The Evolution of World Inequality in Well-being

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Abstract

In this paper we investigate the evolution of the inequality in well-being across different countries between 1975 and 2000. We treat well-being as a multidimensional concept focusing on three important dimensions of life: standard of living, health and education. Inequality in the three dimensions shows a different trend between 1975 and 2000. We propose a flexible measure of well-being and use the tools offered by the recent literature on multidimensional inequality measurement to quantify the evolution of overall intercountry well-being inequality. The empirical results are nuanced, and sensitive to different normative choices on the trade-offs between the different dimensions. In particular the concave transformation of income turns out to be decisive for the evolution of world inequality in well-being.

Keywords: Multidimensional Inequality Measurement, Index of Well-being, Inter-country Inequality.

JEL Classification: D31, D63, I31, O50

1 Introduction

Measuring global inequality has received an increasing amount of attention both in theoretical and in policy oriented research[1]. The focus of this literature is (almost) exclusively on income inequality. There is by now virtual consensus that income inequality across *countries* has *in*creased during the last decades, if one considers each country as a unit of observation and does not weigh for population. There is a lively debate, however, about the relevancy of such unweighted income inequality measures (Milanovic, 2005).

Of course, while the development of income inequality *per se* is worth investigating, income is only one dimension of economic well-being. Any analysis of

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[1] To give but two examples of the latter: global inequality is the focus of the Human Development Report of the United Nations Development Programme (2005) and of the World Development Report issued by the World Bank (2006).

countries, for which 4 indicators in 6 points of time are available (which is slightly less than half of the countries in the World Development Indicators database, representing up to 82% of total population in 2000). Notable absentees in our sample are many Sub-Saharan African countries[13] and virtually all Eastern European Countries, with Latvia and Hungary as exceptions. Detailed information on the countries covered and on the interpolation procedure is given in the appendix.

3.2 Evolution of inequality dimension-by-dimension

To get a feel for the data, we will first look at them dimension-by-dimension. For obvious reasons of comparability with the multidimensional approach introduced before, we calculate inequality for every dimension with the standard unidimensional Atkinson (1970) index[14]:

$$I_j^U(x_{.j}) = 1 - \left[\frac{1}{n}\sum_{i=1}^{n}\left[\left(\frac{x_{ij}}{\mu(x_j)}\right)^{1-\varepsilon}\right]\right]^{1/1-\varepsilon} \qquad j = 1, ..., k. \tag{14}$$

Table 3 summarizes the trends in inequality for the four indicators considered in our dataset. We set $\varepsilon = 2$, which reflects considerable inequality aversion in the different dimensions of well-being. In the following figures we show the development over time for different values of ε. In all the tables and figures inequality is normalized to be 100 in 1975.

indicator	1975	1980	1985	1990	1995	2000
GDP/capita	100.0	100.8	102.3	105.9	108.8	113.0
log(GDP/capita)	100.0	89.6	85.5	86.3	88.1	91.4
Longevity	100.0	88.2	80.0	84.9	97.8	131.4
Literacy Ratio	100.0	84.0	69.4	56.9	45.9	39.0
Enrolment ratio	100.0	83.1	73.0	65.7	62.9	58.9

Table 3: Evolution of the inequality in different dimensions of well-being, measured by the Atkinson Index ($\varepsilon = 2$)

Table 3 and figure 2 both show a clear upward trend in the inequality in GDP per capita. This confirms the general finding in the literature that unweighted income inequality increases (Milanovic, 2005)[15]. For the later interpretation of the HDI, it is useful to consider also the logarithmic transformation of GDP per

[13] Some large Sub-Saharan African countries that are not included in the sample are: Angola, Democratic Republic of Congo, Ethiopia, Gambia, Liberia, Mozambique, Namibia, Sierra Leone, Somalia, South Africa and Uganda.

[14] Alternative measures of inequality, such as the Gini index or generalized entropy inequality index give similar results.

[15] As mentioned before, there is less consensus on the evolution of population weighted income inequality. Most authors find decreasing inequality, which can be largely attributed to the fast growth of populous countries like China and India.

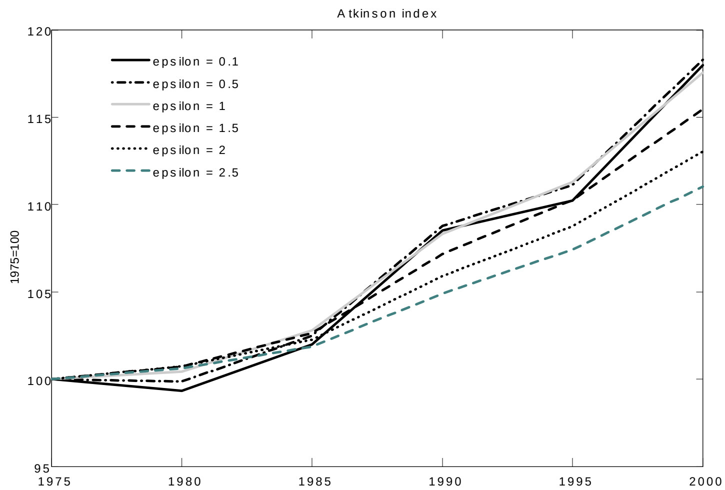

Figure 2: Evolution of the inequality of GDP per capita, measured by the Atkinson index, for different ε-values.

capita instead of GDP per capita itself. As can be seen from the second row of table 3 and from figure 3, this strictly concave transformation alters the trend of income inequality: now inequality decreases in the first decade and increases only mildly in the last decade.

