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Augmented human development in the age of globalization†

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A long-run view of well-being over the last one-and-a-half centuries is presented using an Augmented Human Development Index (AHDI) that combines achievements in health, education, material living standards, and political freedom. The AHDI shows substantial gains in world human development since 1870, although significant room for improvement still remains. The AHDI spread unevenly until 1960, in absolute terms, and up to 1929 in relative ones, and reversed this trend thereafter. The main relative gain went to world countries' middle class, but the main absolute gain accrued to the top decile. AHD trends and distribution do not match, but compare favourably with, those in per capita income. The absolute gap between present-day advanced countries and the rest of the world deepened over time, though fell in relative terms. Life expectancy has led progress in AHD, particularly until 1970, and drove the catching-up by the rest of the world during the epidemiological transition. Political and civil liberties took over thereafter.

Amartya Sen has distinguished three approaches to well-being: utility, opulence, and freedom.[1] The utility approach uses satisfaction and intensity of desire as its criteria. This approach is exemplified by studies that weigh up the various non-monetary dimensions of quality of life and focus on life satisfaction.[2] The opulence approach centres on command over commodities, as is the case in studies of real income and wealth. The freedom approach stresses capabilities, namely, individuals' ability to choose between various combinations of functionings or achievements (that is, a consumption bundle, a health condition, a level of education).[3] The human development paradigm was inspired by the concept of capabilities. Specifically, human development is defined as 'a process of enlarging people's choices', which includes enjoying a healthy life, acquiring knowledge, and achieving a decent standard of living.[4]

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[1] Sen, 'Living standard', p. 76.

[2] For example, Jones and Klenow, 'Beyond GDP?'; Clark, 'Economics of happiness'.

[3] Alkire, 'Human development'; Fleurbaey, 'Beyond income and wealth'. Freedom is seen here in a positive sense ('freedom to'), rather than a negative one ('freedom from'). Cf. Berlin, *Two concepts of liberty*; Sen, 'Freedom of choice'.

[4] UNDP, *Human development report 1990*, p. 10; idem, *Human development report 1993*, p. 105.

In 1990, the United Nations Development Programme (UNDP) introduced the Human Development Index (HDI) in an attempt to track the evolution of a set of capabilities across countries and over time, and to provide through this an 'inclusive approach to the measurement of human flourishing'.[5] Thirty years after the launch of the HDI, it is time to take stock. This article makes three contributions. First, it discusses attempts to construct a measure of well-being that moves beyond GDP, and presents a new Augmented Human Development Index (AHDI) that combines measures of achievements in health, education, material living standards, and political and civil liberties.[6] The timespan covered by the AHDI runs from the late nineteenth century, when human welfare was being widely affected by improvements in global health and education, to the aftermath of the 2008 Great Recession.[7] Its geographical coverage ranges from 115 to 162 countries that represent most of the world population. Second, on the basis of the AHDI, the article provides an overview of international well-being in the age of globalization, including its distribution, and uses growth incidence curves to show where the gains were located during the different phases of globalization. Third, it breaks down the AHDI to show the contribution of the different dimensions to the long-run gains observed over this period. This allows us to identify which dimensions drove gains in different periods, with a further distinction between the drivers of improvements in the most advanced regions, western Europe, the European offshoots—or nations outside Europe largely from European stock—and Japan (labelled here the *OECD* for its resemblance to this organization's membership before 1995), and in the rest of the world (the *Rest*, for short).

The article's main findings are that, on average, augmented human development (AHD) grew substantially around the world from 1870, and in particular during 1913–70, but there is still significant room for improvement. In terms of distribution, although relative inequality in AHD, which depends on the ratio of countries to the mean, initially increased up to the First World War, it experienced a steady long-run decline from the late 1920s. In absolute terms, that is, in terms of absolute differences between countries and regions, however, inequality in AHD rose up to the middle of the twentieth century, and only fell from 1960 onwards.[8] Middle and low human development countries achieved larger relative gains in the long run, but the top 10 per cent of countries obtained the largest absolute gains, even though AHD gains varied in intensity across the distribution during different phases of globalization. Human development spread unevenly across world regions. The absolute gap between the *OECD* and the *Rest* deepened over time, although it fell in relative terms from the late 1920s, driven by longevity up to 1970, and then by political and civil liberties. This result is at odds with the growing relative gap in average incomes.

[5] Heckman and Corbin, 'Capabilities and skills', p. 342.

[6] The AHDI improves on the 'hybrid' historical index of human development (HIHD) (Prados de la Escosura, 'World human development'), which only considers the first three dimensions.

[7] Cf. Riley, *Rising life expectancy*; Benavot and Riddle, 'Primary education'.

[8] Consider, for example, GDP per capita in two countries, country A, $1,000, and country B, $10,000. If GDP per capita is doubled in both countries, the absolute difference between country B and country A will widen, from 9,000 (= 10,000 – 1,000) to 18,000 (=20,000 – 2,000), but in relative terms the difference will not change; country B will continue to be 10 times richer than country A. Cf. Ravallion, 'Competing concepts of inequality', pp. 23–4.

The research highlights an apparent development puzzle: GDP per capita and human development do not always go hand-in-hand, either in levels or in distribution. More specifically, human development experienced major gains across the board during the backlash against economic globalization that occurred in the early twentieth century, resulting from the advance in longevity and education in this period. Furthermore, relative international inequality in per capita income grew until the early 1970s and only fell from the 1990s, while inequality in AHD has steadily reduced since the late 1920s.

Life expectancy was the main contributor to human development progress over the one-and-a-half centuries considered here, although its greatest contribution was concentrated between 1914 and 1970, as the international diffusion of the epidemiological transition took place. Education was the second most important dimension, being a steady contributor to human development over the entire timespan considered. Finally, political and civil liberties added substantially to AHD throughout the twentieth century, especially in its last two decades.

The rest of the article is organized as follows. Section I discusses the concept and measurement of human development. Section II proposes an AHDI that introduces a non-linear transformation of its health and education variables and attempts to incorporate freedom to choose by adding a new dimension, political and civil liberties, proxied by an index of liberal democracy, and compares it to alternative (augmented) human development specifications. Section III presents trends in the AHDI and examines how its gains have been distributed, with special attention to the human development gap between western Europe and its offshoots plus Japan—the *OECD*, as it includes most pre-1995 OECD countries—and the *Rest* of the world. Section IV takes a closer look at the drivers of human development. The article closes with a recapitulation of its main findings.

I. Human development: from concept to measure

Shifting from the conceptual to the practical level in thinking about human development presents a challenge. In order to provide a synthetic measure of human development, proxies for its different dimensions need to be chosen from among the array of available objective measures. In the UNDP's HDI, a healthy and long life is proxied by life expectancy at birth; access to knowledge, by years of education; and command over resources needed for a decent living standard, by the logarithmic transformation of per capita income.

An important distinction exists between longevity and education, on the one hand, and per capita income, on the other. The former are measures of achievement, but also of capability: namely, avoiding premature death or ignorance. This is not true of the latter. Per capita income is not the ultimate object for individuals; it just represents an input that can be turned into a capability: being able to live a full, meaningful life. This implies that being able to command resources is one ingredient in an individual's ability to lead a freer life. That is why per capita income enters the index at a declining rate, since, in terms of capabilities, its return diminishes as its level rises.[9] In the HDI, the transformed income index is

[9] Anand and Sen, 'Income component', p. 100.

also intended to provide a surrogate for dimensions of well-being aside from health and knowledge.[10]

Although conceptually unaltered, the composition of the HDI has varied over time. In 2010, the *Human development report* introduced major changes in the indicators used to represent two of the dimensions of human development.[11] For education, the expected years of schooling for a school-aged child and the mean years of schooling among the population aged 25 years and over were combined using an unweighted arithmetic average.[12] In income, purchasing-power-parity-(PPP-) adjusted per capita gross national income (GNI) replaced PPP-adjusted GDP per capita. This represented an improvement as GNI captures the income accruing to residents of a country, not just the income produced in the country regardless of the share retained at home. In health, measured by life expectancy at birth, no changes were made.

In order to homogenize the indicators for the different dimensions, their original values (I) are transformed into an index taking the form:

$$I = (x - M_o) / (M - M_o), \tag{1}$$

where x is the observed value of a given dimension of welfare, and M_o and M are the minimum and maximum values, or goalposts, to facilitate comparison over time. Each dimension therefore ranges between 0 and 1.

New goalposts were introduced by the UNDP in 2014, that replaced those defined in 2010.[13] For life expectancy at birth, the maximum and minimum values were established at 85 and 20 years, respectively. For education, maximum values were set at 15 for the mean years of schooling among the adult population and 18 for the expected years of schooling for a school-aged child, with the minimum set at 0 for both indicators. For GNI per capita, the maximum and minimum were established at 75,000 and 100 PPP-adjusted 2011 dollars.[14]

An unweighted geometric average of all three dimensions (longevity, education, and income) is used to derive a synthetic HDI, replacing the arithmetic mean used until 2010. This approach is an attempt to reduce the substitutability between its different dimensions, to penalize low and uneven achievements, and to portray each dimension as equally indispensable. Thus, the UN index is calculated as:

$$HDI = (I_{Health}.I_{Education}.I_{Income})^{1/3} \tag{2}$$

[10] Ibid., p. 99.

[11] UNDP, *Human development report 2010*; idem, *Human development report 2014*.

[12] UNDP, *Human development report 2014*. This represented a change with respect to the *Human development report 2010*, in which the unweighted average was geometric. Previously, education attainment was usually proxied by rates of total (primary, secondary, and tertiary) enrolment and adult literacy combined in index form as a weighted arithmetic average (two-thirds literacy and one-third enrolment). Mean years of schooling were used instead of enrolment only once before, in idem, *Human development report 1994*.

[13] The 2010 goalposts were 83.2 and 20 years for life expectancy, and 13.2 and 20.6 years as maxima for mean years of schooling and expected years of schooling, respectively, with 0 as the minima. In the case of GNI per capita, 108,211 and 163 PPP dollars were the maximum and minimum goalposts; UNDP, *Human development report 2010*, p. 216.

[14] The upper limit was set on the basis of Kahneman and Deaton, 'Evaluation of life', p. 16491, finding that 'there is no improvement … in … emotional well-being' as per capita income goes beyond $75,000. The lower limit was supposed to represent a subsistence minimum; UNDP, *Human development report 2014*, technical notes, 2.

