_0=\left[\beta(1-l)^{\varphi}+(1-\beta)H^{\varphi}\right]^{\frac{1}{\varphi}}$$

with, H, given.

The first-order condition is

$$v'(\omega l)\omega=\frac{\beta(1-l)^{\varphi-1}}{\beta(1-l)^{\varphi}+(1-\beta)H^{\varphi}} \tag{4}$$

The LHS is the marginal utility from the larger consumption resulting from the increase in time allocated to market activities; the RHS is the marginal cost in terms of health (the marginal loss in utility from health) resulting from the decrease in time allocated to home production. Since the LHS is negatively related to l and the RHS is positively related, there is a unique optimal value of l, $l^*(\omega,0)$. We can see the result graphically by drawing a downward marginal utility schedule which intersects an upward marginal cost schedule at the optimal level of market time.

The optimal $l(\omega,1)$ solves the following problem:

$$\underset{l}{Max}\ \{v(c_1)+\ln q_1\}$$

subject to

$$c_1=\omega l-\kappa$$

and

$$q_1=\left[\beta(1-l+\delta)^{\varphi}+(1-\beta)H^{\varphi}\right]^{\frac{1}{\varphi}}$$

for given H.

The first-order condition in this case is given by

$$v'(\omega l-\kappa)\omega=\frac{\beta(1-l+\delta)^{\varphi-1}}{\beta(1-l+\delta)^{\varphi}+(1-\beta)H^{\varphi}} \qquad (5)$$

Since the level of consumption is lower now —consumption must be foregone to pay for the sanitation services— the marginal valuation of consumption increases for all l; and since the level of health is larger now, the opportunity cost of time in market activities decreases for all l. As a consequence, $l^*(\omega,1)$ is unambiguously larger than $l^*(\omega,0)$.

Graphically, the marginal utility schedule shifts to the right and the marginal cost schedule shifts down, and intersect each other at higher levels of l, relative to the situation in which the individual does not have access to sanitation services.

Figure 5 shows the individual's optimal allocation of time $l^*(\omega,s)$ resulting in each case. The marginal cost curve for the individuals with access to sanitation services is below and to the right of the corresponding cost curve for those without access; and the marginal utility curve for those with access to sanitation is above and to the right of the corresponding one for those without sanitation. Individuals with access to sanitation services and higher health status spend more time producing consumption goods than the rest of the individuals.

3.3. Equilibrium Access

Once we have derived the pattern of labor supply of all individuals we can find the threshold level $\bar{\omega}$, the labor productivity for which individuals are indifferent between choosing $s=0$ or $s=1$, for the case of convex preferences. The equivalent of equation (1) is now given by

$$v\left(\bar{\omega}\, l^*\left(\bar{\omega},0\right)\right)+\ln q_0\left(1-l^*\left(\bar{\omega},0\right),1-N\left(\bar{\omega}\right)\right)=v\left(\bar{\omega}\, l^*\left(\bar{\omega},1\right)-\kappa\right)+\ln q_1\left(1-l^*\left(\bar{\omega},1\right)+\delta,1-N\left(\bar{\omega}\right)\right)$$

or equivalently,

$$\frac{q_1\left(1-l^*\left(\bar{\omega},1\right)+\delta,1-N\left(\bar{\omega}\right)\right)}{q_0\left(1-l^*\left(\bar{\omega},0\right),1-N\left(\bar{\omega}\right)\right)}=e^{v\left(\bar{\omega}\, l^*\left(\bar{\omega},0\right)\right)-v\left(\bar{\omega}\, l^*\left(\bar{\omega},1\right)-\kappa\right)}. \qquad (6)$$

After substituting $q_1(\cdot)$ and $q_o(\cdot)$ from their functional forms and rearranging terms, this equilibrium equation can be written as

$$N\left(\bar{\omega}\right)=1-\eta\left(\bar{\omega}\right), \qquad (7a)$$

with

$$\eta\left(\bar{\omega}\right)=\left[\frac{\beta\left(\left(1-l^*\left(\bar{\omega},1\right)+\delta\right)^{\varphi}-\left(1-l^*\left(\bar{\omega},0\right)\right)^{\varphi}e^{\varphi v\left(\bar{\omega}l^*\left(\bar{\omega},0\right)\right)-\varphi v\left(\bar{\omega}l^*\left(\bar{\omega},1\right)-\kappa\right)}\right)}{\left(1-\beta\right)\left(e^{\varphi v\left(\bar{\omega}l^*\left(\bar{\omega},0\right)\right)-\varphi v\left(\bar{\omega}l^*\left(\bar{\omega},1\right)-\kappa\right)}-1\right)}\right]^{\frac{1}{\varphi}}. \qquad (7b)$$

From our previous analysis of labor supply and from the properties of the utility function, it can be proved that $\eta'(\omega)>0$ (see the Appendix A1) . Then, the equilibrium value $\bar{\omega}$ is found in the intersection of the upward sloping $N(\omega)$ function with the downward sloping function $1-\eta(\omega)$.