Concerning longevity, Sen (1998) points out that "almost all the poor countries today have higher life expectancy than most of the richer countries had not long ago", and Ram (1998) calls the rapid increase of life expectancy in many poor countries "perhaps the most important single phenomenon to have affected human well-being". Also the Human Development Report (2005) is optimistic on the evolution of life expectancy and its inequality.

> “In a little more than a decade average life expectancy in developing countries has increased by two years. On this indicator human development is converging: poor countries are catching up with rich ones.” (Human Development Report, 2005)

Recent findings in the literature on global health inequality (McMichael et al., 2004; Moser et al., 2005) suggest a less rosy picture, because of the ongoing AIDS epidemic and the rising infection rates in Asia (see also Becker, Philipson and Soares, 2005). As can be seen in table 3 and figure 4, our results are in line with this less optimistic view. After an initial decrease in inequality in life expectancy during the first decade, inequality skyrockets form the late 1980's onwards[16].

[16] The influence of AIDS is clear, even with our restricted data set. When we drop all the

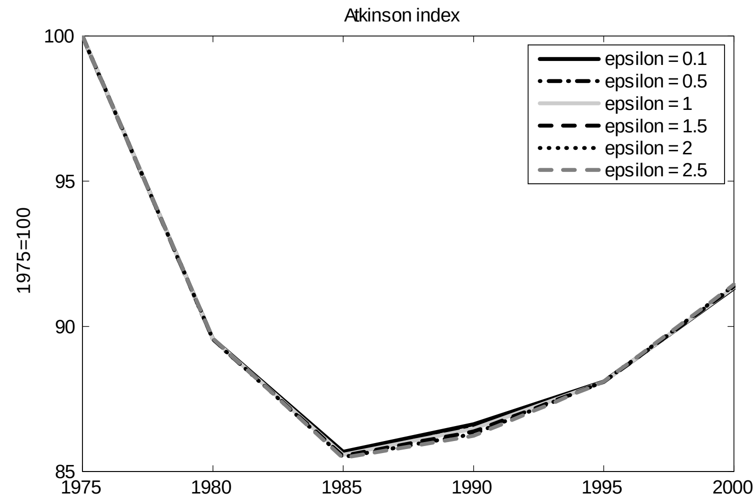

Figure 3: Evolution of the inequality of the logarithm of GDP per capita, measured by the Atkinson index, for different ε-values.

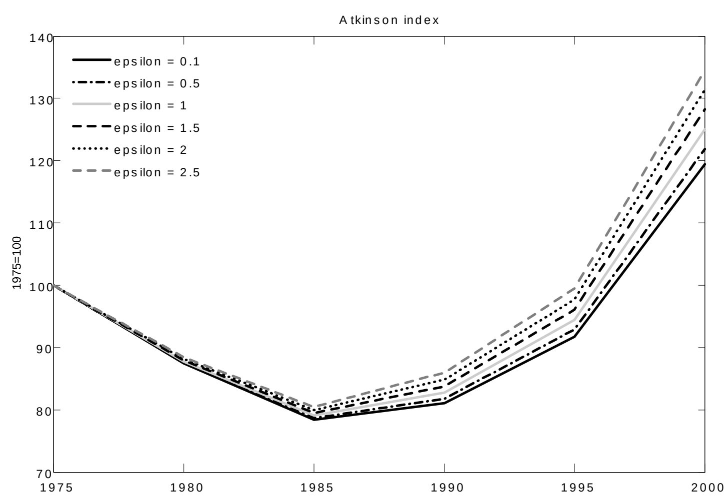

Figure 4: Evolution of the inequality of life expectancy, measured by the Atkinson index, for different ε-values.

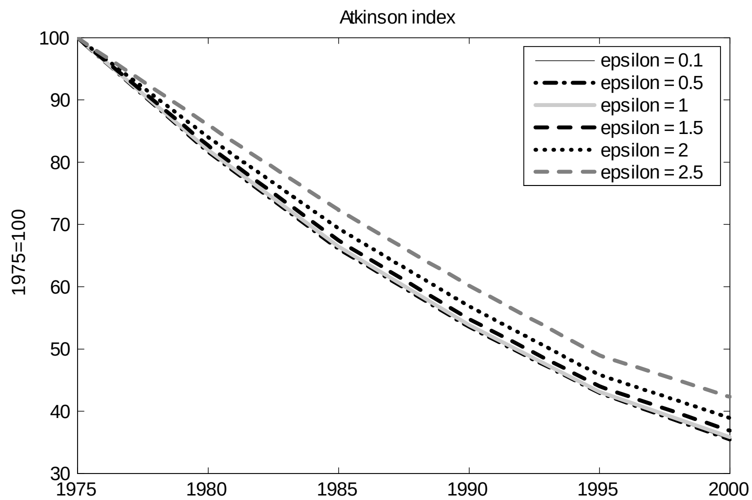

Figure 5: Evolution of the inequality of literacy rate, measured by the Atkinson index, for different ε-values.

Finally, inequality in educational indicators decreased over the entire period (Figures 5 and 6). Authors such as Neumayer (2003) and McGillivray and Pillarisetti (2004) claim that this may be a statistical artefact due to the specific educational indicators used. Literacy rate and enrollment rate are upward bounded and many OECD countries have reached this limit. However, the indicator "average years of schooling" from the dataset of Barro and Lee (1996) is less likely to have a binding upper limit and shows a similar pattern of steep decline in inequality.