The HDI has attracted criticism since its inception.[15] The lack of foundations in welfare economics has been highlighted as its main shortcoming,[16] even though the HDI was explicitly defined as a measure of well-being in terms of capabilities, rather than utility. Some of the main critiques are addressed below.[17]

Longevity and education

The transformation of the original values of the social dimensions (life expectancy, height, literacy, years of schooling) into index form presents a challenge. Social variables are often used in their raw form.[18] Yet the fact that these non-income variables are bounded raises concerns about the use of their original values to make comparisons over space and time.

In the HDI, the linear transformation of the indicators for the social dimensions reduces the size of the denominator by introducing maximum and minimum values (goalposts) and thus widens the index's range (see equation 1). Nonetheless, the values assigned to the goalposts have been challenged as being discretionary. For example, Herrero et al. reject the use of arbitrarily fixed minimum values that, they claim, penalize poorer performers and may determine countries' rankings. They instead propose expressing each dimension, x, as a share of some maximum set value, M.[19]

$$I = x/M \tag{3}$$

It can be argued, nonetheless, that as a natural floor often exists, lower goalposts simply aim at capturing subsistence levels. For example, historical evidence on life expectancy at birth indicates that 20 years was most probably a floor in human societies going back to Neolithic times.[20] This is also the case for per capita income, as human life cannot survive below a basic level of physiological subsistence.[21]

However, when linearly transformed social variables (as in both the UNDP's HDI and Herrero et al.'s proposal) are used to compare countries (or periods), identical absolute changes result in a smaller proportional improvement for the country (period) with the higher starting level (as would also be the case if we were using their original values). Consider, for example, a 10-year improvement in life expectancy at birth, in one case from 30 to 40 years, and in another from 70 to 80 years. Although these changes are identical in absolute terms, the second is smaller relative to the initial level. Put into the index for health used in the 2014 UN HDI, the first country would see a 100 per cent improvement from 0.15 to 0.31, while the second would see a 20 per cent improvement from 0.77 to 0.92. Therefore, a

[15] Srinivasan, 'Human development'.

[16] Dowrick, Dunlop, and Quiggin, 'Social indicators', p. 502.

[17] I will not consider, however, the concern about combining stocks (life expectancy and schooling years) and flows (per capita income) in the HDI, already discussed extensively by Aturupane, Glewwe, and Isenman, 'Poverty', p. 246; Klugman, Rodriguez, and Choi, 'HDI 2010', p. 259.

[18] Acemoglu and Johnson, 'Disease and development'; Hatton and Bray, 'Heights'; Lindert, *Growing public*; Morrison and Murtin, 'Century of education'.

[19] Herrero, Martínez, and Villar, 'Newer Human Development index', pp. 54–5.

[20] Fogel, 'Biotechnology', p. 13; Steckel, 'Anthropometric history', p. 34.

[21] Milanovic, Lindert, and Williamson, 'Pre-industrial inequality', p. 262. Sagar and Najam, 'Human Development Index', p. 254, chose a minimum value for per capita income of $300.

linear transformation does not solve the problem of the comparability of bounded social dimensions across countries or over time.

For health, there is a further problem. In poor countries, the main reduction of mortality takes place among children, as infectious disease declines, whereas in rich countries mortality falls among the elderly as a result of better treatment of cardiovascular and respiratory diseases. Thus, if minimum original values of life expectancy at birth are employed and absolute changes of the same magnitude therefore receive a larger weight when the starting level is lower, the index will arbitrarily give more weight to saving the lives of younger people over the lives of older people.[22]

The limitations of linearly transformed measures become more evident when quality is taken into account. Life expectancy at birth and years of schooling are just crude proxies for the actual goals of human development: a long and healthy life and access to knowledge. Alas, data on health-adjusted longevity, 'healthy life expectancy', only exist from 1990 onwards.[23] Reassuringly, the Global Burden of Disease Study 2016 allows us to compare healthy life expectancy at birth (HALE) with conventional life expectancy at birth (LEB) for the period 1990–2016. This shows that healthy life expectancy at birth rises with raw life expectancy at birth (figure 1).[24]

The available evidence for the last three decades indicates that although morbidity increased in absolute terms, it experienced a relative compression: the proportion of years lived in disability fell.[25] As life expectancy rose, disability for each age cohort declined.[26] More specifically, longer lives—due to a rapid decline in years of life lost—together with a more modest age-adjusted decline in years lived with disability, have led to lower age-standardized disability-adjusted life-years rates across the board.[27] In other words, the quality of life improves for each age cohort as life expectancy at birth increases.[28] Thus, the apparent ethical-measurement conflict observed by Dasgupta fades away.[29]

[22] Deaton, 'Global patterns', p. 9.

[23] Healthy life expectancy at birth (HALE) is a summary measure of health computed using age-specific death rates and years of life lived with disability per capita. Cf. Murray et al., 'Global Burden of Disease'.

[24] Four benchmark estimates for 1990, 2000, 2006, and 2016 from ibid. are pooled in fig. 1. Canning, 'Progress in health', reports a similar finding.

[25] Murray et al., 'Global Burden of Disease'.

[26] Mathers, Sadana, Salomon, Murray, and Lopez, 'Healthy life expectancy'; Salomon, Wang, Freeman, Vos, Flaxman, Lopez, and Murray, 'Healthy life expectancy'; Murray et al., 'Global Burden of Disease'.

[27] Murray et al., 'Global Burden of Disease', p. 1331.

[28] The decline in age-specific disability as life expectancy at birth increases is compatible, however, with years lost to disability (YLD) rising with life expectancy, because YLD tend to concentrate at the end of life; Salomon et al., 'Healthy life expectancy'. So, perhaps the view that while longevity increases, periods of ill health can be longer, but are lived in better health and less disability, due to advances in medical technology (Manton, 'Morbidity and mortality'), qualifies Fries's morbidity compression hypothesis; Fries, 'Ageing'; Fries, Bruce, and Chakravarty, 'Compression of morbidity'; Lindgren, 'Rise in life expectancy'. Nonetheless, Cutler, Ghosh, and Landrum, 'Evidence', and Chernew, Cutler, Ghosh, and Landrum, 'Improvement', find that the reduction in disabled life expectancy runs parallel to the increase in healthy life expectancy, suggesting a compression of morbidity for the US between 1990 and 2010. A note of historical caution is warranted, as evidence for a stable association between death and ill health prior to 1990 is scant and inconclusive; Riley, 'Risk of being sick'; Howse, 'Increasing life expectancy'; Bleakley, 'Disease and development'; idem, 'Malaria eradication'; Cutler, Fung, Kremer, Singhal, and Vogl, 'Malaria'.

[29] Dasgupta, 'Well-being', p. 23, asserts that 'Equal increments are possibly of less and less ethical worth as life expectancy rises to 65 or 70 years and more. But we are meaning performance here. So it would seem that it becomes more and more commendable if, with increasing life expectancy, the index were to rise at the margin'.

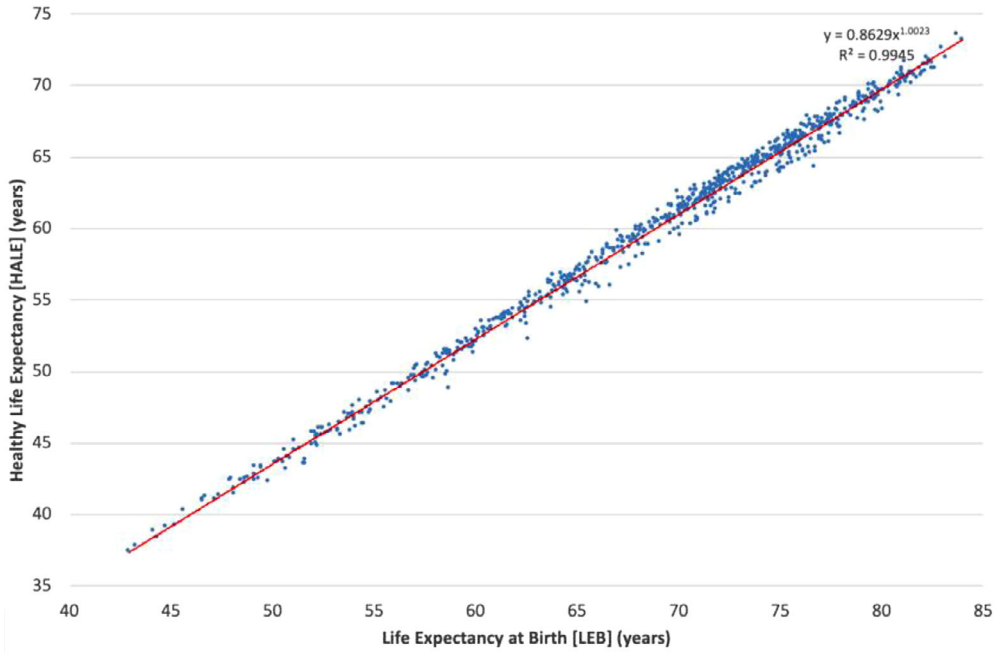

Figure 1. *Healthy life expectancy (HALE) and life expectancy at birth (LEB), 1990–2016*
[Colour figure can be viewed at wileyonlinelibrary.com]
Note: Pool of 1990, 2000, 2006, and 2016 benchmarks.
Source: Murray et al., 'Global, regional, and national disability-adjusted life-years'.

Similarly, the quality of education grows as the quantity of education increases. A comparison between quality-adjusted and quantity indices of education suggests a convex association between them, with quality-adjusted education increasing more than proportionally at higher levels (figure 2).[30]

To sum up, on the basis of the available evidence for the last decades, it can be claimed that more years of life expectancy and schooling imply a higher quality of health and education, respectively, during childhood and adolescence. Hence, when transforming the original values of the health and education variables, one needs to allow for the fact that they are bounded and that their quality improves along with their quantity. The non-linear transformation proposed by Kakwani provides a way to achieve this.[31]

Using an axiomatic approach, Kakwani constructed a normalized index from an achievement function in which an increase in the standard of living of a country at

[30] The measure of quality-adjusted years of education used here is derived as the product of normalized indices (namely, expressed relative to its maximum value) of cognitive skills (as a measure of quality), provided by Altinok, Angrist, and Patrinos, 'Global data set', and years of schooling (as a measure of quantity) is each country's average over 1965–2015 (see online appendix S2). A word of caution is needed, though, as no evidence about the relationship between quality-adjusted years of education and quantity of education exists prior to 1965.
[31] Kakwani, 'Living standards'.