The solution is depicted in Figure 6. The upward sloping function is determined by the parameters of the labor productivity distribution function and the downward sloping one is determined by the parameters of preferences and technology and by the cost of sanitation services.

Now the parameters of the income distribution, which determine the position of the function $N(\omega)$ in Figure 6, affect the level of access to sanitation and average health in the economy. Changes in the parameters of preferences and technology will also affect the equilibrium. In particular, the cost of access to sanitation determines the position of the downward sloping curve in the graph, and therefore the point at which it intersects with the income distribution curve; a higher cost shifts this curve above and to the right, a result that will be important in the discussion of next section.

Figure 7 shows that higher inequality, for a given a median labor productivity, results in a larger share of population without access to sanitation services and thus in a lower level of average health. Figure 8 shows that, given labor productivity dispersion, a higher median labor productivity is associated with a lower share of population without access to the sanitation and higher average health.

Summarizing, the model with standard convex preferences predicts that higher inequality, given median income, results in lower average health, and that richer economies, given inequality, enjoy higher levels of average health.

4. Discussion

Higher inequality negatively affects average health in our model with convex preferences. Deaton (2003), however, does not find compelling empirical evidence supporting this negative relationship in aggregate data across economies. Can our model help us understand why this might be the case? Sections 4.1 and 4.2 provide two plausible explanations.

In Deaton's (2003) discussion of the poverty hypothesis —in which low incomes and poverty are responsible for bad health outcomes— it is implicitly assumed that the poverty line is a constant, and as a consequence income and income inequality cease to have an effect on health with economic development rather soon in time. In section 4.3 we show that in our model the poverty line is a variable endogenously determined by the parameters of preferences and technology, the cost of sanitation, and even by median income and income inequality, and thus to assume it constant can be misleading.

4.1. The Cost-of-Access Hypothesis

In the empirical literature the negative relationship between inequality and health typically vanishes when researchers control for education, urbanization, and for the case of US states and cities, the fraction of blacks in the population.

In our model the cost of access to sanitation can be thought of as a determinant of urbanization; a higher cost, given income and inequality, results in higher shares of population without sanitation. The negative relation between inequality and average health breaks down if the cost of access to sanitation κ is higher in more equal economies.

Figure 9 shows two economies with the same median labor productivity but with different degrees of inequality. In the economy with lower inequality the higher cost of access wholly eliminates the gap that would otherwise exist between levels of access to sanitation services in both economies; both economies enjoy the same level of access and therefore the same level of average health although inequality is larger in one of them.

4.2. The Kuznets Curve Hypothesis

The negative relationship between average health and inequality also breaks down when we allow for the existence of a Kuznets curve across economies.

The Kuznets curve is inverted-U relationship between income inequality and average income found across countries [see for example Barro (2000)]. There is a level of average income for which inequality is greatest; for smaller and larger income levels inequality is lower.

The model predicts that, for a given median labor productivity level, higher inequality in labor productivity is associated with lower average health; the model also predicts that richer economies, holding inequality constant, are associated with better population health.

If we allow for an equivalent of a Kuznets curve in terms of labor productivity, the negative relation between inequality and health predicted by our model breaks down in a cross-economy analysis.

Consider a group of low average labor productivity economies, those to the left of the Kuznets curve; if we observe that higher income economies are more unequal, then inequality will be unrelated to (or positively associated with) average health because the beneficial effect of a larger average income on population health may partly or totally compensate for the negative impact of higher inequality.

Our model supplemented with a Kuznets curve hypothesis in labor productivity thus implies that the relation between inequality and population health could not necessarily be negative across countries with low levels of labor productivity, even when inequality do worsens health, for a given income.

4.3. Poverty and Health

Who are poor in our model economy? Which is the poverty line income? In our simple model the poor are those without access to sanitation: among the poor labor productivity is lower than $\bar{\omega}$, and the poor earn less than $\bar{\omega} l^*(\bar{\omega},0)$, which is the poverty line income. The number of poor individuals is $N(\bar{\omega})$, a version of the well-known "head-count ratio" [see Foster and Sen (1997)]. Notice that the poverty line income increases monotonically with $\bar{\omega}$, so in what follows we study the behavior of $\bar{\omega}$ in order to understand the way the poverty line income changes with changes in median income and inequality.

With convex preferences on consumption and health, and for given parameters of the technology, preferences, and the cost of sanitation, a more equal distribution of labor productivity (given median productivity) or a higher median labor productivity (given inequality) cause $\bar{\omega}$ to increase and $N(\bar{\omega})$ to decrease (see Figures 7 and 8, respectively). This means that richer and more equal societies have higher poverty line incomes but less poverty and better population health.

