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Beyond GDP: Using healthy lifetime income to trace well-being over time with estimates for 193 countries

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ABSTRACT

We measure well-being across 193 countries from 1990 to 2019 using a new indicator: healthy lifetime income (HLI). Apart from the income component as captured by standard per capita gross domestic product, HLI incorporates health as a second important component. Overall, HLI can be interpreted as the income of the average person in an economy during the years in which the person is in good health. We show that HLI has particular strengths as compared with other measures such as the Human Development Index. These include requiring only easily accessible data for its construction, having an immediate economic interpretation and unit of measurement, not needing the application of arbitrary weights of subcomponents, and not being bounded from above. As compared with using per capita gross domestic product as a metric for well-being, we find that countries with better population health tend to fare better in the rankings. This provides a rationale for investments in health and helps shift the focus from material well-being (as an instrumental indicator of well-being) toward health (as an intrinsic goal).

1 introduction

How can we measure economic development and the evolution of well-being over time with low data requirements and a straightforward economic interpretation? Concepts and widely used indicators such as the United Nations' Sustainable Development Goals, the European Union's Sustainable Development Indicator (Bolcárová and Kološta, 2015; Eurostat, 2021), and Germany's National Welfare Index (Diefenbacher et al., 2010; Held et al., 2018) all consider important aspects of development and well-being such as poverty, the quality of education, and gender equality. However, these approaches are prone to high data requirements, often require arbitrary explicit or implicit weights attached to the different sub-components in order to be useful as a guide for policymakers, and are sometimes based on aspects that are very difficult to assess objectively.

For example, a comprehensive measurement system like the National Welfare Index may work well in countries like Germany that gather precisely the data that the index requires. However, it contains variables such as "value of household work", "value of voluntary work", and "damages due to noise" that are difficult to obtain in many other countries and are prone to biases in reporting (see, for example, Bertrand and Mullainathan, 2001; Jahedi and Méndez, 2014). Another example is related to China's attempt to shift its focus from high output growth to high-quality development (19th National Congress, 2017). To evaluate the shift, Li et al. (2019) created a system of 27 indicators in five areas: economic vitality, innovation and efficiency, green development, welfare, and social harmony. The indicator system implies high data requirements and does not define benchmark values or weights of different sub-indicators. In addition, the indicator system lacks health-related components that are, however, very important for the well-being of individuals (Ohrnberger et al., 2017). Finally, one of the 27 indicators is the Social Satisfaction Index, which is based on surveys and can be criticized for departing from an objective assessment due to the reasons already mentioned above.

A very prominent approach for assessing development and the evolution of well-being is the Human Development Index (HDI). The HDI aims to measure well-being objectively (Ul Haq, 2003) and is rooted in Amartya Sen's Capability Approach (Sen, 1985, 1999). Accordingly,

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well-being is measured by assessing the capabilities people have to flourish given their opportunities in terms of income, health, and education. However, also the HDI has some severe disadvantages: First, it merges indices of its three subcomponents income, life expectancy, and education with the weighting of the subcomponents being arbitrary (Bloom et al., 2021). Second, the outcome of the HDI is an index number that lacks an economic interpretation and, as such, has limited use as a guide for economic policymakers. Third, the index cannot be reasonably compared with other economic data that are typically measured in a certain currency unit. For example, setting the debt level of a country in relation to its GDP is a useful guide for the sustainability of this country's public finances; setting the debt level in relation to the HDI, however, leads to a meaningless outcome. Fourth, the HDI is bounded in the interval between 0 and 1 such that a clustering of countries at higher index values occurs with ongoing development. Thus, it becomes increasingly difficult to see differences across countries in terms of the HDI, although their fundamentals could still vary widely. Finally, relative changes among countries cannot be quantified easily because an increase of a country's HDI value from 0.7 to 0.71 may be associated with very different underlying improvements than a change from 0.8 to 0.81.