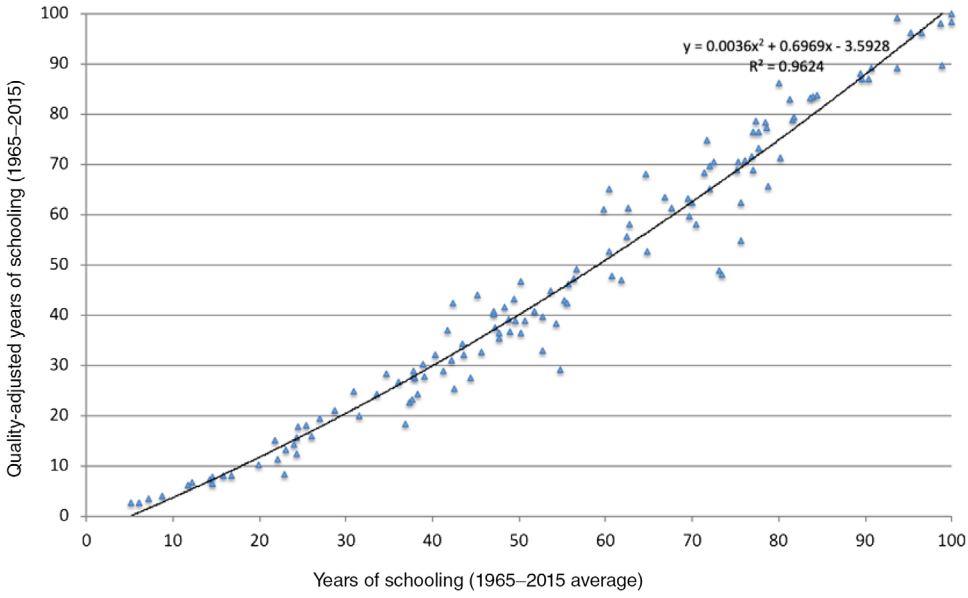

Figure 2. *Quality-adjusted and raw years of schooling, 1965–2015 (normalized) [Colour figure can be viewed at wileyonlinelibrary.com]*

Note: Average, 1965–2015.
Sources: Cognitive skills: Altinok et al., 'Global data set'. Years of schooling: see text and online app. S2.

a higher level implies a greater achievement than would have been the case had it occurred at a lower level:[32]

$$I = (\log(M - Mo) - \log(M - x)) / \log(M - Mo) \quad (4)$$

The same notation used in equation 1 applies: x is an indicator of a country's standard of living; M and M_o are the maximum and minimum values, respectively; and *log* stands for the natural logarithm. The achievement function proposed by Kakwani is a convex function of x. It is equal to 0 if $x = M_o$, and equal to 1 if $x = M$, thus ranging between 0 and 1.

How do the non-linearly transformed variables compare to their original, linearly transformed values, or other approaches to transformation? For world average years of schooling and life expectancy at birth during the years 1870–2015, columns 2 to 6 of table 1 present, respectively, the non-linearly transformed (Kakwani) indices, alongside their conventional UNDP linearly transformed indices, and linear indices that present the share of maximum values, as suggested by Herrero et al. (HMV).[33] These indices are computed using the UNDP 2014 maximum goalposts. In the case of schooling, the HMV index is, by construction, identical

[32] Ibid., pp. 313–15, drawing on Atkinson, 'Measurement of inequality', uses an achievement function, f (x, M_o, M) = $((M - M_o)^{1-\varepsilon} - (M - x)^{1-\varepsilon}) / ((M - M_o)^{1-\varepsilon})$, for $0 < \varepsilon < 1$ [4], with ε being an inequality-aversion parameter, and opts for $\varepsilon = 1$ which satisfies all the axioms of the improvement index, that is, the difference between the values of the achievement index between two periods, while it does not satisfy them for $0 < \varepsilon < 1$. The UNDP social dimensions' transformation represents a particular case, for $\varepsilon = 0$, which yields equation 1.
[33] Herrero et al., 'Newer Human Development Index'.

Table 1. *Alternative indices of years of schooling, life expectancy, per capita income, and liberal democracy, 1870–2015*

	Years of schooling		*Life expectancy at birth*			*Per capita income*					
	Kakwani	*UNDP*	*Kakwani*	*UNDP*	*HMV*	*UNDP*	*Bértola–Vecchi*	*Zambrano*	*HMV*[a]	*HMV-eei*[b]	*Liberal democracy*
1870	0.032	0.084	0.033	0.128	0.334	0.350	0.016	0.094	0.018	0.010	0.093
1880	0.037	0.096	0.036	0.138	0.341	0.368	0.018	0.102	0.020	0.012	0.102
1890	0.042	0.108	0.039	0.151	0.351	0.386	0.021	0.110	0.023	0.014	0.105
1900	0.048	0.123	0.045	0.170	0.365	0.408	0.024	0.121	0.026	0.015	0.115
1913	0.055	0.138	0.053	0.198	0.387	0.438	0.029	0.138	0.031	0.017	*0.137*
1929	0.070	0.173	0.081	0.286	0.454	0.465	0.035	0.154	0.037	0.017	*0.154*
1938	0.081	0.198	0.098	0.335	0.492	0.471	0.037	0.158	0.039	0.018	*0.143*
1950	0.094	0.225	0.143	0.450	0.579	0.496	0.043	0.174	0.045	0.020	*0.208*
1960	0.115	0.267	0.157	0.482	0.604	0.540	0.057	0.206	0.059	0.026	*0.262*
1975	0.153	0.340	0.240	0.633	0.719	0.604	0.085	0.262	0.087	0.035	*0.225*
1985	0.184	0.392	0.271	0.677	0.753	0.626	0.098	0.283	0.100	0.045	*0.277*
1995	0.212	0.436	0.294	0.707	0.776	0.645	0.111	0.303	0.112	0.048	0.366
2005	0.244	0.483	0.325	0.742	0.803	0.683	0.141	0.347	0.143	0.058	0.390
2015	0.274	0.524	0.380	0.796	0.844	0.718	0.175	0.392	0.176	0.085	0.374

Notes: a HMV: Herrero, Martínez, and Villar.
b HMV-eei: Herrero, Martínez, and Villar, egalitarian equivalent income.
Transformation of social dimensions (life expectancy, years of schooling)
UNDP, linear transformation (equation 1), $I = (x - M_o) / (M - M_o)$.
Kakwani, convex transformation (equation 4) $I = (\log (M - M_o) - \log (M - x)) / \log (M - M_o)$.
HMV (Herrero, Martínez, and Villar), (equation 3) $I = x / M$. (In the case of years of schooling, since the minimum goalpost is 0, the results of the HMV and the UNDP transformations are identical.)
Transformation of per capita income
UNDP, linear transformation (equation 1) but with values in natural logarithms (ln), $I = (\ln x - \ln M_o) / (\ln M - \ln M_o)$.
Bértola et al. and Vecchi et al., (equation 1), $I = (x - M_o) / (M - M_o)$.
HMV, (equation 3) $I = x / M$.
HMV-eei, (equation 3) $I = x / M$ but replacing per capita income, y, with the egalitarian equivalent income, $y^e = y^* (1 - G)$, where y represents per capita income, and G the Gini.
Zambrano (equation 5), $I = (x^r - M_o^r) / (M^r - M_o^r)$, with $r = 0.5$ r (a fraction of per capita income growth that translates into capabilities) $0 < r < 1$
Transformation of liberal democracy
Linear transformation (expression [1]), $I = (x - M_o) / (M - M_o)$.
x is the observed value of a given dimension of welfare, and M_o and M are the maximum and minimum values, or goalposts.
Sources: See section I.

to the UNDP transformation, so it is not reported separately. It can be observed that the Kakwani indices show systematically lower values but also faster growth.

Income

The UNDP use of the log of per capita income to proxy a decent standard of living has been challenged since the early stages of the HDI. One alternative proposal has been to use a simple linear transformation without logarithms (equation 1), which would arguably add another equally valuable dimension of human development and avoid underestimating per capita differences across countries as their levels increase.[34] Another suggestion has been to express countries' real per capita income as a percentage of an established maximum level.[35] Recently, Zambrano has proposed a way to normalize per capita income without using the logarithmic

[34] Bértola, Hernández, Rodríguez, and Siniscalchi, 'Human development, pp. 3–4.
[35] Gormely, 'Human Development Index'; Herrero et al., 'Newer Human Development Index', p. 258.

transformation.[36] Unlike the social dimensions (health and education) of the HDI, for which a growth in the level achieved causes a proportional increase in terms of capabilities, Zambrano claims that per capita income growth translates less than proportionally in terms of capabilities; namely, in a fraction of it (r), with r varying within 0 and 1 and being the same for all income levels:

$$I = (x^r - M_o^r) / (M^r - M_o^r) \quad (5)$$

In the particular case of $r = 0$, the result is the UNDP log transformation of income. However, as the value assigned to r is largely discretionary, an element of arbitrariness is introduced into the estimates.

The alternatives to the logarithmic transformation of per capita income (with the exception of Zambrano's proposal) do not address the very different nature of income compared to the other dimensions in the HDI, which are bounded in the cases of longevity and education, and without a known upper limit in the case of real per capita income. Although the convex transformation of the indicators of longevity and education dimensions mitigates the difference between these bounded variables and unbounded variables such as GDP per capita, it does not put them on a level playing field, and some form of compression of the income dimension of human development is required to make it comparable to its social dimensions.[37] Furthermore, the logarithmic transformation of average income may be interpreted as a multiple of the subsistence level, M_o, that is, in terms of the size of the income gap, M/M_o, to be bridged by a country whose average income is at subsistence level.[38] Therefore, although a logarithmic transformation of per capita income, as employed in the HDI, is a second-best solution, it has been adopted here in the absence of a superior alternative.[39]

Columns 7 to 11 of table 1 present indices of real per capita income for the world between 1870 and 2015. It shows the conventional UNDP log-linear transformed index, along with four of the different alternatives that have been suggested: an index employing the linear but non-logarithmic transformation, as proposed by Bértola et al. and Vecchi et al. (Bértola–Vecchi);[40] an index expressing each country's average incomes as a share of an upper bound—here defined as the UNDP's 2014 maximum goalpost, 75,000 dollars—as suggested by Herrero et al. (HMV);[41] an index based on a further adjustment also proposed by Herrero et al. (HMV-eei), the *egalitarian equivalent income*, y^e, derived as $y^e = y * (1- G)$, where y represents per capita income and G represents the Gini;[42] and finally an index

[36] Zambrano, '"Troubling tradeoffs"', p. 535.

[37] Sagar and Najam, 'Human Development Index', p. 254. This reasoning leaves aside the interpretation of per capita income in terms of capabilities.