We can conclude that unweighted income inequality increases over time, that inequality in the logarithm of income and in life expectancy show a U-pattern and that the educational indicators show a steep decrease in inequality. If one wants to derive general conclusions, an aggregation procedure is badly needed.

3.3 Evolution of multidimensional inequality

As a starting point and benchmark, figures 7 and 8 show the development over time of the *unidimensional* inequality measure $I^U_\beta(Z)$ (see eq. (10)) for the HDI and the BPS approach and for different values of ε. With the HDI, we recover the finding that world inequality in well-being declines over the relevant period. As noted, this is in stark contrast to the development of unweighted income

Sub-Saharan African countries from our sample, we find a decreasing trend in inequality over the whole period. These results are available from the authors on request. Note, however, that we could not include Russia in our sample: this is another country where mortality increased in the 1990s.

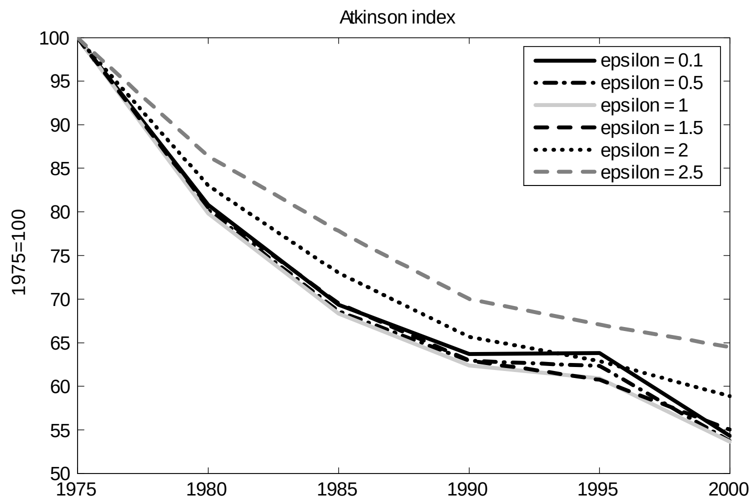

Figure 6: Evolution of the inequality of secondary school enrollment rate, measured by the Atkinson index, for different ε-values.

inequality. Our results for the BPS-index are not directly comparable to those of Becker et al. (2005), because they compute population-weighted inequality measures. With the implied value of $\beta = 0$ and without the educational dimension, the decrease in well-being inequality as measured by the BPS is less pronounced than for the HDI.

Let us now look at the evolution of *multidimensional* inequality, as measured by $I_\beta^M(Z)$ in expression (12). To evaluate the robustness of the results, we calculate $I_\beta^M(Z)$ for a broad range of sensible parameter values. We start from benchmark values which are close to those of the HDI and analyze the sensitivity of the results with respect to ε, the parameter of inequality aversion. Thereafter we relax the assumptions with respect to β, the parameter indicating the substitutability of the different dimensions. We then consider the effect of using different transformation functions, focusing on the weighting scheme, on the choice of a standardization procedure and on the role of the concave transforms as summarized in table (1), or by expressions (5) and (6).

Figure 9 summarizes the trend in well-being inequality measured by the multidimensional Atkinson index, as defined in expression (12) for different values of the degree of inequality aversion ε. We use the transformation functions of the HDI, summarized in table (1) and assume perfect substitutability between the dimension, i.e. $\beta = 1$. In the normative space depicted in figure 1, this analysis amounts to measuring inequality along the dotted line at $\beta = 1$. For all strictly positive ε-values, CIM is satisfied. Comparing figures 7 and 9, it turns out that the shift from $I_\beta^U(Z)$ to the multidimensional measure $I_\beta^M(Z)$ does not

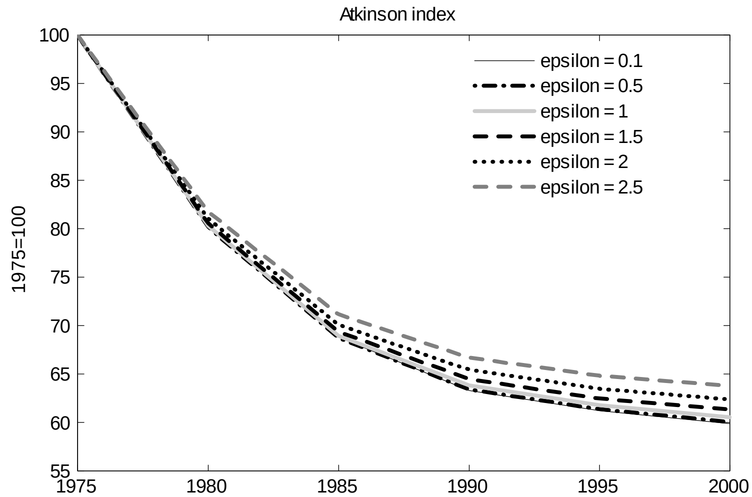

Figure 7: Evolution of the unidimensional inequality of the Human Development Index, measured by the Atkinson index, for different ε-values.