It is generally agreed that the per capita gross domestic product (GDP) of a country has at most a limited use as an indicator for well-being. Even the economist Simon Kuznets, who is widely credited as the "inventor" of GDP, warned against its use as a welfare measure. However, the per capita GDP of different countries is still the main focus of governments and international organizations (see Fan et al., 2018; Fleurbaey, 2009). Two main reasons are that it is comparatively easy to calculate and therefore readily available for many countries over long periods of time, and that it has a straightforward economic interpretation that allows it to be used for further computations (such as the assessment of the sustainability of debt levels of different countries as described above). However, while the per capita GDP of a country approximates per capita income and thereby per capita consumption within that country fairly well, it does not contain any other aspects that are often agreed to be part of a "good life". For example, and perhaps most consequential, per capita GDP does not account for population health (see also Becker et al., 2005). We deem this a strong disadvantage because health is a very important part of well-being, which is pointedly summarized in the quote attributed to the German philosopher Arthur Schopenhauer that "Health is not everything, but without health, everything is nothing". Even from a purely materialistic point of view, ignoring health is problematic. To see this, consider two countries that exhibit the same level of per capita GDP, but in one country people live ten years longer on average than in the other. Clearly, the inhabitants of the country with better health will also have a higher *lifetime* income. A statement that both countries share a similar level of income, which is tempting when focusing solely on per capita GDP, would therefore be highly misleading even if health by itself had no effect on well-being.

Our aim in this contribution is to solve some of the described problems of the different attempts at quantifying economic well-being. In so doing, we build upon previous studies (Bloom et al., 2021; Chen et al., 2022a; Fan et al., 2018) and propose a new indicator that combines the dimensions of income and health in an economically intuitive way: healthy lifetime income (HLI). The indicator value is the product of a country's per capita GDP adjusted for purchasing power (pppGDPpc) with the number of years that a person in this country can expect to live in good health (healthy life expectancy, or HALE). Thus, the indicator has a clear and straightforward economic interpretation, is measured in a currency unit (purchasing power adjusted international dollars) that can be compared to other economic variables, and has weights that are a direct mathematical consequence of its definition. In addition, the indicator is not bounded between 0 and 1, and all the relevant data for its calculation are accessible for most countries. By including health, HLI captures an aspect that many consider an *intrinsic* goal for well-being (as compared with income, which is an *instrumental* goal). Using HLI, we measure economic development across countries in five-year intervals spanning a time period from 1990 to 2019 (the final interval having only four years due to a lack of data for 2020). This way we observe clear increases in well-being worldwide but still a failure of poor countries to fully catch up with the well-being levels of richer countries.

In the paper "Measuring high-quality development and progress toward 'common prosperity' in China" (Chen et al., 2022a), we followed Bloom et al. (2021) and applied inequality-adjusted healthy lifetime income (IHLI) and inequality-adjusted lifetime income (ILI), two indicators that include the Gini coefficient as a measure of inequality, to assess the progress of China's high-quality development strategy. We showed that progress toward the goal of "common prosperity" was less pronounced than progress toward raising incomes in isolation, and we discussed several policy measures to foster "common prosperity." While IHLI and ILI provide valuable insights into the evolution of well-being, their reliance on the Gini coefficient is a limiting factor because related data are not universally available. Thus, IHLI and ILI cannot be calculated for as many countries as HLI. In this contribution we show that HLI is a good substitute that captures almost the same information as IHLI but is available for many more countries, which facilitates comparisons of well-being across countries and over time. This is the first study wherein we have calculated HLI for most countries in the world. Furthermore we have analyzed the trends of the evolution of HLI for different regions and income groups in five-year intervals using the most recent data available.

2. Background on our approach to economic well-being

At this stage, it is important to clarify how our approach fits into the broader literature on well-being. The philosophical literature distinguishes between three broad theories of *individual* well-being, i) hedonism, ii) desire theories, and iii) objective list theories (Crisp, 2021). In a nutshell, individual well-being is determined by the balance of pleasure (or positive experiences) over pain (or negative experiences) according to hedonism, the satisfaction of desires net of frustrations according to desire theories, and a host of objectively valuable things such as loving relationships, achievement, creativity, happiness, etc. according to objective list theories (Chappell and Meissner, 2022; Crisp, 2021). There is a substantial overlap between these theories because people in general desire what determines well-being according to objective list theories, and these things, in turn, tend to give them pleasure (Chappell and Meissner, 2022).

In contrast to the philosophical literature, the psychological literature on individual well-being considers two general perspectives: the hedonic view that associates a "good life" mainly with the maximization of pleasure and the minimization of pain, and the eudaimonic view that focuses on meaning, self-realization, virtue, and reflection as means of achieving a "good life" (Ryan and Deci, 2001). Thus, according to the hedonic view, also this strand of literature attaches a crucial role to pleasure and the satisfaction of desires in determining well-being.

