Inequalities in Life Expectancy and the Global Welfare Convergence

Hippolyte d'Albis, Florian Bonnet

PARIS SCHOOL OF ECONOMICS
ECOLE D'ECONOMIE DE PARIS

WORKING PAPER N° 2018 – 03

Inequalities in Life Expectancy and the Global Welfare Convergence

Hippolyte d'Albis
Florian Bonnet

JEL Codes: I31, J17, O57
Keywords: World inequality, Well-being indicators, Life expectancy

PARIS-JOURDAN SCIENCES ECONOMIQUES
48, BD JOURDAN – E.N.S. – 75014 PARIS
TÉL. : 33(0) 1 80 52 16 00=
www.pse.ens.fr

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE – ECOLE DES HAUTES ETUDES EN SCIENCES SOCIALES
ÉCOLE DES PONTS PARISTECH – ECOLE NORMALE SUPÉRIEURE
INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE – UNIVERSITE PARIS 1

Inequalities in Life Expectancy and the Global Welfare Convergence*

Hippolyte d'Albis[†] Florian Bonnet[‡]

February 9, 2018

Abstract

Becker, Philipson and Soares (2005) maintain that including life expectancy gains in a welfare indicator result in a reduction of inequality between 1960 and 2000 twice as great as when measured by per capita income. We discuss their methodology and show it determines the convergence result. We use an alternative methodology, based on Fleurbaey and Gaulier (2009), which monetizes differences in life expectancy between countries at each date rather than life expectancy gains. We show that including life expectancy has no effect on the evolution of world inequality.

JEL Codes: I31, J17, O57.

Keywords : World inequality, Well-being indicators, Life expectancy.

*The authors thank the editor of this journal, R. Lee, H. Pifarré i Arolas, R. Soares and an anonymous referee for their comments.

†Paris School of Economics, CNRS, hippolyte.dalbis@psemail.eu

‡Université Paris 1 Panthéon-Sorbonne, Paris School of Economics, florian.bonnet@psemail.eu

1 Introduction

Becker et al. (2005) propose a methodology aggregating per capita income and life expectancy in a single indicator of welfare they call “full income”. They show that ”full income” inequality between countries declined much more in 1960-2000 than per capita income inequality. They conclude that changes in life expectancy, which occur at different rates across countries, lead to a convergence in levels of welfare. Their work has been extended by Jones and Klenow (2010) and Edwards (2012), including inequalities of mortality within countries or giving a monetary value on leisure time, but without challenging the main findings in Becker et al. (2005).

Under Becker et al. (2005)’s approach, the monetization of life expectancy for each country is calculated by using life expectancy gains between two dates. This method makes it impossible to calculate their “full income” indicator for the initial date in the study, namely 1960. The authors thus compare “full income” values for later dates with the per capita income value in 1960, which amounts implicitly to assuming that “full income” in 1960 was equal to per capita income. We show that this assumption is conceptually fragile and determines the convergence result the authors obtain.

To avoid dependence on initial conditions, we use an alternative methodology based on the work of Fleurbaey and Gaulier (2009). Their evaluation is based on comparing life expectancy between countries at each observation date. We calculate a “mortality adjusted income” and show that inequalities between countries vary in the same magnitude as measured by per capita income. Our results suggest that the variations in life expectancy specific to each country do not lead to reducing inequalities in welfare between countries.

2 Method

Becker et al. (2005)’s “full income” indicator is based in theory on a life-cycle model with uncertain life span like that developed by Yaari (1965) and Barro and Friedman (1977) among others. The program of a representative agent born in t in country i is to maximize an intertemporal utility:

$$\int_t^{\infty} e^{-\rho(z-t)} s_{t,i}(z-t) u(c_{t,i}(z)) dz, \tag{1}$$

under the budget constraint:

$$\int_t^{\infty} e^{-r(z-t)} s_{t,i}(z-t) y_{t,i}(z) dz = \int_t^{\infty} e^{-r(z-t)} s_{t,i}(z-t) c_{t,i}(z) dz. \tag{2}$$