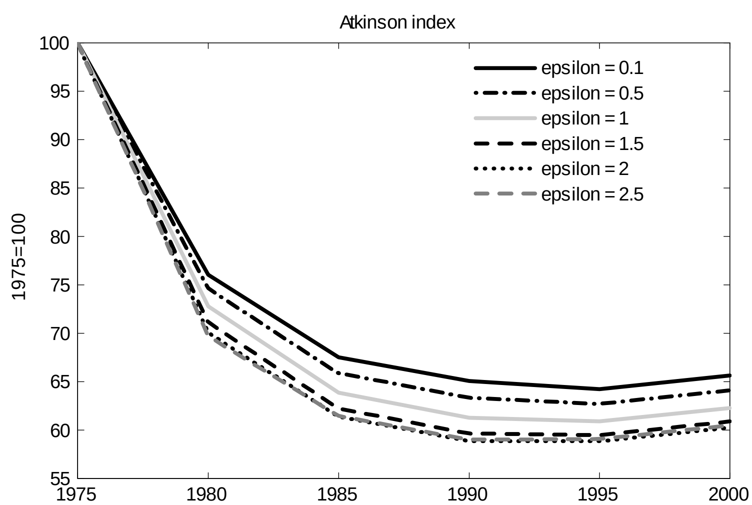

Figure 8: Evolution of the unidimensional inequality of the BPS approach, measured by the Atkinson index, for different ε-values.

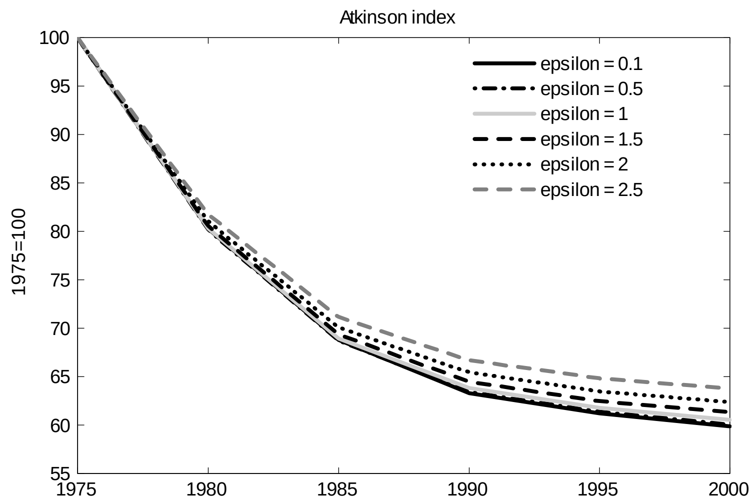

Figure 9: Evolution of well-being inequality, measured by the multidimensional Atkinson index, for different ε-values.

have a strong effect on the results. The most striking finding is that the basic result of a decrease in well-being inequality over time is robust for changes in ε. Let us therefore now see whether this result is also robust for changes in the other crucial parameters.

We first focus on the role of β, which captures the substitutability between the dimensions. We put $\varepsilon = 2$ and relax β to the range $[-5, 1]$, which amounts to a horizontal movement in the normative space of figure 1. The smaller β, the lower the substitutability between the dimensions or the more an equal development across the dimensions is preferred. Remember that the BPS-index has $\beta = 0$. As can be seen from figure 6, the smaller β the larger the relative decrease in inequality. Yet, again, relaxing the linear aggregation procedure of the HDI to a more general one, does not change the trend in well-being inequality dramatically. We indicate in bold the evolutions corresponding to parameter combinations satisfying CIM, i.e. $\varepsilon + \beta > 1$.

Let us now consider the effect of implementing different transformation functions. The first component is the weighting scheme, applied to the different dimensions. Both the HDI and the BPS-index weigh the considered dimensions equally. An alternative procedure, used by some authors, is to derive the weights directly from the data. In this respect especially the use of principal components analysis has been popular. Ram (1982) suggested the use of the first principal component to obtain the weights of the dimensions of the Physical Quality of Life Index. In the setting of the Human Development Index, Noorbakhsh (1998) applies a similar procedure based on the three dimensions of human development: standard of living, health and education. The weights

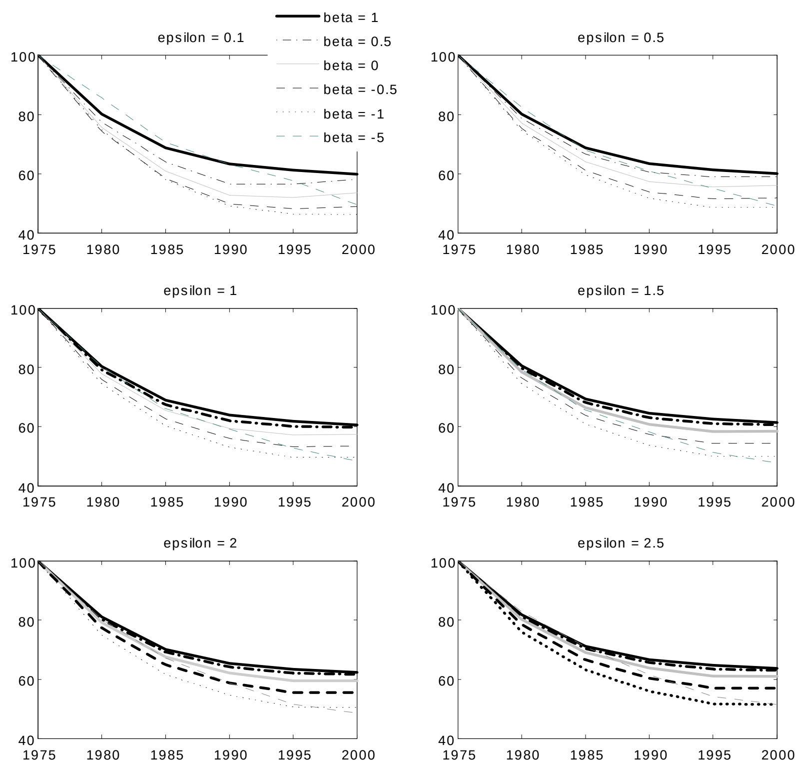

Figure 10: Evolution of well-being inequality, measured by the multidimensional Atkinson index, for different ε and β-values.