Jeremy Bentham, who is widely seen as the father of Utilitarianism, was heavily influenced by hedonism when defining well-being at an aggregate level. Overall, Utilitarianism calls for the greatest pleasure for the greatest number of people, with each person having the same weight, in order to maximize *social* well-being. This philosophy acts as the starting point of the standard economic concept of well-being in which individual utility and thereby social well-being both depend positively on consumption (as a means for fulfilling desires and achieving pleasure) according to the mathematical formulation of a Benthamite utility function. Most prominently, this features in the neoclassical growth model as one of the workhorse models of modern macroeconomics (see Cass, 1965; Koopmans, 1965; Ramsey, 1928). This framework is widely used for assessing the individual and social optimality of various economic policy measures. Along these lines, our approach clearly follows the economic tradition and the fact that a higher income level is *instrumental* for achieving a higher level of consumption in a given period of time. Thus, a higher income leads to a

higher period utility and thereby raises *current* individual and social well-being.

In addition to the channel by which income affects well-being positively, we take into account health as an *intrinsic* goal of well-being. This also implies that we consider lifetime duration and therefore address another important aspect that emerges when measuring well-being over time: the tension between maximizing well-being in the short run and the sustainability of doing so in the long run. To illustrate this, one can interpret the sole focus on current per capita GDP as an extreme form of discounting in which the future plays no role for current well-being. At the other extreme, no discounting at all would imply the need to consider the stream of future per capita GDP over an infinite time horizon. The computation of healthy lifetime income as a measure of well-being occupies a middle ground in which the implicit social discount rate is positive and determined by the mortality rate and the rate at which individuals fall ill during their lives. For theoretical foundations of why the length of life should feature in considerations of well-being, see also the contributions of Becker et al. (2005), Hall and Jones (2007), and Jones and Klenow (2016).

At the end of this short description of the background of our approach, it is important to stress that our indicator aims at providing an objective measure for well-being as opposed to a purely subjective measure such as happiness (for an overview of the two approaches and their advantages and disadvantages, see, for example, Voukelatou et al., 2021). While both objective and subjective approaches have shortcomings, we aim to provide a more objective measure in this contribution because it facilitates comparisons between countries over time. If we used a purely subjective measure, we would need to ensure that the same individuals are traced over time, which would pose severe difficulties in any type of survey. In addition, objective measures do not suffer from economic and cognitive biases to a similar extent as subjective measures (Jahedi and Méndez, 2014). However, this is not to say that subjective measures would be inferior. Jahedi and Méndez (2014) show that they are very useful, particularly when complementing objective measures, and Frey and Stutzer (2002) describe the usefulness of subjective measures in assessing well-being from an economic point of view.

To summarize in one sentence, we can state that our suggested well-being indicator follows a utilitarian approach that is itself mainly grounded in the philosophical and psychological approaches of hedonism and desire theories.

3. Data and methods

To measure well-being across many countries over time, we propose the calculation of Healthy Lifetime Income (HLI). HLI consists of the following two components: i) gross domestic product per capita adjusted for purchasing power (pppGDPpc) to capture material living standards and ii) healthy life expectancy at birth (HALE) to capture health and longevity. Formally, the indicator is defined as the product of these two components as

$$\mathrm{HLI} = \mathrm{pppGDPpc} \times \mathrm{HALE}. \tag{1}$$

Thus, we essentially multiply the average income of a person in the economy under consideration by the years of life in which the average person could expect to exhibit good health. This implies that the indicator refers to the total income earned during the healthy years of life given the current state of the economy and the current state of population health. To construct HLI for a global ranking and to compute trends, we use the World Bank's (2022) World Development Indicators data on pppGDPpc in international dollars (INT$) with a base year of 2017 and the Global Burden of Disease Study (2019) (GBD 2019) data on HALE.

HALE is the expression of the number of years a person can expect to live in good health. It takes into account the number of years a person lived in poor health, which stands in contrast to life expectancy (LEXP; GBD, 2019). When HALE is compared with LEXP, aspects of inequality play a more pronounced role in the former because poorer parts of the population are typically less healthy (Nazroo, 2015; Wood et al., 2006). Whereas two countries considered to differ greatly in well-being may have a similar LEXP, when HALE is included, the differences are magnified. LEXP alone does not reflect health and thereby inequality to the same degree as HALE. Thus, the use of HALE as an HLI component enables HLI to more accurately reflect the well-being of a country's population.