[38] Zambrano's original notation has been changed to match that of equation 1. Cf. Zambrano, 'Axiomatization', pp. 863–4.

[39] Zambrano's ('"Troubling tradeoffs"') proposal does not seem to me a less discretional option, or a more intuitive or simpler one. Kakwani, 'Living standards', p. 324, considers the logarithm of GDP per head an adequate measure of economic welfare in the absence of income distribution information.

[40] Bértola et al., *Human development*, pp. 3–4; Vecchi, Amendola, Gabbuti, and Vecchi, 'Human development', p. 468.

[41] Herrero et al., 'Newer Human Development index', p. 256.

[42] As Herrero et al., 'Newer Human Development Index', establish a maximum level for the inequality-adjusted income of G-K 2011 $60,000, over a maximum unadjusted income of G-K 2011 $75,000, I applied their ratio (60/75) to the maximum income in G-K 1990 $47,000, obtaining a maximum inequality-adjusted income

based on the non-logarithmic transformation proposed by Zambrano, here with an r value of 0.5.[43] It can be observed that compared to the UNDP logarithmic transformation, these indices exhibit much lower levels and higher growth rates which imply larger differences across countries and over time.

Freedom

One aspect of the choice of HDI components that has attracted criticism is the absence of an equity dimension.[44] Since 2010, the *Human development report* has included an inequality-adjusted index, but a dearth of reliable historical data on inequality for most countries of the world precludes the use of this approach here.[45]

A more relevant issue is that, so far, attempts to portray human development in index form have only been made in terms of achievements or functionings.[46] However, the ability to choose between alternative bundles of functionings, a defining feature of human development as a measure of capabilities, is not considered in the HDI. But without agency—that is, the ability to pursue and realize the goals a person has reason to value—and freedom, any index falls short of being even a reduced-form measure of human development and simply becomes another 'basic needs' metric.[47] However, attempts to incorporate agency and liberty into the HDI have been discouraged by threats from totalitarian countries.[48]

Unlike inequality, for which no comprehensive historical data are available, the inclusion of freedom in a historical HDI is feasible. Dasgupta and Weale added civil and political liberties to a set of demographic and educational indicators in order to provide a comprehensive view of well-being, and Crafts expanded the exercise to Britain and other western European countries during the industrial revolution.[49] More recently, Bértola et al. and Vecchi et al. have added democratization and political and civil rights, respectively, as a fourth dimension to their HDI historical estimates.[50]

of $37,600. Global income inequality comes from van Zanden, Baten, Foldvári, and van Leeuwen, 'Global inequality', p. 294, completed with Lakner and Milanovic, 'Global income distribution', p. 229, and Milanovic, 'Global income distribution', p. 10, for the post-2000 years.

[43] Zambrano, '"Troubling tradeoffs"', p. 536, uses a value of 0.5 as an example, and this is the value I have used here.

[44] The income dimension was adjusted for inequality in the early stages of the HDI but this was then abandoned because of the lack of reliable data across countries, while no attempt was made to compute inequality for the social dimensions; UNDP, *Human development report 1993*. Cf. Hicks, 'Inequality-adjusted Human Development Index'.

[45] Cf. Klugman et al., 'HDI 2010', pp. 280–2, and Herrero et al., 'Newer Human Development Index', pp. 256–8, for critical assessments of the UNDP attempt. Herrero et al., 'Newer Human Development Index', p. 257, note, in particular, that since the available data on longevity and education are unrelated to the social and economic stratification behind income inequality, the inequality-adjusted HDI is difficult to interpret. Nonetheless, they introduced an inequality adjustment to income (an egalitarian equivalent income) that can be interpreted as a 'capability measure that transforms income into material wellbeing'; ibid. Bértola et al., 'Human development', attempt to include inequality in the three dimensions of human development for a group of Latin American and western European countries over the long run.

[46] At least, directly, since it could be argued that functionings in health and education also imply capabilities. Security is another important dimension that deserves to be included (I owe this remark to Ewout Frankema). However, the inclusion of civil and political rights in the freedom index partially offset it.

[47] Ivanov and Peleah, 'Centrally planned development', pp. 17–18.

[48] Klugman et al., 'HDI 2010', p. 265.

[49] Dasgupta and Weale, 'Measuring the quality of life', pp. 120–2; Crafts, 'Dimensions', pp. 621–2.

[50] Bértola et al., 'Human development', p. 5; Vecchi et al., 'Human development', pp. 475–80.

Agency and freedom cover a wide range of capabilities, from civil to economic and political liberties, for which unfortunately there are not enough comprehensive data at a global level over the last 150 years. A partial solution is to consider a variable that represents political and civil liberties.

One practical issue is the choice of the variables that may serve to proxy political and civil liberties. Varieties of Democracy (V-Dem), the latest and most complete database encompassing 201 countries over the period 1789–2018, provides a Liberal Democracy Index, which combines electoral democracy (including free competition, extensive participation, and rulers' responsiveness to citizens), a collective and positive freedom, with civil liberties (protection of individual and minority rights and limits on government including the rule of law, an independent judiciary, and effective checks and balances), a measure of negative freedom.[51] The Liberal Democracy Index is more comprehensive than historical indices such as Polity IV Project's Polity2 index and Vanhanen's Index of Democratization.[52]

Table 1, column 12, shows the evolution of a population-weighted index of liberal democracy in the world since 1870. Three main spurts are noticeable, in the early twentieth century, in the aftermath of the Second World War, and following the demise of socialism in Russia and eastern Europe. By the early twenty-first century, the index reaches a level four times that of the late nineteenth century.

Aggregation

The decision to aggregate the different dimensions of human development into a synthetic index has provoked adverse reactions. Ravallion argued against the use of composite indices due to their limited theoretical underpinning and implicit trade-offs.[53] The alternatives that have been suggested include addressing each dimension's indicator separately (in the case of Aturupane et al.); resorting to a 'dashboard' of indicators (Ravallion); and producing an ordinal, rather than a cardinal measure (Dasgupta and Weale).[54] In defence of an aggregate index of well-being, it has been argued that summarizing a set of indicators into a single number avoids the risk of divergence between different dimensions of well-being and offers an alternative to per capita income.[55]

Two aspects of the process of aggregation have also been the focus of debate. First, the equal weighting given to the dimensions in the HDI has been questioned. Why should each dimension (longevity, education, and income) receive the same weight in the index over space and time?[56] A substantive objection to the use of fixed weights is that the relative values of the index components are not necessarily the same across countries (or individuals) or over time.[57] Moreover, it has been argued that the weights used in the HDI are based on judgement rather than on welfare

[51] Coppedge et al., 'Varieties of democracy'.

[52] Cf. Knutsen, Teorell, Wig, Cornell, Gerring, Gjerløw, Skaaning, Ziblatt, Marquardt, Pemstein, and Seim, 'Historical Varieties of Democracy dataset'. Polity2 (Marshall, Gurr, and Jaggers, 'Polity IV') and the Index of Democratization (Vanhanen, 'Measures of democracy') can be depicted as *de jure* and *de facto* measures of political institutions, that is, formal rules and outcomes, respectively (Földvari, 'Political institutions', p. 760).

[53] Ravallion, 'Mashup indices'; idem, 'Troubling tradeoffs'.

[54] Aturupane et al., 'Poverty'; Ravallion, 'Mashup indices'; Dasgupta and Weale, 'Measuring the quality of life'.

[55] Krishnakumar, 'Trade-offs'.

[56] Hopkins, 'Human development revisited', p. 1471; Kelley, 'Human Development Index', p. 319.

[57] Srinivasan, 'Human development', p. 240.

theory.[58] However, the notion that each of the dimensions is equally essential in determining the level of human development is one of the main attributes of the concept.[59] A technical test of the validity of this approach has been developed, based on applying principal component analysis (PCA) to the HDI. PCA estimates the optimal weights for each HDI component over time by weighting attributes by their variance. Perhaps counterintuitively, the results obtained from using PCA suggest stable one-third weights are appropriate for each dimension of the index, offering some support for the UNDP methodology.[60]

The second substantive debate about the aggregation of the dimensions of the HDI centres on the shift from additivity to multiplicativity of the index's components introduced in 2010.[61] The reason for the change was that the assumption of perfect substitutability between dimensions implicit in the arithmetic average was deemed to be in flagrant contradiction with the notion that each dimension was equally crucial in determining the HDI. Substitutability among the components of the index could be restricted by using their geometric average.[62] Yet, even though the geometric average favours a more balanced combination of human development dimensions, it is less intuitive than the arithmetic average.[63]

Several harsh criticisms of the multiplicative method of aggregation have been put forward.[64] Critically, Ravallion attacks the implicit trade-offs between the new index's dimensions, measured by their marginal rate of substitution.[65] The 2010 HDI, he argues, 'generates a steep income gradient in the index's implicit valuations of life expectancy and schooling'.[66] In particular, the value assigned to longevity relative to average income rises with per capita income, reaching a value 17,000 times higher for the richest countries than for the poorest ones.[67] Ravallion's bottom line is that the embodied social values of the new HDI imply that we value longevity (or education) more in rich countries than in poor ones.[68] Thus, he suggests, the HDI's implicit trade-offs lead to the unacceptable conclusion that 'the most

[58] Dowrick et al., 'Social indicators', p. 503.

[59] Desai, 'Human development'; Sagar and Najam, 'Human Development Index', p. 251.

[60] Cf. UNDP, *Human development report 1993*; Ogwang, 'Principal components'; Nguefack-Tsague, Klasen, and Zucchini, 'On weighting the components'.

[61] Cf. UNDP, *Human development report 2010*.

[62] Desai, 'Human development', p. 356; Sagar and Najam, 'Human Development Index', p. 252.

[63] Klasen, 'Human development indices', p. 8.

[64] Ravallion, 'Troubling tradeoffs'; Chakravarty, 'Reconsideration of the tradeoffs'; Anand, 'Recasting human development'.

[65] Ravallion, 'Troubling tradeoffs', pp. 202–7, claimed that, in comparison with the additive method, the new multiplicative method downgrades life expectancy, penalizing poor countries. He recommended keeping the arithmetic average and using Chakravarty's ('Generalized Human Development Index') proposal to reduce substitutability.

[66] Ravallion, 'Troubling tradeoffs', p. 206.