When the absolute income —or poverty— hypothesis is invoked to claim that with economic development average income and inequality will cease to be associated with population health, a constant poverty line income is implicitly assumed. In our model, if the threshold value of labor productivity below which people are poor was constant, then an increase in median labor productivity or a decline in inequality would produce a sharp decrease in the fraction poor. But since this threshold is determined endogenously, instead, a comparable increase in median labor productivity or a decline in inequality reduces the fraction poor much less. In other words, it may take much longer than it is now expected for economic development to render income per capita and inequality irrelevant for population health.

Appendix 1

The sign of the derivative $\eta'(\omega)$ in (7a) is a crucial determinant of the sign of the relation between inequality and population health in the model. If $\eta'(\omega) > 0\,(<0)$, then population health is negatively (positively) related to inequality in labor productivity. We show here that $\eta'(\omega) > 0$ under the general assumptions regarding preferences and production functions postulated in section 3.2. To begin notice from (7b) that $\eta(\omega)$ is the ratio of two functions of ω; let $\Omega(\omega) > 0$ be the numerator and $\Theta(\omega) > 0$ the denominator in (7b). Then $\eta'(\omega) = \frac{\Omega'(\omega)\Theta(\omega) - \Omega(\omega)\Theta'(\omega)}{[\Theta(\omega)]^2}$; we show that $\Omega'(\omega) > 0$ and $\Theta'(\omega) < 0$.

It is straightforward to get

$$\Theta'(\omega) = \left[(1-\beta)\left(e^{\varphi\left[v\left(\omega l^*(\omega,0)\right)-v\left(\omega l^*(\omega.1)-\kappa\right)\right]}-1\right)\right]^{\frac{1}{\varphi}-1}(1-\beta)e^{\varphi\left[v\left(\omega l^*(\omega,0)\right)-v\left(\omega l^*(\omega,1)-\kappa\right)\right]}$$
$$\cdot\left\{v'\left(\omega l^*(\omega,0)\right)\left[l^*(\omega,0)+\omega\frac{\partial l^*(\omega,0)}{\partial\omega}\right]-v'\left(\omega l^*(\omega,1)-\kappa\right)\left[l^*(\omega,1)+\omega\frac{\partial l^*(\omega,1)}{\partial\omega}\right]\right\}$$

(A1.1)

Then, from the discussion in section 3.2 we know that i) $\frac{\partial l^*(\omega,s)}{\partial\omega} > 0$**,** $s = 0,1$**; ii)** $e^{\varphi[\cdot]} > 1$ **since** $v\left(\omega l^*(\omega,0)\right) > v\left(\omega l^*(\omega,1)-\kappa\right)$**, from the equilibrium condition (6); iii)** $l^*(\omega,1) > l^*(\omega,0)$ **and iv)** $v'\left(\omega l^*(\omega,1)-\kappa\right) > v'\left(\omega l^*(\omega,0)\right)$**, from equations (4) and (5); all these conditions render** $\Theta'(\omega) < 0$**.**

Now,

$$\Omega'(\omega)=\left[\beta\left(\left(1-l^*(\omega,1)+\delta\right)^{\varphi}-\left(1-l^*(\omega,0)\right)^{\varphi}e^{\varphi[\cdot]}\right)\right]^{\frac{1}{\varphi}-1}$$
$$\cdot\beta\left\{\left(1-l^*(\omega,1)+\delta\right)^{\varphi-1}\left(-\frac{\partial l^*(\omega,1)}{\partial\omega}\right)-\left(1-l^*(\omega,0)\right)^{\varphi}\frac{\partial e^{\varphi[\cdot]}}{\partial\omega}-\left(1-l^*(\omega,0)\right)^{\varphi-1}\left(-\frac{\partial l^*(\omega,0)}{\partial\omega}\right)e^{\varphi[\cdot]}\right\}$$

(A1.2)

From the discussion of (A1.1) we had concluded that $\frac{\partial e^{\varphi[\cdot]}}{\partial\omega}<0$, and since conditions i)–iii) hold, then it is the case that $\Omega'(\omega)>0$.

Appendix 2

It is easy to see that the equilibrium of the model economy is not optimal. Individual choice of location, and hence individual access to sanitation services, has an external effect on the quality of the disease environment. Since this external effect is positive, it is clear that equilibrium $\overline{\omega}$ is larger than the optimum, i.e. the share of population with access to sanitation services is lower than optimal.

As was the case with the equilibrium allocation, the optimum can be completely described by a threshold level of labor productivity for which individuals are indifferent between having access to sanitation or not. Let's denote $\overline{\omega^o}$ the threshold level of labor productivity which determines the optimal share of population with access to sanitation.

Under standard assumptions about utility (convex preferences, for instance) and production functions, $\overline{\omega^o}$ is the solution to a very difficult problem.