To accommodate the potential critique that our indicator does not reflect inequality beyond what HALE captures, we build upon Bloom et al. (2021) and use a different indicator — Inequality-Adjusted Healthy Lifetime Income (IHLI) — to derive corresponding trends across the different countries for which we can compute both HLI and IHLI. Then we show that the correlation between the country rankings based on HLI and IHLI is very high. This, combined with the fact that HLI is much more widely available than IHLI, provides our rationale for arguing in favor of using HLI for cross-country comparisons over time instead of IHLI. Formally, IHLI consists of three components: The first, pppGDPpc, and second, HALE, are the same as in the case of HLI. However, the product of pppGDPpc and HALE is further weighted down by multiplying it by an inverse measure of inequality, (1-Gini), according to:

$$\mathrm{IHLI} = \mathrm{pppGDPpc} \times \mathrm{HALE} \times (1 - \mathrm{Gini}). \tag{2}$$

To calculate IHLI, we use the same data sources as above for pppGDPpc and HALE. In addition, we use the Standardized World Income Inequality Database (SWIID) of Solt (2020) for the Gini coefficient of disposable income.

As compared with IHLI, HLI is available for many more countries in the world for a comparatively long time. In addition, HLI retains the advantages of IHLI in that it has an immediate economic interpretation, is not bounded from above, thus preventing the clustering at higher values, and it reasonably reflects the progression of well-being in different countries by capturing income and health.

4. Results

Table 1 displays the results of the calculations for the years 1990, 1995, 2000, 2005, 2010, 2015, and 2019, showing HLI values over time for 193 countries from 1990 to 2019. The results have the interpretation of the income of the average person during the time in which they are in good health and are expressed in purchasing power adjusted international dollars (henceforth INT$).

We notice some interesting trends at the top and at the bottom of the ranking. In 1990, the United Arab Emirates (UAE) had the highest HLI with INT$ 6,748,882, and Mozambique had the lowest HLI with INT$ 21,013. In that year, UAE had an HLI that was about 321 times that of Mozambique. In 1995, UAE had again the highest HLI. Thereafter, the ranking of UAE fell below the number one spot from 2000 to 2019 in each five-year interval. In most years, UAE had a lower HLI value than would be expected based on its high per capita GDP because its HALE values were lower than in many European countries. By contrast, Luxembourg had a stable top-ranking performance in 2000, 2005, 2010, 2015, and 2019.

Mozambique remained at the bottom of the ranking in 1995 and 2000 with HLI values of INT$ 21,364 and INT$ 28,443, respectively. However, in 2005, Burundi dropped below Mozambique with a value of INT$ 34,668 in 2005 and INT$ 42,945 in 2010. In 2015, the Central African Republic replaced Burundi at the bottom of the ranking, with an HLI value of INT$ 37,002. In 2019, the country with the lowest HLI was again Burundi with a value of INT$ 41,708. We can contrast this with the country with the highest HLI in that year, which was Luxembourg again, this time with a value of INT$ 8,272,031, a remarkable contrast by a factor of about 200 as compared with Burundi. Fig. 1 illustrates the distribution of HLI worldwide in 2019. In terms of comparisons among continents, countries in Europe and North America tend to exhibit the

Table 1
Healthy lifetime income values over time for 193 countries, 2017 INT$.