[67] Interestingly a similar argument about hidden (and questionable) trade-offs was already used by Ravallion ('Good and bad growth') to criticize arithmetic aggregation. He claimed the implicit monetary valuation of an extra year of life expectancy rises dramatically with income as, by construction, the UNDP HDI implicitly values life relatively less in poor countries than in rich ones. It is worth stressing that the logarithmic transformation of income is about five times more important than the geometric average in explaining the trade-off between life expectancy and income across countries; Zambrano, '"Troubling tradeoffs"', p. 522. This point was actually already made by Ravallion himself long ago, when he argued that the striking trade-off between per capita income and longevity arises 'from the fact that the marginal effect on the HDI of longer life is a constant', while at the same time, 'the marginal effect of extra income falls very sharply as income increases'; Ravallion 'Good and bad growth', p. 633.

[68] Interestingly, in their utility approach to welfare, Jones and Klenow, 'Beyond GDP?', p. 2439, also find the 'implied value of life … substantially lower in poor countries'.

promising way to promote human development in the world would be by investing in higher life expectancy in rich countries'.[69] In response to Ravallion's objection, it can be argued that, for rich countries, the high value of longevity in terms of income simply means that per capita income contributes negligibly to increasing capabilities.[70]

The move to employing a geometric average for the HDI has two further consequences that should be recognized. First, the combination of the logarithmic transformation of per capita income in this multiplicative framework makes the HDI, according to Zambrano, 'very conservative in allowing income to be transformed into capabilities at high income … and very aggressive in allowing capabilities to shrink as income losses take place at very low income levels'.[71] In addition, the geometric mean gives the HDI a cardinal dimension that allows comparison of its change over space and time.[72]

II. An Augmented Human Development Index

After surveying the issues at stake in the construction of a synthetic index to capture the dimensions of human development, I propose a historical index on the basis of a new world dataset of life expectancy at birth, years of schooling for those aged 15 years and over,[73] per capita GDP,[74] plus a new dimension, political and civil liberties, represented by the Liberal Democracy Index, that aims to capture agency and freedom so that the resulting AHDI provides a crude measure of capabilities.

In designing the new index, I accept the goalposts (maximum and minimum values) set in the 2014 *Human development report*, that replaced those in place since 2010.[75] For life expectancy at birth, the maximum and the minimum values are 85 and 20 years, respectively. For education, the maximum and minimum values of average years of total schooling (primary, secondary, and tertiary) are 15 and 0, respectively. For liberal democracy, 0 and 1 are the lower and upper bounds. In addition, arbitrary 'floor' values have been adopted in order to allow the inclusion of countries for which no data exist in earlier periods and, at the same time, to avoid zero values in the transformed variables. Thus, 25 years of life expectancy at birth, 0.1 years of schooling, and a value of 0.01 for liberal democracy have been used

[69] Ravallion, 'Troubling tradeoffs', p. 208.

[70] Klugman et al., 'HDI 2010', pp. 278–80. Whether a social welfare approach is appropriate to assess human development seems to be the issue at stake. Canning, 'Progress in health', p. 1786, provides a clarifying illustration by comparing two metrics for health status, QALY and DALY. QALY (quality-adjusted life years) uses a utilitarian social welfare function in which health is valued in terms of individuals' willingness to trade them off. Alternatively, DALY (disability-adjusted life years) depends on adjustments for disability based on objective criteria. In the capabilities approach, well-being is measured by the objective size of the choice set, and not by the utility of the choices, as a healthy lifespan represents a constraint on individuals' choice.

[71] Zambrano, 'Axiomatization', p. 864

[72] Herrero et al., 'Newer Human Development index', p. 251. This view is at odds with the characterization of the index as purely ordinal; Vecchi et al., 'Human development', p. 467.

[73] Note that due to the dearth of data, this specification differs from that in the UNDP (2010) HDI, which measures education as the unweighted geometric average of expected years of schooling and mean years of schooling. Nonetheless, making a virtue out of necessity, I could argue along with Herrero et al., 'Newer Human Development index', pp. 249–50, that using one single indicator for education facilitates the interpretation of the human development index.

[74] This is due to the lack of historical estimates of per capita GNI.

[75] UNDP, *Human development report 2014*. The 2010 goalposts were used in the 'hybrid' historical index of human development in Prados de la Escosura, 'World human development'.

as 'floor' levels. Per capita GDP is expressed in Geary–Khamis (PPP) 1990 dollars (hereafter G-K 1990 $), to adjust for the difference in price level across countries, and the goalposts are set at $100 and $47,000, respectively.[76] I have assumed G-K 1990 $300 equates to a basic level of physiological subsistence and use this value as an adequate 'floor' for income.[77]

Indices for education and life expectancy are obtained following Kakwani, through a convex transformation, as in equation 4.[78] In the case of political and civil liberties, a linear transformation (derived with equation 1) has been adopted. The reason is that, unlike the other bounded variables considered here, the Liberal Democracy Index measures quality as well as quantity. Lastly, the adjusted per capita income index has been derived with equation 1, but with all its terms expressed in logs.

Then, following the 2014 *Human development report*, the indices for each dimension have been combined as an equally weighted geometric average using a modified version of equation 2, in which I_k represented the indices derived with Kakwani's non-linear (convex) transformation for longevity and education. The AHDI is thus defined as:

$$AHDI = \left(I_{kHealth}.I_{kEducation}.I_{Income}.I_{Liberal\ Democracy}\right)^{1/4} \tag{6}$$

Data constraints mean that the country coverage varies over the timespan considered here. From 1870 onwards, 115 countries are considered, with the number rising to 121, 146, 161, and 162 countries in samples starting in 1913, 1950, 1980, and 1990, respectively. The countries in these samples represent over 90 per cent of the world population, and nearly 100 per cent after 1950 (the sources and procedures are presented in online appendix S2). Regional and world averages for the original values of each variable have been transformed into indices for each dimension, and then combined to derive human development indices.

When the coverage of countries varied between the five regional and world samples, splicing was applied using the more recent period, for which the coverage is larger, as the benchmark. Thus, the new series (Y^R) results from using the *level* provided by the series closer to the present (that has wider spatial coverage) at the year T in which the two series overlap (Y_T), and re-scaling the earlier series (X_t) with the ratio between the two series for the year (T) at which they overlap (Y_T/X_T):

$$Y^R{}_t = (Y_T/X_T)_* X_t \qquad \text{for } 0 \leq t \leq T \tag{7}$$

Given the strength of objections from a range of researchers to the use of a geometric average to combine the dimensions of human development in the HDI, it seems reasonable to compare the performance of indices obtained alternatively as arithmetic and geometric averages. Thus I have also computed an version of

[76] Sagar and Najam, 'Human Development Index', p. 254; Milanovic et al., 'Pre-industrial inequality', p. 262. G-K 1990 $47,000 corresponds to G-K 2011 $75,000, that is, the maximum set in UNDP, *Human development report 2014*. In the case of the minimum, $100, I have kept it without adjusting it for price variation, as a higher 'floor' has been introduced for countries' per capita income.

[77] In general terms, the upward bias that the 'floor' introduces for the poorest countries does not change the overall picture.

[78] Kakwani, 'Living standards'.

Table 2. *Multiplicative and additive Augmented Human Development Indices*

	Geometric mean	*Arithmetic mean*	*Ratio geometric/arithmetic*
1870	0.077	0.127	0.60
1880	0.084	0.136	0.62
1890	0.091	0.143	0.63
1900	0.100	0.154	0.65
1913	0.115	0.171	0.67
1929	0.142	0.193	0.74
1938	0.152	0.198	0.77
1950	0.193	0.235	0.82
1960	0.225	0.269	0.84
1975	0.266	0.306	0.87
1985	0.305	0.339	0.90
1995	0.348	0.379	0.92
2005	0.381	0.410	0.93
2015	0.409	0.437	0.94

Sources: See section II.

the augmented index using an unweighted arithmetic average of its dimensions ($AHDI_a$), which implies increasing their substitutability:

$$AHDI_a = \left(I_{kHealth} + I_{kEducation} + I_{Income} + I_{Liberal\ Democracy}\right)/4 \quad (8)$$

Although both indices share the same trends, the geometric-average index has a lower initial level and faster growth.[79] The contrast between the two indices for average world AHD over the period 1870–2015 is visible in table 2. This confirms the penalization of low and uneven levels of dimensions when the geometric formula is used, a feature that is consistent with the indispensability of each dimension to human development.

How does this new historical index compare to alternative specifications for a multiplicative HDI that incorporates political and civil liberties alongside the standard dimensions? Table 3 shows the AHDI alongside six other possible approaches to constructing the index. The first two historical indices are derived using the UNDP (column 2) and Zambrano (column 3) specifications for the three conventional dimensions (longevity, education, and income) plus the addition of the fourth dimension, political and civil liberties, as incorporated in the AHDI; these are labelled 'UNDP' and 'Zambrano', respectively.[80] It is noticeable that the AHDI exhibits systematically lower levels than these alternative methodologies, as a result of the Kakwani transformation of the education and health dimensions, which also translates into faster growth over time. The 'Zambrano' specification produces intermediate values that fall between the 'UNDP' specification and the AHDI.

Table 3 presents four other alternative specifications for an AHDI. The 'Bértola–Vecchi' specification (column 4) is obtained using the UNDP linear transformation

[79] These results largely confirm those of Klasen, 'Human Development Indices', p. 9, who emphasizes the stability of country ranking using alternatively the arithmetic and geometric aggregation.

[80] Note that the 'Zambrano' specification shares with the 'UNDP' specification the transformation of all dimensions except that for income, in which equation 5 is used in the 'Zambrano' specification.