implied by a principal components analysis for our data, normalized so as to sum to 1, are reported in table 4. Changes in the trend of well-being inequality due to this alternative weighting scheme are minor (see figure 11). The relative decrease in inequality is a little bit stronger, which is attributable to the larger relative weight on the educational variables. Of course, the use of more extreme weighting schemes allows to obtain virtually any trend in well-being inequality since the dimensions separately show such a diverse pattern. This brings the weighting problem to the center of the discussion. Choices on weights are essentially normative choices, which should reflect universally acceptable social preferences over the different dimensions. The principal components approach, however, does not have any welfare-theoretic justification. In fact, the larger weights given to the educational variables in table 4, are merely a statistical artefact: given that there are two educational variables, it is not surprising that they explain a larger part of the common variance. Weighting schemes are very likely to be controversial and should therefore be stated explicitly, for example, as marginal rates of substitution.

θ_j	1975	1980	1985	1990	1995	2000
log (GDP/capita)	0.1663	0.1772	0.1871	0.1995	0.1986	0.2040
Longevity	0.1952	0.1899	0.1846	0.1894	0.1875	0.2059
Literacy Ratio	0.3204	0.3067	0.2874	0.2659	0.2273	0.2034
Enrolment ratio	0.3181	0.3262	0.3409	0.3452	0.3866	0.3867

Table 4: Weights of the dimensions based on the first principal component, normalized to 1.

Returning to the weighting scheme of the HDI, a second component of the transformation functions is the standardization procedure. By using the standardization procedures described in table (1), the achievements on the different dimensions of well-being are rescaled to a value between 0 and 1. This rescaling is more or less arbitrary. A first alternative amounts to rescaling the dimensions by the inverse of a measure of central tendency such as the mean of the transformed dimension $\mu\left(f_j\left(x_{ij}\right)\right)$:

$$z_{ij}^{alt1} = \frac{f_j\left(x_{ij}\right)}{\mu\left(f_j\left(x_{ij}\right)\right)} \qquad i = 1, ..., n; \quad j = 1, ..., k. \tag{15}$$

This kind of rescaling has a minor effect on the trend of well-being inequality, as can be seen in figure 12 for the mean[17]. Note that the Tsui-index (with $\beta = 0$), given in (13), is invariant to all multiplicative transformations.

A second alternative standardization procedure has been proposed by Hirschberg, Maasoumi and Slottje (1991) in their paper on measuring quality of life across countries. They propose the following standardization procedure:

$$z_{ij}^{alt2} = \frac{f_j\left(x_{ij}\right) - \mu\left(f_j\left(x_{ij}\right)\right)}{\sigma\left(f_j\left(x_{ij}\right)\right)} + 10 \qquad i = 1, ..., n; \quad j = 1, ..., k. \tag{16}$$

[17] The results for other measures of central tendency such as the median or even the maximum are very similar.

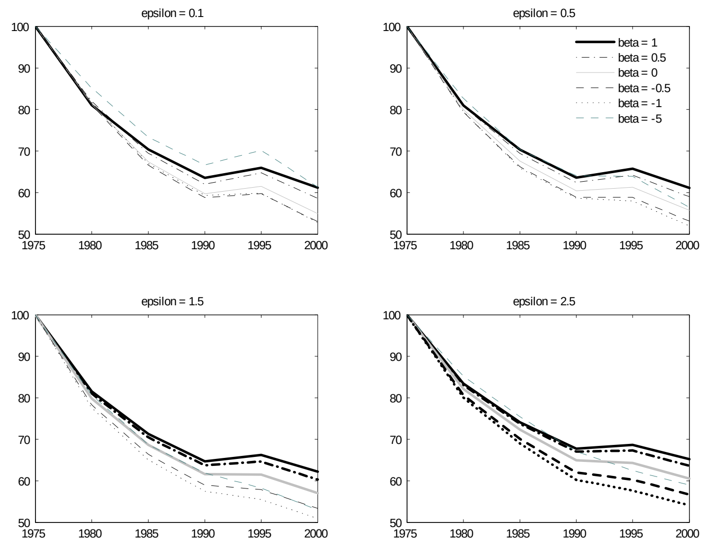

Figure 11: Evolution of well-being inequality, measured by the multidimensional Atkinson index, with principal component weigths, for different ε and β-values. .