Country	HLI						
	1990	1995	2000	2005	2010	2015	2019
Afghanistan				63,365	101,129	109,437	111,742
Albania	308,246	292,465	389,572	537,922	737,783	815,931	940,152
Algeria	519,395	481,545	542,463	670,931	713,953	769,255	763,947
Andorra							
Angola	250,121	184,102	216,628	303,899	404,485	445,089	380,880
Antigua and Barbuda	1,006,391	1,007,314	1,200,559	1,306,443	1,209,742	1,235,593	1,455,646
Argentina	898,490	1,116,074	1,209,280	1,278,056	1,560,240	1,598,261	1,473,828
Armenia	321,154	185,873	257,911	477,898	605,306	749,046	909,851
Australia	2,048,551	2,207,355	2,598,959	2,916,574	3,131,160	3,344,446	3,466,701
Austria	2,468,017	2,693,930	3,146,933	3,388,943	3,603,713	3,706,107	3,942,096
Azerbaijan	451,565	171,511	236,738	426,014	864,758	926,262	910,008
Bahamas, The	2,378,016	2,160,031	2,538,678	2,589,554	2,345,164	2,305,311	2,346,141
Bahrain	2,355,200	2,911,270	3,088,809	3,011,496	2,908,029	3,193,690	3,017,205
Bangladesh	91,106	108,823	130,730	158,456	208,251	279,266	358,165
Barbados	910,935	849,824	994,365	1,041,651	1,042,075	1,031,462	1,033,831
Belarus	555,204	350,563	488,396	723,519	1,074,427	1,186,493	1,254,341
Belgium	2,347,082	2,519,997	2,896,551	3,152,847	3,293,651	3,434,235	3,621,030
Belize	306,066	370,997	400,519	463,752	466,410	473,210	465,341
Benin	105,783	112,235	124,783	133,400	145,208	162,169	186,207
Bhutan	150,679	187,796	231,532	326,386	503,923	631,094	750,266
Bolivia	247,559	283,087	315,642	347,230	407,481	498,982	550,567
Bosnia and Herzegovina		119,037	500,373	614,795	729,067	842,075	997,482
Botswana	452,317	425,648	426,875	507,176	652,246	784,934	886,853
Brazil	609,822	671,661	709,651	783,507	944,335	970,945	960,784
Brunei Darussalam	4,354,280	4,542,738	4,394,796	4,475,050	4,391,463	4,102,490	4,052,656
Bulgaria	772,178	696,695	651,121	927,928	1,158,075	1,288,704	1,502,568
Burkina Faso	44,835	47,602	59,295	74,018	87,218	101,372	117,826
Burundi	50,832	36,066	32,153	34,668	42,945	44,248	41,708
Cabo Verde	107,147	153,313	250,045	311,702	402,215	409,259	463,434
Cambodia		60,944	78,326	118,390	159,367	213,870	268,611
Cameroon	171,458	129,755	135,719	151,024	162,869	187,758	207,482
Canada			2,561,663	2,927,900	3,154,788	3,362,344	3,464,085
Central African Republic	50,072	42,675	39,700	40,504	50,245	37,002	43,244
Chad	47,031	44,037	41,074	76,089	85,658	95,509	83,487
Chile	624,008	861,292	1,028,831	1,240,098	1,441,258	1,675,950	1,725,893
China	86,118	148,338	218,896	345,984	591,552	857,495	1,094,894
Colombia	517,777	593,852	582,994	667,135	797,606	975,109	1,013,777
Comoros	157,221	144,633	152,706	158,661	166,914	175,692	184,578
Congo, Dem. Rep.	84,820	47,989	34,875	37,636	44,048	57,787	61,854
Congo, Rep.	239,753	207,046	203,416	230,191	274,428	289,463	218,134
Costa Rica	665,737	759,713	856,683	976,622	1,162,048	1,330,658	1,454,935
Côte d'Ivoire	206,190	174,577	185,190	164,030	189,965	236,136	292,910
Croatia		965,803	1,196,467	1,566,090	1,639,051	1,681,156	2,001,023
Cuba							
Cyprus	1,657,025	1,890,274	2,202,054	2,556,694	2,640,357	2,401,676	2,902,375
Czech Republic	1,479,852	1,460,108	1,640,373	2,018,783	2,259,466	2,467,782	2,811,372
Denmark	2,546,552	2,820,991	3,265,691	3,489,466	3,493,380	3,695,983	3,996,888
Djibouti						258,488	310,007
Dominica	486,093	527,420	606,328	643,907	758,640	742,459	778,274
Dominican Republic	391,829	477,128	600,429	656,373	825,771	970,798	1,182,393
Ecuador	522,305	551,159	530,885	612,111	671,914	788,726	758,840
Egypt, Arab Rep.	343,173	378,304	467,870	509,795	633,316	651,376	734,839
El Salvador	318,353	386,155	415,929	439,609	476,181	518,087	575,134
Equatorial Guinea	45,883	80,430	556,579	1,712,514	1,915,492	1,589,140	1,064,138
Eritrea							
Estonia		760,872	1,105,089	1,669,234	1,734,697	2,107,969	2,479,966
Eswatini	276,781	273,368	237,525	249,868	312,798	396,632	437,930
Ethiopia	31,656	29,530	32,652	43,142	69,541	104,112	133,775
Fiji	493,364	524,281	552,287	625,726	624,792	747,560	816,395
Finland	2,154,484	2,099,743	2,684,446	3,053,171	3,170,129	3,165,247	3,417,163
France	2,259,770	2,388,825	2,727,775	2,902,429	2,974,230	3,088,844	3,290,368
Gabon	958,296	974,833	860,075	838,434	793,816	892,265	879,106
Gambia, The	120,359	114,345	122,278	120,469	130,649	117,485	129,834
Georgia	677,893	201,305	308,301	460,280	617,464	812,330	966,676
Germany	2,413,867	2,622,983	2,911,376	3,019,555	3,258,420	3,556,813	3,759,963
Ghana	125,306	135,607	147,269	167,710	208,141	270,053	322,544
Greece	1,631,220	1,686,413	1,981,684	2,380,672	2,339,796	1,978,116	2,076,233
Grenada	538,250	539,997	735,157	905,521	852,801	967,867	1,079,959
Guatemala	297,025	336,336	376,849	401,287	447,283	505,664	544,351
Guinea	68,727	75,099	81,592	88,616	94,903	107,617	138,246
Guinea-Bissau	85,499	92,604	78,147	78,151	86,565	93,068	103,974
Guyana	263,377	366,072	432,265	446,008	559,298	649,254	763,556
Haiti	169,297	137,498	147,654	148,260	84,078	167,673	170,346