Table 3. *Alternative Augmented Human Development Indices, 1870–2015*

	(1) *Prados de la Escosura*	(2) *UNDP*	(3) *Zambrano*	(4) *Bértola and Vecchi*	(5) *HMV*[a]	(6) *Bértola (Kakwani)*	(7) *HMV-eei*[b]
1870	0.077	0.137	0.098	0.063	0.083	0.036	0.072
1880	0.084	0.149	0.108	0.071	0.091	0.040	0.079
1890	0.091	0.160	0.117	0.077	0.098	0.044	0.086
1900	0.100	0.177	0.131	0.087	0.108	0.049	0.093
1913	0.115	0.201	0.151	0.102	0.123	0.058	0.105
1929	0.142	0.244	0.185	0.128	0.146	0.074	0.120
1938	0.152	0.258	0.197	0.136	0.152	0.080	0.125
1950	0.193	0.320	0.246	0.173	0.187	0.105	0.153
1960	0.225	0.367	0.289	0.209	0.223	0.128	0.183
1975	0.266	0.414	0.335	0.254	0.263	0.163	0.209
1985	0.305	0.463	0.380	0.291	0.301	0.192	0.246
1995	0.348	0.520	0.430	0.334	0.344	0.224	0.277
2005	0.381	0.556	0.469	0.375	0.383	0.257	0.306
2015	0.409	0.579	0.497	0.406	0.413	0.287	0.344

Notes: a HMV: Herrero, Martínez, and Villar.
b HMV-eei: Herrero, Martínez, and Villar, egalitarian equivalent income.
AHDI combines the social dimensions and per capita income with equation 6, $AHDI = (I_{k\,Health} \cdot I_{k\,Education} \cdot I_{Income} \cdot I_{Liberal\ Democracy})^{1/4}$.
Bértola–Vecchi and Zambrano use UNDP linear transformation of social variables (tab. 1).
UNDP, HMV, and HMV-eei use their own transformation of social variables and per capita income (tab. 1).
Bértola (Kakwani) combines the Kakwani transformation of years of schooling and life expectancy with the Bértola–Vecchi transformation of per capita income (tab. 1).
Sources: See section II.

of the non-income dimensions and a non-log linear transformation of per capita income, as suggested by Bértola et al. and Vecchi et al.'s 'extended' HDI.[81] The 'HMV' (column 5) specification results from taking on board Herrero et al.'s proposal to transform the original values of the human development dimensions by computing them as shares of maximum values.[82] Counterintuitively, these two indices are highly coincidental with the AHDI, as the higher values for the transformed non-income dimensions in the 'Bértola–Vecchi' and 'HMV' specifications offset the lower value for the transformed income dimension.

The fifth alternative specification (column 6) corresponds to Bértola et al.'s full proposal, with a geometric average of Kakwani's indices for life expectancy and years of schooling, and linear indices for per capita income (with no log transformation) and political and civil liberties, labelled 'Bértola (Kakwani)'.[83] Finally, the last alternative, labelled 'HMV-eei' (column 7), includes Herrero et al.'s 'newer' HDI components, which transforms the original values of the human development dimensions (health, education, and political and civil liberties) by computing their shares of maximum values, and adjusts per capita income for inequality, using the *egalitarian equivalent income* formula $y^e = y^* (1- G)$.[84] It can

[81] Bértola et al., 'Human development'; Vecchi et al., 'Human development'. Note that as the 'Bértola–Vecchi' specification employs the UNDP transformation of social dimensions, it actually follows Bértola and Ocampo, *Economic development*, p. 43, Relative Index, RI1.
[82] Note that the 'HMV' specification only partially follows Herrero et al., 'Newer Human Development Index', since it is not adjusted for income for inequality.
[83] Note that 'Bértola (Kakwani)' specification actually follows very closely Bértola et al., 'Human development', and Bértola and Ocampo, *Economic development*, Relative Index RI2.
[84] Herrero et al., 'Newer Human Development Index'.

be seen that my proposed AHDI specification produces higher values, with the absolute difference increasing as the levels get higher, even though their growth rates are similar, while the 'Bértola (Kakwani)' specification presents the lowest level across time.

In conclusion, the different specifications for an AHDI share common trends. The AHDI proposed here uses a specification that results in an intermediate position among the alternative options for such an index.

III. Trends in augmented human development

AHD has improved substantially over the last century-and-a-half, reaching in 2015 a level 5.3 times that of 1870, which implies a cumulative growth rate of 1.2 per cent per year. Nonetheless, as the world average in 2015 remained below 0.5 (on a 0–1 scale), there is still significant room for improvement (table 3, column 1). Different phases can be observed in the long-run upward trend in world human development: milder growth before the First World War, followed by acceleration up to 1970 (aside from a slowdown in the 1930s), and a gradual slowdown in the growth rate thereafter.

These results represent the population-weighted average of countries' mean levels of AHD and, just as the pace of its progress varied through time, we should also expect it to have been distributed unevenly across countries. Inequality in the international distribution of AHD increased up to the end of the nineteenth century and experienced a steady long-run decline from the late 1920s, except for a partial reversal in the 1940s (figure 3, continuous line). [85]

This account of the evolution of AHD inequality focuses on inequality measured in relative terms: it depends on countries' ratios to the international mean, meaning inequality does not alter if AHD changes by the same proportion around the globe. However, if such a global change does occur, it could widen absolute differences in AHD.[86] For this reason, focusing on absolute differences in inequality is often preferred. Figure 3 also presents an absolute measure of AHD inequality, based on the absolute distance between high and low AHD countries (the dotted line), that allows us to compare relative and absolute AHD inequality. While relative inequality fell from the late 1920s, in absolute terms AHD inequality continued rising until the 1950s and only declined after 1960.

So much for the aggregate evolution of inequality, but how did AHD vary across the distribution? The annual cumulative growth rate by country deciles, from bottom to top (the so-called growth incidence curve) shown in figure 4 provides a nuanced picture of the distribution of progress in AHD. It can be observed that, in the long run, the middle (45th to 60th) deciles experienced the main relative gains (the continuous line in figure 4), followed by those in the lower part of the distribution. The more than proportional improvement of AHD in middle and low

[85] I measure inequality using the MLD (mean logarithm deviation) or Theil L index, that is, the natural logarithm of the ratio of the arithmetic mean AHDI to the geometric mean AHDI (Theil, 'International inequality', p. 147), which is sensitive to changes at the bottom of the distribution.

[86] Relative inequality depends on proportionate differences in AHDI, while absolute inequality depends on the absolute differences, namely, the distance or gap between high and low AHDI countries. The absolute inequality measure is derived as the mean AHDI times the relative inequality measure; cf. Anand and Segal, 'Global distribution of income', p. 967. See n. 8 for an example of absolute and relative inequalities.

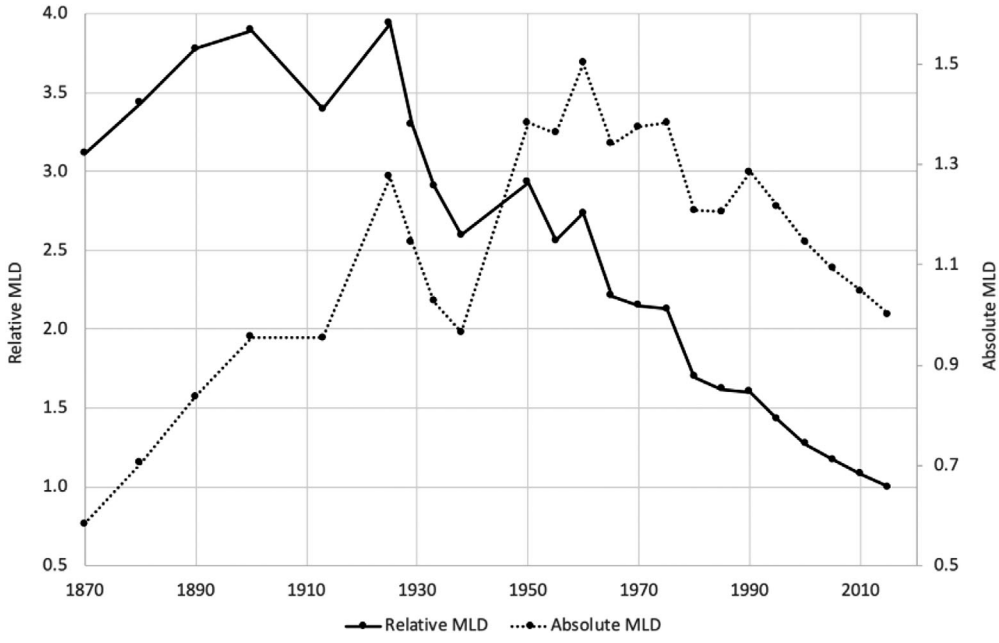

Figure 3. *Relative and absolute international Augmented Human Development Index inequality, 1870–2015 (mean logarithm deviation, population weighted) (2015 = 1)*
Sources: See text.

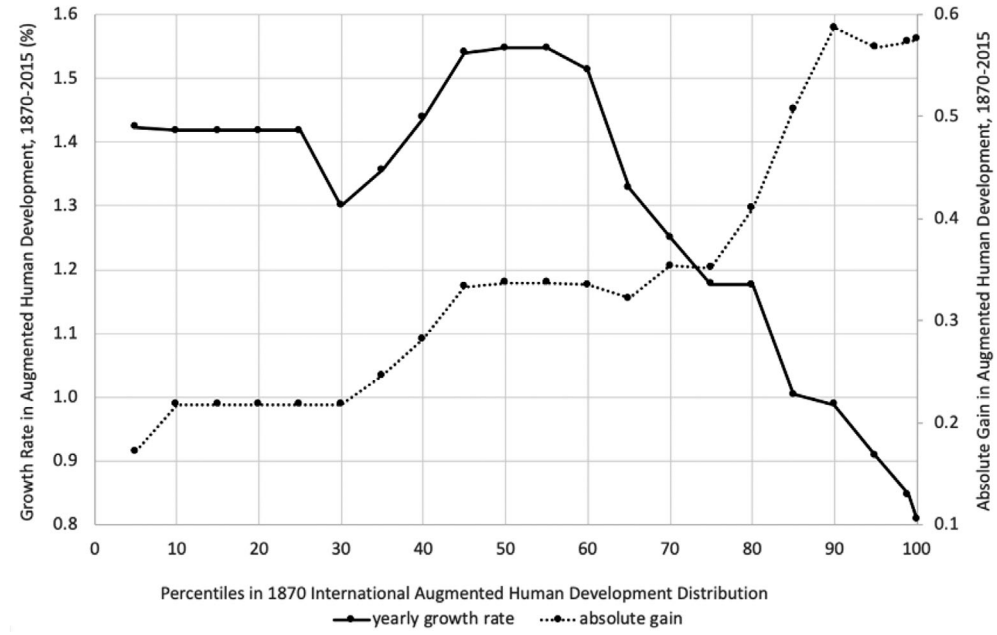

Figure 4. *Absolute and relative Augmented Human Development Index growth incidence curves, 1870–2015*
Note: Vertical axis: growth rate between 1870 and 2015; horizontal axis: distribution by deciles in 1870.
Sources: See text.

human development countries is consistent with the reduction in relative AHD inequality discussed above.

However, a glance at the absolute gain in human development achieved by each decile between 1870 and 2015 (the dotted line in figure 4) indicates that the absolute size of the increase was directly related to the initial level at which countries began. Deciles in the middle of the distribution achieved higher absolute gains than those at the bottom, but still saw lower absolute gains than the top deciles. In other words, the gap or distance between high and low AHD countries widened over this period. In particular, absolute gains were significantly larger for countries in the top 10 per cent. Between 1870 and 2015, middle-level countries in terms of AHD (those in the 45th–60th percentiles) grew at 1.5 per cent per year, while those in the top 10 per cent grew at 0.8 per cent; however, for the middle countries the absolute improvement in their AHDI level was only 0.336, while the top 10 per cent saw an increase of 0.577.