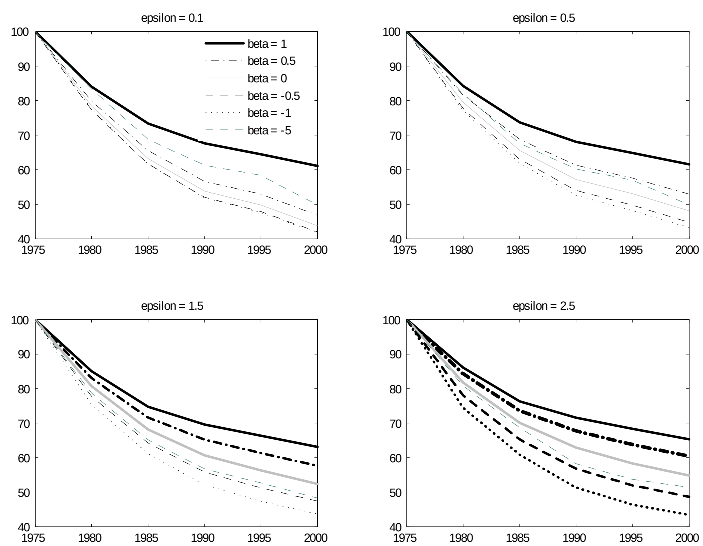

Figure 12: Evolution of well-being inequality, measured by the multidimensional Atkinson index with a simple rescaling standardization, for different ε and β-values.

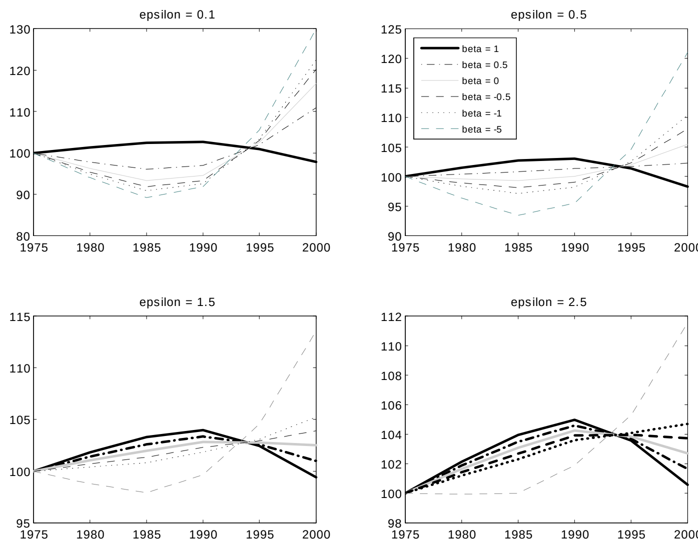

Figure 13: Evolution of well-being inequality, measured by the multidimensional Atkinson index, with the Hirschberg et al. standardization, for different ε and β-values.

$\sigma\left(f_j\left(x_{ij}\right)\right)$ denotes the standard deviation of the transformed data. This procedure standardizes the data such that the mean equals 10 and the standard deviation 1 and is obtained by calculating standard z-scores, which are translated over an arbitrary distance to the right, to make sure that all values are non-negative and calculation problems are avoided. Figure 13 shows that the trend in inequality after applying (16) is remarkably different from the other cases. Moreover, the obtained results are very sensitive to the number of standard deviations by which the distribution is shifted. This is not surprising since we are considering here a translation procedure in the context of scale-invariant (but translation-sensitive) inequality measures. Moreover, the choice of 10 standard deviations is fully arbitrary and does not capture any intuitively appealing normative viewpoint. Although this standardization is sometimes used in the design of composite indicators[18], we believe it to be less attractive in this context.

Finally we investigate the effect of the concave transformations on the trend in inequality. Here the results are remarkable. Let us look at income first. The logarithmic transformation embodied in the HDI can be generalized by using the functional form (5) proposed by Becker et al. (2005). Figure 14 summarizes the

[18] Morisson and Murtin (2005) use standard (untranslated) z-scores to standardize the data in their measurement of multidimensional well-being inequality. To avoid computational problems with nonpositive values, Morrisson and Murtin measure inequality by the standard error. Other examples of a standardization based on z-scores can be found in Salzman (2004).

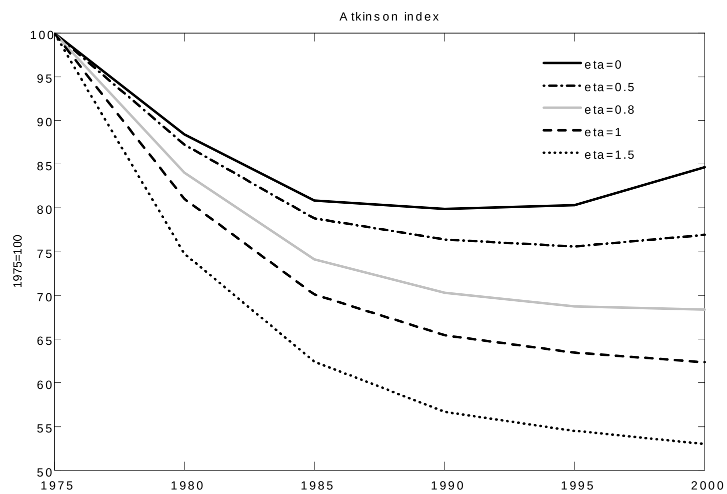

Figure 14: Evolution of well-being inequality, measured by the multidimensional Atkinson index, for different values of η.

sensitivity of the trend in well-being inequality for the η parameter, capturing the concavity of the transformation function of income. The case $\eta = 1$ is the HDI-case case with the logarithmic transformation. The BPS-specification implies $\eta = 0.8$. The concave transformation has a clear effect on the inequality trends: for $\eta = 0$, inequality in well-being is no longer decreasing over the whole time period, but shows a distinct U-shape.