(*continued on next page*)

Table 1 (*continued*)

Country	HLI						
	1990	1995	2000	2005	2010	2015	2019
Honduras	240,230	244,147	251,680	281,867	302,864	323,928	361,487
Hungary		1,018,126	1,222,527	1,562,487	1,601,573	1,826,281	2,174,257
Iceland		2,292,284	2,881,486	3,383,315	3,378,350	3,760,082	4,117,324
India	92,567	111,057	139,021	181,471	243,839	324,346	404,847
Indonesia	253,764	339,908	334,381	401,052	504,749	627,563	738,855
Iran, Islamic Rep.	539,865	603,271	686,098	851,874	1,002,253	963,064	995,983
Iraq	435,743	249,734	547,753	436,193	526,723	608,933	690,180
Ireland	1,725,774	2,123,932	3,193,281	3,880,991	3,679,449	5,019,493	6,096,030
Israel		1,777,927	2,054,928	2,090,229	2,399,091	2,670,138	2,917,700
Italy	2,427,683	2,617,865	2,946,986	3,078,468	3,008,091	2,863,662	3,045,156
Jamaica	569,150	658,958	611,838	670,476	629,751	630,316	650,304
Japan	2,281,933	2,448,654	2,585,614	2,752,652	2,768,653	2,966,843	3,079,046
Jordan	494,546	523,820	557,491	684,733	758,198	689,064	684,574
Kazakhstan	806,326	484,404	586,797	943,836	1,235,639	1,508,235	1,664,386
Kenya	193,548	164,344	152,825	164,735	198,187	230,210	259,763
Kiribati	102,415	100,158	108,504	109,238	99,292	113,413	112,577
Korea, Dem. People's Rep.							
Korea, Rep.	802,316	1,182,146	1,539,385	1,975,663	2,427,712	2,790,571	3,092,564
Kuwait		4,341,003	3,732,464	4,995,947	4,077,834	3,859,541	3,508,797
Kyrgyz Republic	305,537	146,049	183,011	210,246	255,671	306,030	341,446
Lao PDR	91,890	114,463	147,654	195,208	277,969	389,973	478,777
Latvia		561,758	800,817	1,263,481	1,359,452	1,749,186	2,056,617
Lebanon	455,775	838,893	925,919	925,960	1,266,814	1,064,630	957,155
Lesotho	71,013	77,898	71,982	76,320	98,989	114,629	120,168
Liberia			82,335	63,455	78,153	87,770	83,609
Libya			1,695,855	2,053,825	2,161,948	1,185,482	1,426,672
Liechtenstein							
Lithuania		643,140	871,943	1,312,066	1,532,435	2,004,553	2,473,900
Luxembourg	4,632,340	5,329,352	6,687,228	7,446,670	7,966,479	7,995,078	8,272,031
Madagascar	90,516	79,318	84,036	83,450	85,464	87,324	93,226
Malawi	41,069	42,693	45,347	47,520	67,903	79,149	86,971
Malaysia	648,245	898,361	1,017,330	1,175,471	1,340,801	1,625,512	1,865,905
Maldives		639,763	843,026	836,553	1,109,752	1,191,429	1,348,459
Mali	62,099	65,756	75,679	96,013	106,825	112,550	125,977
Malta	1,075,654	1,336,202	1,880,329	2,006,947	2,302,777	2,824,251	3,226,128
Marshall Islands	183,561	225,028	184,169	191,834	202,308	204,349	232,288
Mauritania	238,930	253,247	239,830	263,443	280,079	307,455	332,230