Gains in AHD were spread unevenly across the world. When and to what extent did different world regions share in them? Table 4 shows that absolute differences widened between the *OECD*, on the one hand, and the *Rest*, on the other (table 4, columns 14–15). In relative terms, however, the gap waned from the beginning of the twentieth century, especially in its central decades, and again from 1990 onwards. As a result, by 2015, although the level of AHD in the *Rest* only equalled half that seen in the *OECD*, this was double the ratio that existed a century earlier, when AHD in the *Rest* was at a quarter of the level found in the *OECD*.

How does AHD compare to GDP per capita? It is widely assumed that real GDP per capita adequately captures trends in welfare.[87] Does historical evidence confirm this assumption? AHD (excluding the income dimension to avoid duplication) exhibits slightly slower long-run growth than GDP per capita: 1.4 per cent per annum compared to 1.6 per cent, respectively, across the years 1870–2015.[88] However, a closer look reveals an apparent development puzzle: progress in economic growth and human development do not match (figure 5). During the backlash against economic globalization between 1914 and 1950, while real per capita GDP growth slowed down as world commodity and factor markets disintegrated, human development experienced major gains across the board. The paradox increases further when we consider that research on subjective well-being suggests that economic uncertainty—which would have characterized the interwar years— impacts negatively on well-being in a broad sense (that is, health).[89] In the post-1950 era, however, AHD advanced significantly less rapidly than real GDP per capita. For example, during the Golden Age (1950–73), while real per capita income grew faster and international income differences widened, AHD progressed at a slower but more egalitarian pace.

If we take a glance at the evolution of AHD and income in the *Rest* in comparison to the *OECD* over this long period, further discrepancies appear (figure 6). In terms of per capita income, we observe a sustained deterioration in the ratio between the *Rest* and the *OECD*, aside from a reversal in the 1930s. Per capita income in the *Rest* equalled nearly one-third of the *OECD* level in 1870, but had fallen to less

[87] See, for example, Oulton, 'Hooray for GDP!'.
[88] The rate of growth of human development falls to 1.2 when all dimensions, income included, are considered.
[89] I owe this remark to Nick Crafts.

Table 4. *Augmented human development across world regions, 1870–2015*

	Latin America	*East Europe*	*Russia*	*Sub-Saharan Africa*	*North Africa*	*Middle East*	*China*	*East Asia*	*South Asia*	*Japan*	*West Offshoots*	*West Europe*	*OECD*	*The* Rest
1870	0.063	0.103	0.069	0.027	0.038	0.038	0.040	0.035	0.030	0.087	0.239	0.168	0.171	0.049
1880	0.067	0.108	0.066	0.028	0.038	0.037	0.041	0.036	0.032	0.095	0.238	0.194	0.192	0.051
1890	0.075	0.115	0.066	0.029	0.045	0.038	0.041	0.036	0.035	0.116	0.265	0.213	0.213	0.053
1900	0.081	0.130	0.070	0.035	0.052	0.041	0.041	0.041	0.042	0.139	0.301	0.232	0.237	0.057
1913	0.100	0.151	0.097	0.041	0.056	0.051	0.056	0.048	0.045	0.172	0.331	0.260	0.266	0.067
1929	0.127	0.212	0.089	0.051	0.071	0.068	0.067	0.070	0.066	0.209	0.387	0.308	0.318	0.087
1938	0.133	0.223	0.102	0.061	0.079	0.084	0.076	0.091	0.082	0.223	0.415	0.300	0.324	0.103
1950	0.192	0.192	0.127	0.077	0.109	0.124	0.068	0.127	0.118	0.304	0.469	0.399	0.409	0.130
1960	0.230	0.237	0.181	0.104	0.116	0.132	0.077	0.154	0.153	0.465	0.507	0.448	0.472	0.162
1975	0.240	0.281	0.200	0.121	0.154	0.221	0.125	0.185	0.176	0.575	0.598	0.526	0.558	0.198
1985	0.316	0.302	0.228	0.139	0.212	0.238	0.179	0.211	0.227	0.656	0.660	0.596	0.627	0.243
1995	0.405	0.461	0.377	0.186	0.250	0.289	0.212	0.295	0.270	0.719	0.712	0.647	0.680	0.293
2005	0.458	0.513	0.352	0.214	0.289	0.342	0.245	0.392	0.305	0.779	0.748	0.696	0.726	0.331
2015	0.480	0.545	0.373	0.266	0.313	0.354	0.250	0.415	0.323	0.803	0.776	0.729	0.753	0.364

Sources: See text.

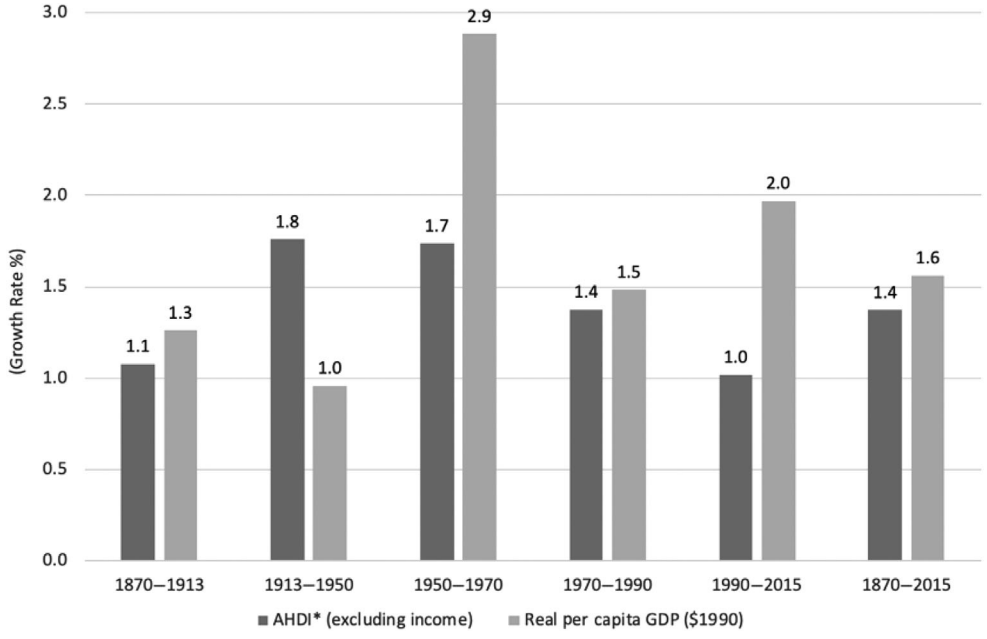

Figure 5. *Augmented human development* and real per capita GDP growth (%)* excluding the income dimension*

Sources: See text.

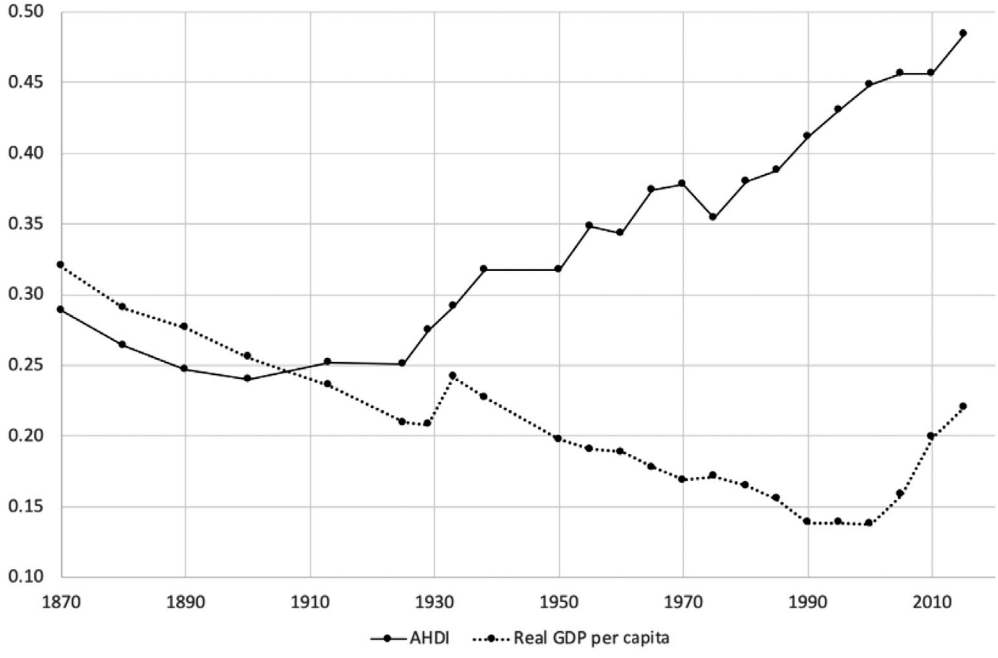

Figure 6. *Relative Augmented Human Development Index and real GDP per capita in the* Rest, *1870–2015 (*OECD = *1)*

Sources: See text.

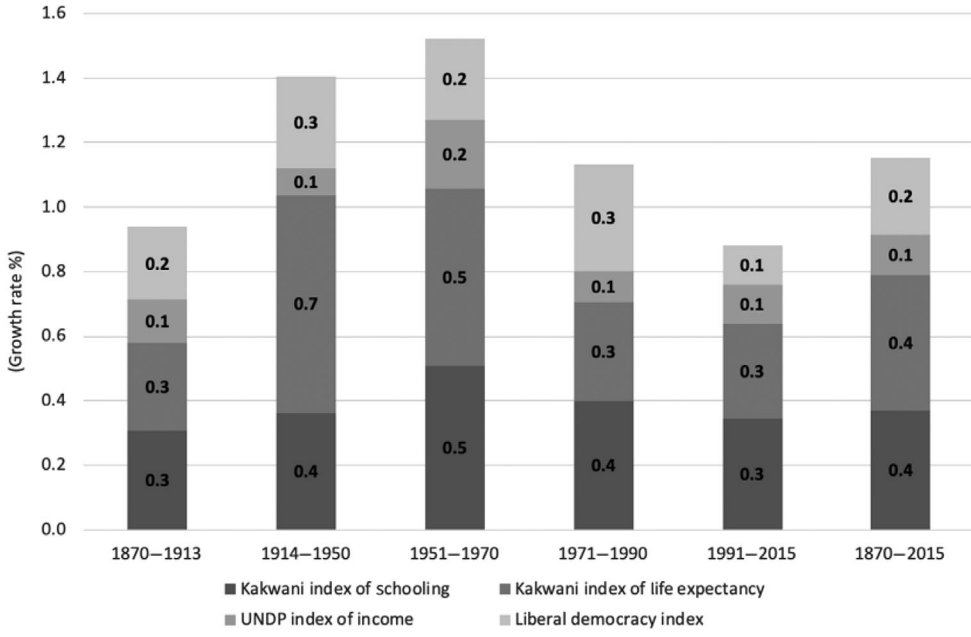

Figure 7. *Drivers of augmented human development in the world, 1870–2015 (%)*
Sources: Derived using equation 9. See text.

than 15 per cent of the *OECD* level in 2000, although it reversed thereafter. This long downward trajectory contrasts sharply with the *Rest*'s steady catching-up with the *OECD* in terms of human development since 1929.