Variables $c_{t,i}(z)$ and $y_{t,i}(z)$ represent consumption and income at date $z \geq t$, and $s_{t,i}(z-t)$ the probability of surviving to age $z-t$ which is rectangular in Becker et al. (2005). Also, ρ and r are the subjective discount rate and interest rate respectively. Assuming $r = \rho$ and $y_{t,i}(z) = y_{t,i}$, consumption is constant and equal to income. The intertemporal utility, denoted $v(y_{t,i}, s_{t,i})$, can be written as:

$$v(y_{t,i}, s_{t,i}) = u(y_{t,i})a(s_{t,i}), \tag{3}$$

which corresponds to the product of the utility of income, $u(y_{t,i})$, and the value of an annuity calculated using survival function $s_{t,i}$,

$$a(s_{t,i}) = \int_t^\infty e^{-r(z-t)} s_{t,i}(z-t)dz. \tag{4}$$

Becker et al. (2005) calculate a compensatory income, denoted $w(s_{t_1,i}, s_{t_2,i})$, using life expectancies $s_{t_1,i}$ and $s_{t_2,i}$ observed at dates t_1 and t_2. The compensatory income is the extra income that would procure an individual the same welfare as they would have had at date t_2 if life expectancy had remained at the value observed in t_1. It is determined by equalising the intertemporal utility at t_2, namely $v(y_{t_2,i}, s_{t_2,i})$, with a utility for which life expectancy is held at the value observed in t_1:

$$v(y_{t_2,i}, s_{t_2,i}) = v(y_{t_2,i} + w(s_{t_1,i}, s_{t_2,i}), s_{t_1,i}), \tag{5}$$

where $y_{t_2,i} + w(s_{t_1,i}, s_{t_2,i})$ represents the "full income" of Becker et al. (2005) for country i at date t_2. Using Equation (3) to simplify Equation (5), the "full income" may be rewritten as follows:

$$y_{t_2,i} + w(s_{t_1,i}, s_{t_2,i}) = u^{-1}\left(\frac{u(y_{t_2,i})a(s_{t_2,i})}{a(s_{t_1,i})}\right). \tag{6}$$

Since functions $u(.)$ and $a(.)$ are increasing, "full income" is an increasing function of the rise in life expectancy between the two dates. On the other hand, it is not possible with this method to calculate "full income" for the initial date t_1. The authors thus assume that "full income" in t_1 is equal to per capita income (calling t_1 the "base year"). They then compare the changes in per capita income inequality (using indicators represented by $G(.)$) $G(y_{t_2,i}) - G(y_{t_1,i})$, with the changes in "full income" inequality: $G(y_{t_2,i} + w(s_{t_1,i}, s_{t_2,i})) - G(y_{t_1,i})$.

However, it does not strike us as appropriate to assume that "full income" in t_1 is equal to per capita income. In practical terms, this amounts to assuming that there had been no increase in life expectancy before t_1. We consider equally problematical that this may produce aberrant results, as in the following example. Suppose that two countries, A and B, have the same per capita income at the initial date: $y_{t_1,A} = y_{t_1,B}$, but that A has a higher life expectancy than B: $s_{t_1,A} > s_{t_1,B}$. From t_1 to t_2, suppose that the growth of per capita income is nil in both countries: $y_{t_1,i} = y_{t_2,i}$, that the life expectancy in A does not rise: $s_{t_1,A} = s_{t_2,A}$, and that the life expectancy in B rises but does not reach that of A: $S_{t_2,A} \geq S_{t_2,B} > S_{t_1,B}$. It is clear that per capita income inequality has not changed, $G(y_{t_2,i}) = G(y_{t_1,i})$, but the two countries are less different than before. However, with the Becker et al. (2005) method, the result is that the two countries' "full incomes" have become less equal since only one country has enjoyed an increase in its life expectancy: we indeed obtain that $w(s_{t_1,A}, s_{t_2,A}) = 0$ and $w(s_{t_1,B}, s_{t_2,B}) > 0$, which implies that $G(y_{t_2,i} + w(s_{t_1,i}, s_{t_2,i})) > G(y_{t_1,i})$. With this method one would deduce divergence, whereas in fact B is catching up with A.