If $\lambda(\omega)$ is the optimal weight in the social welfare function corresponding to an individual with labor productivity ω, the planner's problem is to choose the $\overline{\omega^o}$ that maximizes social welfare W

$$W=\left\{\int_0^{\overline{\omega^o}}\lambda(\omega)\,u\left(c_0(\omega),q_0(\omega)\right)n(\omega)d\omega+\int_{\overline{\omega^o}}^{\infty}\lambda(\omega)\,u\left(c_1(\omega),q_1(\omega)\right)n(\omega)\,d\omega\right\},$$

subject to the resource constraint of the economy

$$\int_0^{\overline{\omega^o}}c_o(\omega)n(\omega)d\omega+\int_{\overline{\omega^o}}^{\infty}c_1(\omega)n(\omega)d\omega+\left[1-N\left(\overline{\omega^o}\right)\right]\kappa=\int_0^{\infty}(\omega\ell)n(\omega)d\omega$$

An analytical solution which allows us to explicitly compare the equilibrium and the optimum can be found under the conditions assumed in section 3.1; i.e. quasilinear preferences and a labor supply invariant across individuals. In this case, the optimal value $\overline{\omega^o}$ is the one that maximizes the so-called *Marshallian* social —or aggregate— surplus (SS)

$$SS = \int_0^\infty \ln q(\omega) n(\omega) d\omega - C\left(\kappa, \overline{\omega^o}\right),$$

where the first term is the social valuation of individuals' health when $1 - N\left(\overline{\omega^o}\right)$ individuals have access to the sanitation, and $C\left(\kappa, \overline{\omega^o}\right)$ is the social cost, in terms of consumption, of achieving that level of access. See Mas-Colell *et al.* (1995), section 10.D, for a discussion of welfare analysis in quasilinear economies. Social surplus is then given by

$$SS = \int_0^{\overline{\omega^o}} \ln q_0(\omega) n(\omega) d\omega + \int_{\overline{\omega^o}}^\infty \ln q_1(\omega) n(\omega) d\omega - \int_{\overline{\omega^o}}^\infty \kappa n(\omega) d\omega$$

Notice that $q_0(\omega) = q_0\left(\overline{\omega^o}\right)$ for all $\omega < \overline{\omega^o}$, and $q_1(\omega) = q_1\left(\overline{\omega^o}\right)$ for all $\omega > \overline{\omega^o}$; and that $\int_{\overline{\omega^o}}^\infty n(\omega) d\omega = 1 - \int_0^{\overline{\omega^o}} n(\omega) d\omega$, then we can find the optimum threshold value by solving the following problem:

$$\underset{\overline{\omega^o}}{Max}\, SS = N\left(\overline{\omega^o}\right) \ln q_o\left(\overline{\omega^o}\right) + \left(1 - N\left(\overline{\omega^o}\right)\right)\left(\ln q_1\left(\overline{\omega^o}\right) - \kappa\right),$$

The first-order condition for the optimum is

$$\ln q_1\left(\overline{\omega^o}\right) - \ln q_o\left(\overline{\omega^o}\right) + \Phi\left(\overline{\omega^o}\right) = \kappa \ . \qquad \text{(A2.1)}$$

The threshold income should be such that the marginal social gain from access to sanitation just compensates the marginal social cost of doing so.

Let's bear in mind that in the equilibrium with a quasilinear utility, $\overline{\omega}$ solves equation (2), reproduced here for expositional convenience:

$$\ln q_1\left(\overline{\omega}\right) - \ln q_o\left(\overline{\omega}\right) = \kappa \ . \qquad \text{(A2.2)}$$

The gain and loss involved in this decision are social in nature. Notice that the difference between equations (A2.1) and (A2.2) is the term $\Phi\left(\overline{\omega^o}\right) > 0$, which measures the gain in public health from a marginal increase in access to sanitation not taken into account in individual cost-benefit analysis.[5]

Since the social and private costs are equal but the social gain is larger than the private one, it must be that $\overline{\omega^o} < \overline{\omega}$. That is, the optimal threshold value of labor productivity is lower than in equilibrium, or equivalently, the optimal share of population with access to sanitation is higher than the equilibrium share.

Now we compute the Pigouvian taxes that implement the optimal proportion of population in each location. As it is well known, the idea behind Pigouvian taxation is to implement the optimum through the market itself. Taxation schemes are then devised so that the equilibrium allocation results in an optimal one. In our case the optimal allocation can be implemented by combining a subsidy for those who choose to locate in the city center with a lump-sum tax over the whole population.

Let τ be the lump-sum tax and z the lump-sum subsidy. Under the Pigouvian scheme, an individual with productivity ω who chooses to dwell in the center shall enjoy a level of consumption $c = \omega\ell - \tau - (\kappa - z)$; or a level of consumption $c = \omega\ell - \tau$ if it chooses to dwell in the outskirts of the city.

The government must satisfy its budget constraint. If $\overline{\omega^o}$ is the optimal threshold level of labor productivity, then total government revenues are $\int_0^\infty \tau\, n(\omega) d\omega = \tau$, while total government disbursements amount to $\int_{\overline{\omega^o}}^\infty z\, n(\omega) d\omega = z\left[1 - N\left(\overline{\omega^o}\right)\right]$. In order to meet its budget constraint the government sets τ relative to z such that $\tau = z\left[1 - N\left(\overline{\omega^o}\right)\right]$ holds.