Moreover, in the absence of a concave transformation of income, a smaller β and ε parameter value further strengthen the trend of increasing well-being inequality (see figure 15). The combination of no transformation of income ($\eta = 0$), a low degree of substitutability of the dimensions (β small) and a mild inequality aversion (ε small) lead to a relative *increase* in well-being inequality in the period considered. In the graphical representation of the normative space in figure 1, the area with increasing well-being inequality is situated in the south-west of the colored area.

The argument of diminishing returns can be made for the longevity dimension as well. Different degrees of diminishing returns can be captured by different values for the parameter r in the transformation function (6), introduced by Becker et al. (2005). As can be seen from figure 16, higher interest rates r diminish the decrease in inequality further.

The sensitivity of the results with respect to the concave transformations is not really surprising, since they by definition dampen the effect of increasing values at the higher end of the distribution. The result is more than a technical artefact, however. It raises the deeper question of what is well-being and how it should be measured. The concave transformation of income implements in a cer-

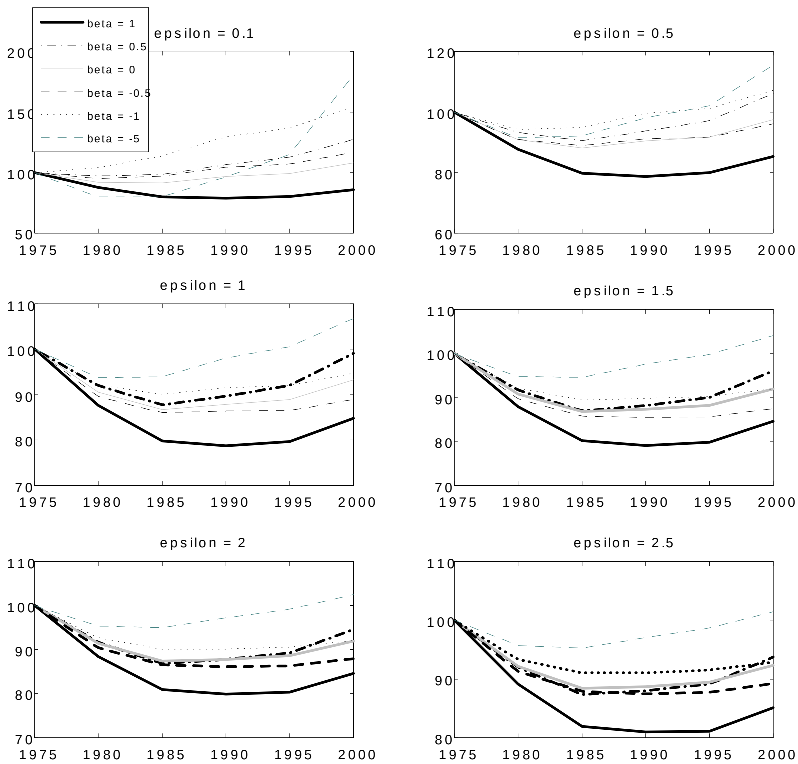

Figure 15: Evolution of well-being inequality, measured by the multidimensional Atkinson index, without logarithmic transformation, for different ε and β-values.

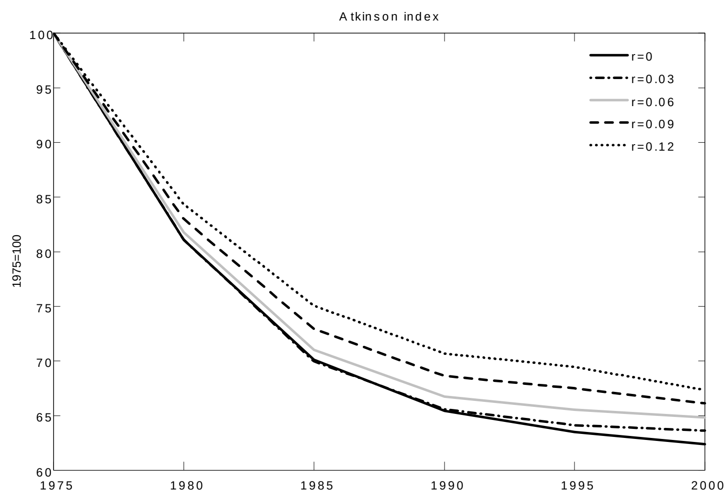

Figure 16: Evolution of well-being inequality, measured by the multidimensional Atkinson index, for different values of r.

tain sense the assumption of decreasing marginal well-being of income, implying that an income increase is worth less to a rich than to poor country. It therefore also implies that a proportional increase in all incomes will *lower* inequality in well-being measured by a scale-invariant inequality measure. It turns out that it is basically this assumption that drives the result (obtained both with the HDI and with the BPS) that well-being inequality shows a decreasing trend in recent decades.

4 Conclusion

In this paper we apply some methods from the recent literature on multidimensional inequality measurement to quantify the evolution of well-being inequality across countries. We treat well-being as a multidimensional concept focusing on three important dimensions of life: standard of living, health and education. Inequality in the three dimensions shows a different trend over the last 25 years. We propose a flexible multidimensional inequality index that allows separating the effect of different normative choices of transformation, standardization and aggregation procedures. We then perform a detailed sensitivity analysis for the different normative choices. We find out, that for many parameter values, international inequality declines, albeit at a declining pace. However, extreme weighting schemes can lead to virtually any trend in well-being inequality given the different evolution of the underlying dimensions. Moreover, the combination of no transformation of the income dimension, a low substitutability of the dimensions and a mild inequality aversion lead to a sharp increase in well-being inequality over the last years. The most striking finding is the crucial effect of the concave transformation applied to income both in the Human Development Index and in the full income-concept proposed by Becker, Philipson and Soares (2005). This observation underlines the need for clarity on the underlying normative choices in empirical work on multidimensional welfare and inequality measurement.