We propose to use an alternative indicator, which we call "mortality-adjusted income", following Fleurbaey and Gaulier (2009). Its principle is to calculate a willingness to pay, denoted $x(s_{t,i}, s_{t,i^*})$, by comparing for a given date the life expectancy in country i, with that of the country with the highest life expectancy, denoted i^*. This willingness to pay corresponds to the reduction in income an individual in country i would be willing to accept to enjoy the life expectancy in country i^*.

$$v(y_{t,i}, s_{t,i}) = v(y_{t,i} - x(s_{t,i}, s_{t,i^*}), s_{t,i^*}), \tag{7}$$

where $y_{t,i} - x(s_{t,i}, s_{t,i^*})$ corresponds to our "mortality adjusted income". Using Equation (3) to simplify Equation (7), we obtain:

$$y_{t,i} - x(s_{t,i}, s_{t,i^*}) = u^{-1}\left(\frac{u(y_{t,i})\, a(s_{t,i})}{a(s_{t,i^*})}\right). \tag{8}$$

The greater the gap in life expectancy between i and i^*, the lower the "mortality adjusted income". The advantage of the willingness to pay is that it can be calculated for each country and each date, including the initial date of observation. To take the earlier illustrative example where life expectancy in country B catches up with that in country A, it can immediately be seen that our indicator leads to the conclusion that inequality is shrinking: as $x(s_{t_2,B}, s_{t_2,A}) < x(s_{t_1,B}, s_{t_1,A})$, we have $G\left(y_{t_2,i} - x(s_{t_2,i}, s_{t_2,i})\right) < G\left(y_{t_1,i} - x(s_{t_1,i}, s_{t_1,i})\right)$.

The basic difference between "mortality adjusted income" and "full income" is the following. The former is static: its value at date t depends on variables observed in t, whereas the latter includes dynamic elements: the past development of life expectancy is used to calculate the current level of welfare.

3 Results

Our sample consists of 95 countries, from which Hong Kong is removed in our robustness tests. The economic data are taken from the Penn World Tables (PWT). Like Becker et al. (2005), we use Version 6.1 and define per capita income as per capita GDP. The life expectancy figures come from the World Development Indicators (World Bank), and Equation (3) is simplified as follows:

$$a(s_{t,i}) = \int_0^{e_{t,i}} e^{-rz} dz, \tag{9}$$

where $e_{t,i}$ is life expectancy at date t in country i. Like Becker et al. (2005), we use a CRRA utility function:

$$u(c) = \frac{c^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}} + \alpha, \tag{10}$$

and choose the following parameter values: $\gamma = 1.25$, $\alpha = -16.2$ and $r = 0.03$.

Table 1 shows values for 6 inequalities indicators computed for 1960, 1990 and 2000. As explained above, indicators values for Becker et al. (2005) "full income" and per capita income are similar in 1960. Table 1 reveals that, whatever the indicator, values for values for "mortality adjusted income" decrease less than values for "Full income" between 1960 and 2000.

Table 1: EVOLUTION OF CROSS-COUNTRY INEQUALITY, 1960-2000

	Per capita income			"Full income"		"Mortality adjusted income"		
	1960	1990	2000	1990	2000	1960	1990	2000
Gini coeff.	0.570	0.572	0.535	0.547	0.497	0.587	0.584	0.548
Rel. mean dev.	0.955	0.959	0.869	0.910	0.787	0.997	0.981	0.896
Coeff. of var.	1.235	1.297	1.226	1.216	1.096	1.293	1.334	1.258
Std. dev. of logs	1.024	1.008	0.960	0.970	0.935	1.055	1.031	0.986
Interdecile range	14.16	15.77	14.12	14.95	12.77	15.48	16.98	14.88
Reg. to the mean		-0.001 (p = 0.01)	-0.012 (p = 0.00)	-0.006 (p = 0.00)	-0.026 (p = 0.00)		-0.002 (p = 0.01)	-0.014 (p = 0.00)

Notes : Per capita income is GDP per capita in 1996 international prices, adjusted for terms of trade (Penn World Tables 6.1). All inequalities indicators weighted by country population. Sample includes 95 countries.
"Full income" is computed using the methodology of Becker et al (2005) who monetize the difference of life expectancy between two dates for each country. "Mortality adjusted income" is computed using the methodology of Fleurbaey and Gaulier (2009) who monetize the difference of life expectancy between two countries at each date.