The individual must choose between the level of utility associated with having access to the sanitation services and the level of utility resulting from the lack of access to the services,

$$\underset{s\in\{0,1\}}{Max} \left\{ u\left(c_s^*, q_s^*\right) \right\}$$

To find the solution we resort again to the intuition that there must be a threshold value of ω at which individual will be indifferent between choosing a location in the city center and choosing one in the outskirts of the city; with taxation $\overline{\omega}$ now satisfies the equivalent of (A2.2) given by

$$\ln q_1\left(\overline{\omega}\right) - \ln q_0\left(\overline{\omega}\right) = \kappa - z \qquad \text{(A2.3)}$$

[5] $\Phi\left(\overline{\omega^o}\right) = -\frac{1}{N'\left(\overline{\omega^o}\right)}\left[N\left(\overline{\omega^o}\right)\frac{q_0'\left(\overline{\omega^o}\right)}{q_0'\left(\overline{\omega^o}\right)} + \left(1 - N\left(\overline{\omega^o}\right)\right)\frac{q_1'\left(\overline{\omega^o}\right)}{q_1\left(\overline{\omega^o}\right)} \right] > 0$, because $q_s'\left(\overline{\omega^o}\right) < 0$, $s = 0,1$.

The RHS of this equation is the net cost of choosing a location in the city center. Given that the LHS is identical to that in (A2.1), the threshold value $\overline{\omega}$ must be lower with the subsidy; and as a consequence a larger share of the population gains access to sanitation services.

For $\overline{\omega}$ to be optimal, the subsidy rate z must be chosen so that the following is satisfied (see equations A2.1 and A2.3).

$$z = \Phi\left(\overline{\omega}\right) \qquad \text{(A2.4)}$$

Then, z and $\overline{\omega}$ must be found by solving equations (A2.3) and (A2.4) simultaneously. Total government revenues then amount to $\tau = \Phi\left(\overline{\omega^o}\right)\left[1 - N\left(\overline{\omega^o}\right)\right]$.

Basically the Pigouvian scheme makes the marginal private cost of access sensible to changes in the income distribution, and it is thus able to affect marginally the share of the population with access.

Also notice that average health improves and the gap in health status between the "rich" and the "poor" decreases, but at the expense of an increase in consumption inequality —consumption among the "poor" is reduced by an amount τ and consumption among the "rich" is increased by $z - \tau$.

Finally, poverty is reduced as $N\left(\overline{\omega^o}\right) < N\left(\overline{\omega}\right)$. But recall this measure of poverty is a version of the "head-count ratio"; so it is not surprising that redistribution from all the population, even from those more *deeply* poor (those with income way below the poverty line income) towards those who are only marginally poor (those with income just below the poverty line income) is welfare improving [see Foster and Sen (1997), section A.6.2, for a similar discussion].

Figures

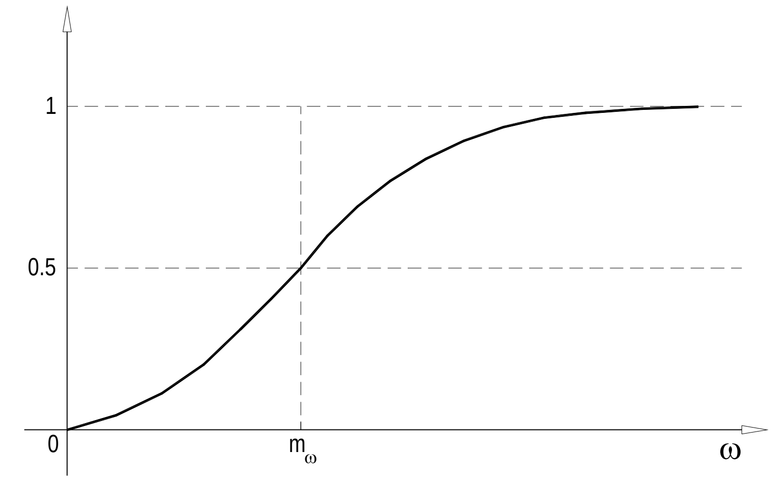

Figure 1: The cumulative distribution function $N(\omega)$ associated with the income distribution density $n(\omega)$.