Mauritius	490,469	593,810	748,325	861,139	1,078,617	1,291,695	1,490,067
Mexico	918,088	932,978	1,144,112	1,158,424	1,159,256	1,263,945	1,285,903
Micronesia, Fed. States	162,663	189,923	190,385	202,157	207,418	195,395	196,389
Moldova		331,514	307,239	439,384	527,248	656,385	848,670
Monaco							
Mongolia	267,420	218,878	245,748	329,544	432,692	661,167	754,614
Montenegro			805,170	912,342	1,101,915	1,208,922	1,431,796
Morocco	222,631	226,178	265,164	322,481	393,196	450,473	481,675
Mozambique	21,023	21,364	28,443	37,167	47,970	61,474	65,112
Myanmar	27,590	34,734	49,216	89,818	157,411	217,748	288,421
Namibia	323,737	332,437	321,656	375,396	479,088	588,688	556,872
Nauru				285,492	357,833	748,984	758,326
Nepal	81,355	97,279	116,881	133,018	161,201	200,196	243,123
Netherlands	2,456,447	2,676,294	3,234,672	3,427,203	3,659,015	3,739,903	4,010,252
New Zealand	1,813,721	1,956,739	2,199,318	2,541,011	2,601,197	2,856,333	2,999,902
Nicaragua	216,614	210,443	254,640	277,389	299,819	368,411	358,210
Niger	46,918	43,216	42,532	47,036	53,942	60,540	67,413
Nigeria	155,321	138,045	141,356	197,110	256,629	298,508	287,787
North Macedonia	705,805	562,724	645,246	716,654	874,150	985,443	1,096,629
Norway	2,796,034	3,312,031	3,884,636	4,277,804	4,279,254	4,458,296	4,560,860
Oman	1,788,206	1,992,805	2,358,166	2,256,283	2,401,882	2,201,477	2,025,912
Pakistan	174,555	188,600	194,633	222,249	242,499	270,035	304,176
Palau			804,834	907,155	896,795	1,094,694	1,019,812
Panama	713,935	843,293	983,500	1,108,925	1,455,037	1,952,421	2,177,069
Papua New Guinea	132,804	179,571	158,021	156,296	186,508	227,864	241,923
Paraguay	556,671	608,799	560,080	562,426	685,360	784,842	838,292
Peru	318,403	385,226	419,166	506,879	681,288	838,517	898,854
Philippines	249,986	252,277	272,210	310,450	365,353	452,813	559,186
Poland	701,389	783,685	1,051,759	1,246,198	1,603,726	1,885,373	2,260,499
Portugal	1,512,421	1,660,691	2,010,960	2,101,752	2,188,924	2,181,205	2,453,534
Qatar			5,388,393	5,533,615	6,144,584	6,298,405	5,966,809
Romania	814,215	739,692	758,683	1,069,109	1,319,914	1,579,167	1,982,501
Russian Federation	1,299,012	756,722	836,026	1,145,048	1,444,087	1,594,997	1,737,311
Rwanda	41,201	29,914	37,965	57,898	84,460	110,770	133,278
Saint Kitts and Nevis	828,614	986,835	1,236,389	1,387,371	1,492,781	1,649,564	1,804,612
Saint Lucia	721,368	774,791	829,515	869,599	926,567	920,591	990,334
Saint Vincent and the Grenadines	419,786	500,150	574,931	708,798	748,790	789,640	856,708