IV. Drivers of augmented human development

The comparison between the historical trajectories of per capita income and human development may inform current controversies. Should policy in developing societies give priority to economic growth on the grounds that it will automatically promote access to a healthier and longer life, more knowledge, and greater political and civil liberties? The finding that trends in GDP per capita and human development were uncorrelated for quite lengthy periods challenges this view. Exploring the specific drivers, or proximate determinants, of human development over the long run may provide a more precise answer.

Given the AHDI's multiplicative structure, in which dimensions enter with equal weights, growth in the AHDI equals the weighted sum of each dimension's growth rate, with the weights set at 1/4 for each dimension. Thus, using lower case for rates of variation:

$$ahdi = \tfrac{1}{4} i_{\text{kHealth}} + \tfrac{1}{4} \text{i}_{\text{kEducation}} + \tfrac{1}{4} \text{i}_{\text{Income}} + \tfrac{1}{4} \text{i}_{\text{Liberal Democracy}} \quad (9)$$

It is the non-income dimensions that have driven the majority of the world's human development gains over time (figure 7 and online appendix table S1). Life expectancy was the main contributor to progress in human development through

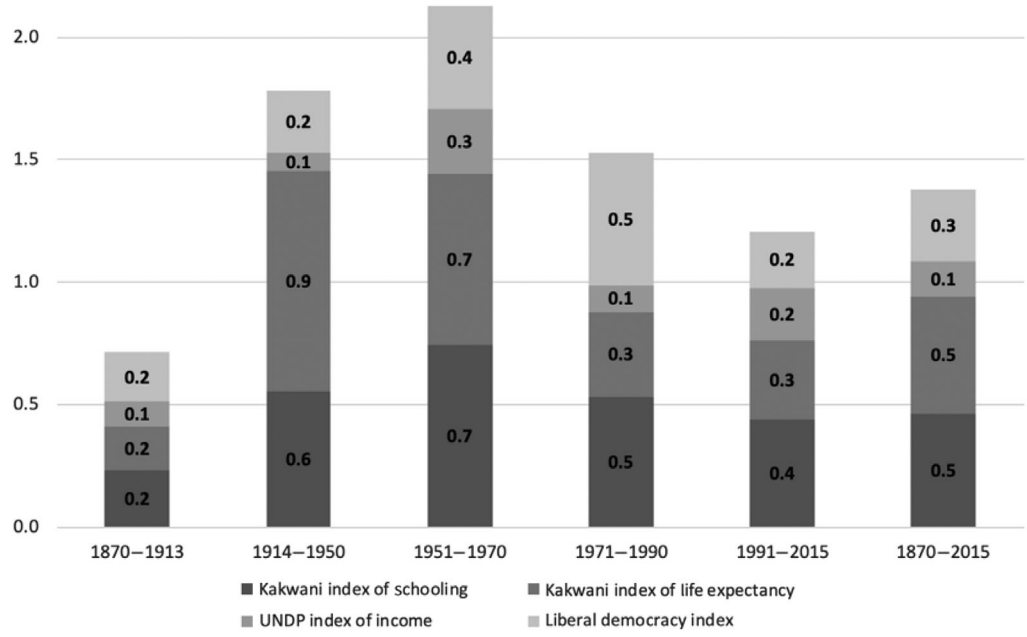

Figure 8. *Drivers of augmented human development in the* Rest, *1870–2015 (%)*
Sources: Derived using equation 9. See text.

the one-and-a-half centuries considered here (37 per cent), closely followed by education (32 per cent). Moreover, life expectancy's contribution was concentrated in the 1914–50 period and in the 1960s, when it provided about half of the gains in human development. Education led the late nineteenth-century advance and was a steady contributor to human development over the entire timespan considered (except for the 1940s). Political and civil liberties made substantial contributions to growth in the 1950s and during the last two decades of the twentieth century.

What explains the timing and depth of the contributions of life expectancy and schooling to human development? It is commonly assumed that economic progress largely explains this, as higher levels of income per capita facilitate the allocation of more resources to social services that improve people's health and education. However, over the last hundred years, gains in longevity and education have taken place across the board, including countries where social spending has hardly expanded and growth in income has faltered.

Another stylized fact that is often found in the literature is that global health improvements only occurred after the Second World War era, with the help of international institutions, as new drugs from the West diffused across the rest of the world.[90] However, in developing countries, life expectancy provided half the gains in human development between 1914 and 1950 (figure 8 and online appendix table S2). This suggests that the epidemiological transition spread beyond advanced countries much earlier than has been presumed, and this too requires an explanation.

[90] Acemoglu and Johnson, 'Disease and development', pp. 935–6.

Health improvements can be depicted in terms of a health function.[91] Movements along the function represent gains attributable to economic growth and result in improving nutrition—which strengthen the immune system and reduce morbidity[92]—and increases in the public provision of health.[93] This has often been the focus of country studies. However, we also need to consider shifts in the position of the health function.

Outward shifts in the health function that derive from improvements in medical knowledge have been the main source of the sustained increase in life expectancy since the late nineteenth century.[94] The major improvement in longevity between 1920 and 1970 originated in the discovery and diffusion of the germ theory of disease, which led to the epidemiological or health transition.[95] Persistent gains in lower mortality and higher survival rates were achieved throughout the epidemiological transition as infectious disease gave way to chronic disease as the main cause of death.[96] Two main consequences resulted from the diffusion of the germ theory of disease. On the one hand, germ theory led to the introduction of new vaccines (from the 1890s) and drugs to cure infectious diseases (sulphonamides from the late 1930s, and antibiotics from the 1950s), along with chemicals such as DDT, which is instrumental in battling malaria.[97] On the other hand, it led to the diffusion of preventive methods that lower disease transmission, including knowledge dissemination through schooling and the introduction of low-cost improvements in public health, even where low incomes precluded the purchase of the new drugs. The latter has been stressed much less in existing research, but had a deep impact in less developed regions. The result was to reduce mortality throughout the life course, but especially infant mortality and maternal death.[98] This helps explain why the epidemiological transition in developing countries began in the first half of the twentieth century, at a time when a large proportion of the *Rest* was still under colonial rule and the new drugs were largely unaffordable for the population.

Although a second episode in which longevity, along with education, made a massive contribution to human development took place in the 1960s, a decade of governmental activism in the developing world, by 1970, the diffusion of the epidemiological transition was largely exhausted in the *Rest*. This helps to explain the weakened contribution of life expectancy to improving human development after 1970.

Schooling, which had contributed to progress in human development in the *Rest* during the 1930s and the Golden Age (1950–70), became the main driver during the 1970s and until the turn of the century. Political and civil liberties led human development gains in the 'long' decade up to the First World War, the 1950s, and the years 1980–2000.

[91] Preston, 'Mortality'; Easterlin, 'How beneficent is the market?'.
[92] Stolnitz, 'Mortality trends'; McKeown and Record, 'Reasons'; McKeown, Record, and Turner, 'Interpretation'; Fogel, *Escape from hunger*.
[93] Loudon, 'Maternal mortality'; Cutler and Miller, 'Public health'.
[94] Riley, *Poverty and life expectancy*; Cutler, Deaton, and Lleras-Muney, 'Determinants of mortality'.
[95] Preston, 'Mortality'.
[96] Omran, 'Epidemiological transition'; Riley, *Rising life expectancy*.
[97] Easterlin, 'How beneficent is the market?'; Jayachandran, Lleras-Muney, and Smith, 'Modern medicine'; Lindgren, 'Rise in life expectancy'; Desowitz, *Malaria capers*.
[98] Riley, *Rising life expectancy.*

The renewed contribution of life expectancy to human development since 1990, largely restricted to the *OECD*, is associated with a *second health transition* which has led to mortality falling among the elderly as a result of better treatment of respiratory and cardiovascular disease and vision problems, helped by better health and nutrition in their childhood.[99] The diffusion of new technologies has resulted in longer and healthier life years.[100] The fact that the *Rest* has not participated so far in the second health transition, along with the AIDS-HIV pandemic in Sub-Saharan Africa and the collapse of socialism in large areas of the world, help explain life expectancy's negative contribution to the *Rest's* catching-up with the *OECD* during the years 1990–2010.

V. Conclusions

This article has presented a long-run view of human development, defined using a capability measure of well-being, over the last one-and-a-half centuries, on the basis of a new *augmented* index that adds political and civil liberties to the UNDP's conventional HDI dimensions of longevity, education, and living standards.

World human development achieved substantial gains, especially over the period 1913–70, but substantial room for improvement still remains. Longevity has been the leading force behind long-run progress in human development, even though its contribution weakened after 1970 once the epidemiological or health transition was exhausted. At this point, the lead passed to political and civil liberties. Advances in human development were unevenly spread. The absolute gap between the *OECD* and the *Rest* of the world deepened over time, but the gap fell in relative terms. This result compares favourably with the continuous growth in the income gap that is apparent until the end of the twentieth century.

This presents a development puzzle: economic growth and human development do not always go hand-in-hand, even if increases in income per capita contribute to better health and education. The spread of medical progress, in particular, and public policies account for the mismatch. The major advance across the board in human development during the backlash against globalization between 1914 and 1950 evidenced this.

A pressing question emerges from the period, with which this article closes: why has a second health transition, that would contribute further to catching up, not yet begun in the *Rest* of the world? A lack of public policies and the polarizing effect of new medical technologies are potential explanatory hypotheses that deserve further investigation.

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[99] Eggleston and Fuchs, 'New demographic transition'; Deaton, *Great escape*.

[100] Mathers et al., 'Healthy life expectancy'; Murray et al., 'Global Burden of Disease'.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

S1. Drivers of augmented human development, 1870–2015
S2. Sources and procedures