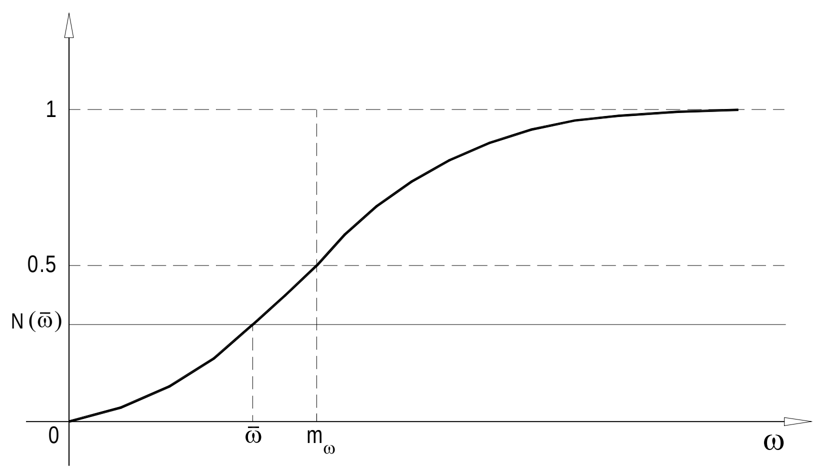

Figure 2: Equilibrium with quasilinear utility. The equilibrium share of population with sanitation services is fully determined by the utility and technology parameters, and is independent of the parameters of the income distribution density.

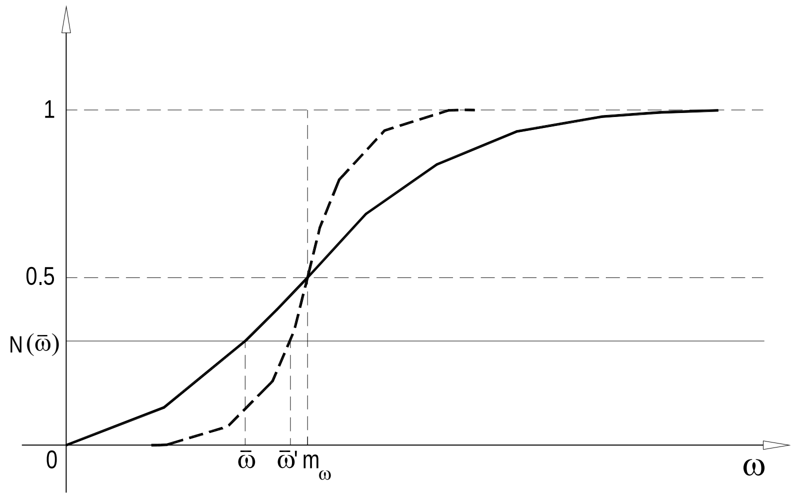

Figure 3: Two economies with different degrees of inequality in labor productivity have the same share of population without access to the sanitation services, and thus the same level of average health, with quasilinear preferences.

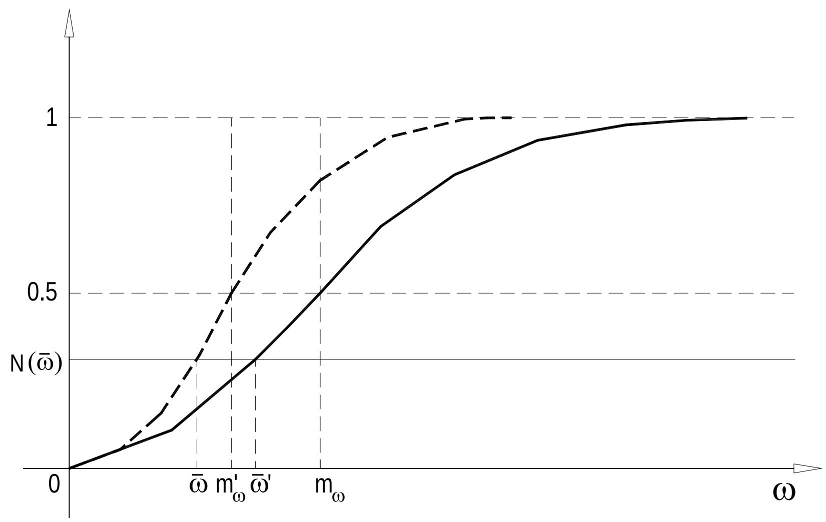

Figure 4: The richer economy (to the right) has the same share of population without access to the sanitary infrastructure as the poorer one, and thus the same level of average health, with quasilinear preferences.