As an example, the growth rates were computed for the Gini coefficients and reported in Table 2. As in the Becker et al. (2005) article, the Gini coefficient calculated from "full incomes" decreases much more than the per capita income Gini. On the other hand, the Gini coefficient calculated from "mortality adjusted incomes" varies in a similar fashion to the per capita income Gini. With both indicators, inequality rises from 1960 to 1968, plateaus until 1978, and then falls to 2000. Our indicator suggests that the variations in life expectancy specific to each country do not contribute to reducing inequalities of welfare between countries. On the other hand, changes in per capita income per country are determining factors. Our result may appear surprising, given that inequality in life expectancy has halved during this period. It is explained by the fact that per capita income inequality is much greater than life expectancy inequality.

Table 2: EVOLUTION OF GINI COEFFICIENTS, 1960-2000

Per capita income	"Full income"	"Mortality adjusted income"
-6 %	-12.8 %	-6,7 %

Notes : Per capita income is GDP per capita in 1996 international prices, adjusted for terms of trade (Penn World Tables 6.1). Gini coefficients weighted by country population. Sample includes 95 countries.

Table 3 presents the results computed under alternative assumtions. Column 1 relates to the indicator as presented above. In Column 2, the "mortality adjusted income" is calculated from distributions of survival probability (DSP) and not merely life expectancy, which alters the calculation of $a(s_{t,i})$, no longer provided by Equation (9) but by a discretization of Equation (4). This modelling gives a more comprehensive vision of variations in mortality (d'Albis et al., 2014) that is not limited to variations in the mean. To do so, we use the survival tables published by the United Nations Population Division. In Column 3, we further replace income by total per capita consumption (TCP). As in Jones and Klenow (2010), this sums private consumption and government expenditure. The data are taken from PWT 6.1. In Column 4, we use a fixed reference (FR) that is the country with the highest life expectancy along the period (Japan in 2000), instead of a yearly reference. Whatever specification is used, our indicator of inequality of welfare is close to that of per capita income.

Table 3: ROBUSTNESS CHECKS - GINI COEFFICIENTS OF "MORTALITY ADJUSTED INCOME"

"Mortality adjusted income"	"Mortality adjusted income" DSP	"Mortality adjusted income" DSP + TCP	"Mortality adjusted income" FR
-6.7 %	-6.5 %	-5.5 %	-5.6%

Notes : "Mortality adjusted income" computed using the methodology of Fleurbaey and Gaulier (2009). "Mortality adjusted income" - DSP replaces Life Expectancy by the whole Distribution of Survival Probability (DSP) in the previous indicator. "Mortality adjusted income" - DSP + TCP replaces GDP per capita by Total per Capita Expenditure (TCP) i.e the sum of private consumption and public expenditures, in the previous indicator. "Mortality adjusted income" FR uses a fixed reference instead of a yearly reference.

We also checked that our results were robust with respect to more recent versions of the PWT: the variations observed above remain the same.

References

Barro, R. J. and J. W. Friedman (1977). On uncertain lifetimes. *Journal of Political Economy 85*(4), 843–849.

Becker, G. S., T. J. Philipson, and R. R. Soares (2005). The quantity and quality of life and the evolution of world inequality. *American Economic Review 95*(1), 277 – 291.

d'Albis, H., L. J. Esso, and H. Pifarré i Arolas (2014). Persistent differences in mortality patterns across industrialized countries. *PloS one 9*(9), e106176.

Edwards, R. D. (2012). The cost of uncertain life span. *Journal of Population Economics 26*(4), 1485–1522.

Fleurbaey, M. and G. Gaulier (2009). International comparisons of living standards by equivalent incomes. *The Scandinavian Journal of Economics 111*(3), 597–624.

Jones, C. I. and P. J. Klenow (2010). Beyond GDP? Welfare across countries and time. Technical report, National Bureau of Economic Research.

Yaari, M. E. (1965). Uncertain lifetime, life insurance, and the theory of the consumer. *The Review of Economic Studies*, 137–150.