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Appendix 1. Sample and data coverage

The table below gives an overview of the 97 countries of the sample and the manipulations that are carried out to solve the problem of missing data. Similar to the literature on global income inequality we removed from the sample countries with a missing data-point for the indicator GDP per capita. For the other dimensions we removed countries with two consecutive missing data-points. (Those countries are not reported in the table).

For countries with only one data-point missing, we carried out the following manipulations. First, we approximated the missing point by a close data-point, which was not more than two years away. If no such data were available, linear interpolations and extrapolations were carried out, based on the closest available neighboring data. By these manipulations, which do not alter the broad picture of our results, the number of countries in the sample increased from 69 up to 97.

For many highly literate countries no literacy data are available. We followed the approach used in the Human Development Reports, and set the literacy rate of those countries equal to 99%. Contrary to the common practice in the Human Development Reports, we do not truncate GDP/capita to an arbitrary maximum of 40.000 US$ corrected for PPP nor do we truncate enrollment rate at 100%. Hence, some countries can obtain an indicator higher than 1 for some dimensions.

Country	**Manipulation**
Algeria	
Argentina	
Australia	Literacy rate = 99%
Austria	Literacy rate = 99%
Bangladesh	
Barbados	Literacy rate = 99%, interpolated data point (enrollment rate 1985)
Belgium	Literacy rate = 99%
Belize	Extrapolated data point (enrollment rate 1975)
Benin	Close data point (enrollment rate 1999 instead of 2000)
Bolivia	
Botswana	
Brazil	
Burkina Faso	Extrapolated data point (literacy rate 2000)
Burundi	
Cameroon	Close data point (enrollment rate 2001 instead of 2000)
Canada	Literacy rate = 99%
Central African Republic	Extrapolated data point (enrollment rate 2000)

Country	**Manipulation**
Chad	Close data point (enrollment rate 1999 instead of 2000), interpolated data point (enrollment rate 1980)
Chile	
China	
Colombia	
Congo. Rep.	Close data point (enrollment rate 1999 instead of 2000)
Costa Rica	
Cote d'Ivoire	Close data point (enrollment rate 1999 instead of 2000)
Cyprus	
Denmark	Literacy rate = 99%, close data point (enrollment rate 1999 instead of 2000)
Dominican Republic	
Ecuador	
Egypt. Arab Rep.	Extrapolated data point (literacy rate 2000)
El Salvador	Interpolated data point (enrollment rate 1985)
Fiji	Extrapolated data point (literacy rate 2000)
Finland	Literacy rate = 99%
France	Literacy rate = 99%
Georgia	Literacy rate = 99%, extrapolated data point (enrollment rate 1985)
Ghana	
Greece	Literacy rate = 99%
Guatemala	
Haiti	Extrapolated data point (enrollment rate 2000)
Honduras	Extrapolated data point (enrollment rate 2000)
Hungary	Close data point (enrollment rate 1999 instead of 2000)
Iceland	Literacy rate = 99%
India	
Indonesia	
Iran. Islamic Rep.	
Ireland	Literacy rate = 99%
Israel	
Italy	Literacy rate = 99%
Jamaica	
Japan	Literacy rate = 99%
Kenya	
Korea. Rep.	Literacy rate = 99%

Country	**Manipulation**
Latvia	Extrapolated data point (enrollment rate 1975)
Lesotho	
Luxembourg	Literacy rate = 99%
Malawi	Extrapolated data point (enrollment rate 1975)
Malaysia	
Mali	Close data point (enrollment rate 1998 instead of 2000)
Malta	
Mauritania	
Mexico	
Morocco	
Nepal	
Netherlands	Literacy rate = 99%
New Zealand	Literacy rate = 99%
Nicaragua	
Niger	
Nigeria	Extrapolated data point (enrollment rate 2000)
Norway	Literacy rate = 99%
Oman	
Pakistan	Close data point (literacy rate 1998 instead of 2000), extrapolated data point (enrollment rate 2000)
Panama	
Paraguay	
Peru	Close data point (enrollment rate 1998 instead of 2000)
Philippines	
Portugal	Literacy rate = 99%
Rwanda	
Saudi Arabia	
Senegal	
Singapore	Extrapolated data point (enrollment rate 2000)
Spain	Literacy rate = 99%
Sri Lanka	Close data point (enrollment rate 2001 instead of 2000)
Sudan	
Swaziland	Close data point (enrollment rate 2001 instead of 2000)
Sweden	Literacy rate = 99%
Switzerland	Literacy rate = 99%

Country	**Manipulation**
Syrian Arab Republic	
Thailand	
Togo	Close data point (enrollment rate 1999 instead of 2000)
Trinidad and Tobago	
Tunisia	
Turkey	
United Kingdom	Literacy rate = 99%
United States	Literacy rate = 99%
Uruguay	
Venezuela. RB	
Zambia	Extrapolated data point (enrollment rate 2000)
Zimbabwe	

Table 5: sample and data coverage