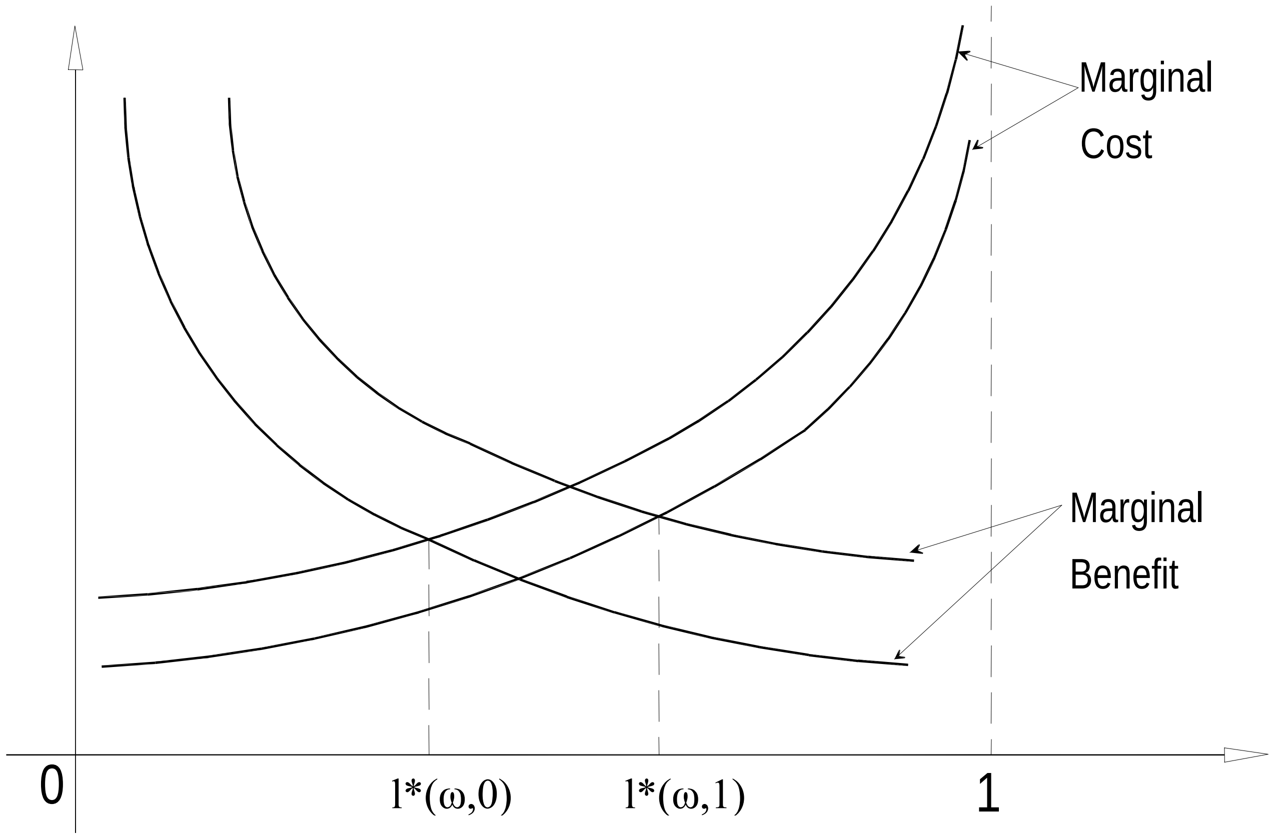

Figure 5: Individual's optimal choice of time devoted to market activities. Individuals with access to the sanitation services work more in market activities because the marginal cost of time in terms of foregone health is lower and the marginal utility from consumption is larger.

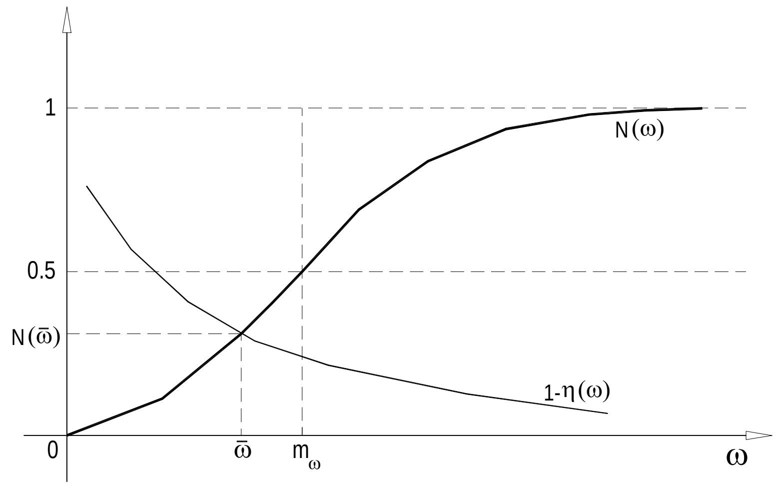

Figure 6: With convex preferences and flexible labor supply, the threshold level of labor productivity and the share of population with access to the sanitation services now depend on the parameters of the income distribution as well as on the parameters of preferences and technology.

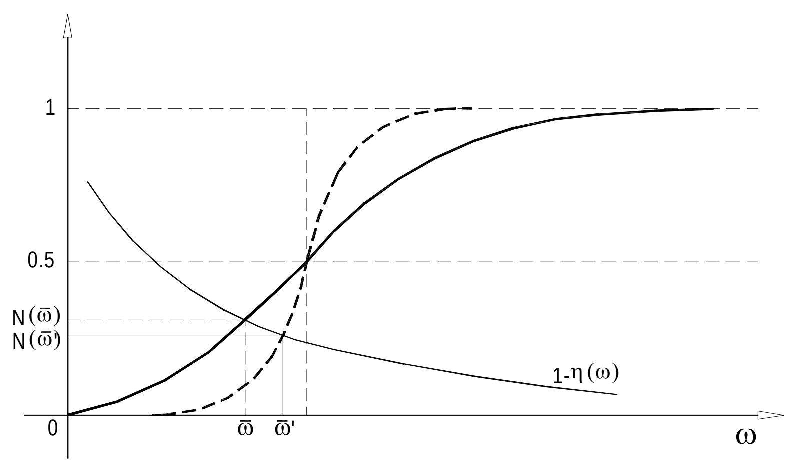

Figure 7: The economy with lower inequality in labor productivity has lower share of population without access to the sanitation services, and its population thus enjoys a larger level of average health.

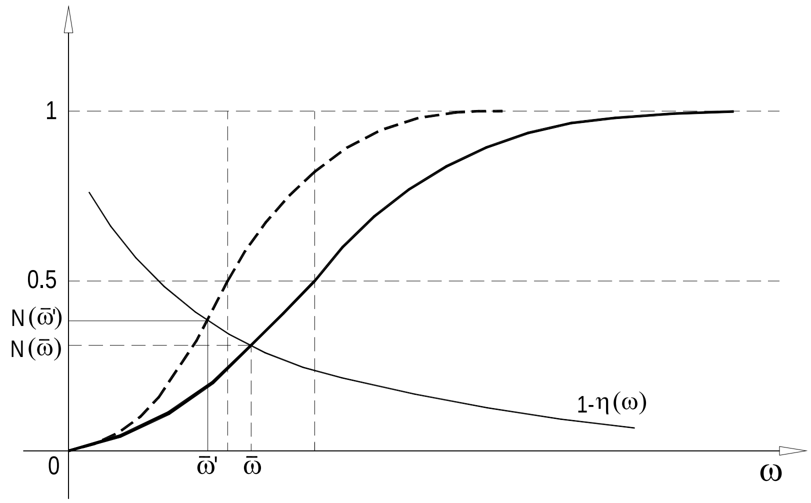

Figure 8: The economy with larger median labor productivity has lower share of population without access to the sanitation services and its population enjoys a larger level of average health.

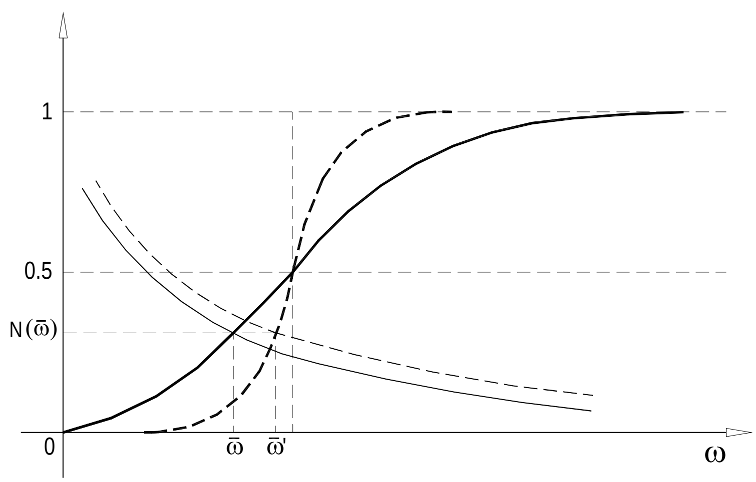

Figure 9: The low inequality economy has a larger cost of access to sanitation, and its population ends up having the same average health as the high inequality economy.

Conclusions

Our model, like any simplification of reality, has shortcomings one would like to mend. Probably the most important is its static nature, which prevents us from modeling health in a more realistic way. Health demand is usually derived from the demand for healthy time; so demand for health is governed by forward looking behavior and expectations about future income. Our decision to do away with dynamics is motivated by the obvious fact that in a dynamic setting with investments in health capital the income distribution is endogenous. An explicit analytical or graphical solution of the model would then be impossible and we would have to resort to numerical methods. Where that would take us is not obvious, probably to the discussion of health poverty traps and to the rediscovery that initial inequality influences economic growth; but it is also true that in a dynamic setting we would be able to explicitly analyze the conditions under which the Kuznets curve hypothesis mentioned in section 4.1 would be operative.

The second most important shortcoming is that the supply of the good from which sanitation services are obtained is not explicitly modeled. In a more realistic set-up the cost of sanitation would be determined within the model, and a full analysis of the cost-of-access hypothesis of section 4.2 could be done. An obvious solution for this would be to put a government into the model. This would solve the shortcoming but would force us to consider issues of ownership and other political economy considerations. In our current brave-new-world model economy it is as if individuals produced sanitation services with units of the consumption good. Each individual simply decides whether to do away with some consumption and allocate that amount to sanitation or not, according to its preferences and labor productivity.

This model, however, allows us to probe further into the relation between income, poverty, and health than previous theoretical accounts, and in that sense it is an improvement.

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