(*continued on next page*)

Table 1 (*continued*)

Country	HLI						
	1990	1995	2000	2005	2010	2015	2019
Samoa	228,309	233,176	271,753	348,495	368,006	369,079	409,738
San Marino			5,227,834	5,769,179	5,098,466	4,110,887	4,297,410
Sao Tome and Principe				169,321	203,681	233,461	249,458
Saudi Arabia	2,466,772	2,604,728	2,579,969	2,750,200	2,754,473	3,109,963	3,030,609
Senegal	126,959	123,305	137,624	152,264	160,548	173,718	201,634
Serbia		482,464	560,403	782,595	944,884	1,026,616	1,214,225
Seychelles	928,358	990,556	1,227,854	1,186,286	1,371,540	1,685,392	1,890,042
Sierra Leone	64,785	48,744	47,506	57,503	68,963	79,380	92,186
Singapore	2,487,432	3,311,083	3,907,470	4,793,784	5,690,110	6,589,324	7,320,274
Slovak Republic		843,715	1,010,575	1,309,331	1,691,461	1,924,441	2,158,686
Slovenia		1,404,806	1,739,697	2,101,173	2,297,059	2,365,334	2,741,127
Solomon Islands	115,995	150,743	114,879	107,870	125,146	131,307	140,286
Somalia						51,491	61,116
South Africa	624,691	569,270	533,507	568,298	675,601	755,408	770,187
South Sudan							
Spain	1,841,767	1,970,755	2,395,635	2,650,196	2,647,553	2,672,418	2,921,371
Sri Lanka	236,569	296,765	371,614	444,244	588,656	789,153	875,621
Sudan	142,920	168,071	216,721	259,645	275,733	278,837	256,352
Suriname	838,371	783,038	796,061	978,334	1,180,558	1,211,636	1,197,918
Sweden	2,314,238	2,351,066	2,817,878	3,185,568	3,381,041	3,624,925	3,772,927
Switzerland	3,764,323	3,655,342	4,081,952	4,310,746	4,658,825	4,858,439	5,109,680
Syrian Arab Republic							
Tajikistan	242,315	81,642	78,231	115,506	144,854	182,414	221,490
Tanzania	66,761	59,485	65,572	84,796	107,198	133,903	156,272
Thailand	442,080	619,515	615,945	803,103	968,838	1,110,078	1,261,197
Timor-Leste			129,094	133,545	178,644	202,750	223,584
Togo	90,680	80,803	84,052	78,626	84,901	105,139	120,965
Tonga	234,789	292,503	313,582	336,023	327,747	378,647	407,550
Trinidad and Tobago	638,645	755,421	1,083,461	1,590,852	1,923,252	1,972,699	1,748,733
Tunisia	366,876	404,898	508,159	598,464	712,565	744,474	770,179
Turkey	757,879	843,352	1,000,509	1,212,059	1,329,306	1,736,614	1,912,165
Turkmenistan	422,090	229,421	272,598	330,197	531,089	808,117	976,928
Tuvalu	150,492	172,935	195,488	190,539	196,709	226,855	270,732
Uganda	38,439	45,444	54,428	69,978	96,984	115,222	126,073
Ukraine	1,012,016	465,417	447,928	677,512	761,766	714,115	827,476
United Arab Emirates	6,748,882	6,168,814	6,246,091	5,548,480	3,415,296	4,170,215	4,394,754
United Kingdom	2,040,955	2,206,506	2,600,963	2,904,587	2,902,447	3,116,281	3,273,591
United States	2,584,942	2,774,837	3,263,362	3,555,268	3,597,700	3,850,431	4,086,788
Uruguay	710,507	836,916	948,982	966,280	1,290,094	1,508,363	1,553,479
Uzbekistan	222,447	154,820	171,705	208,451	293,402	383,910	447,348
Vanuatu	159,268	163,551	172,292	159,945	175,716	167,007	179,512
Venezuela, RB							
Vietnam	126,441	174,034	233,421	313,154	407,743	526,108	666,242
Yemen, Republic of							
Zambia	99,464	78,267	79,102	100,675	154,234	182,499	191,158
Zimbabwe	145,456	123,035	116,455	76,714	83,510	121,335	123,751

Source: Own calculations based on World Bank (2022) and Global Burden of Disease Study 2019 (GBD 2019). **Note**: Blank cells imply that the countries on the list have not yet published the necessary data.

highest HLI values, followed by Oceania, Asia, and South America. African countries on average exhibit the lowest HLI values.

In Figure A1 in the appendix, we draw a similar map for 1990. While Fig. 1 includes 183 countries for which we had the necessary data to compute HLI in 2019, Figure A1 only includes the 155 countries for which data were available in 1990. Comparing the two figures shows that progress has been made worldwide, with Fig. 1 being dominated by green and yellow colors, indicating higher values of HLI.

In Fig. 2, we illustrate the changes in the rankings between 1995 (to increase data availability as compared with 1990) and 2019 for the 170 countries for which we were able to calculate HLI in both years. The color codes range from dark red (a decrease of 42–43 places in the global ranking) to dark green (an increase of 62–80 places in the global ranking). Asian countries generally improved the most, while some African and South American countries fell in the ranking. While Europe generally exhibits a moderate decline in the rankings, the United States is comparatively stable. The three countries with the greatest increases in the HLI ranking were Equatorial Guinea (up 80 places from 150 to 70), Bosnia and Herzegovina (up 66 places from 139 to 66), and China (up 62 places from 130 to 68). Over the same period, Gabon's HLI ranking declined the most (falling 43 places from 42 to 85), followed by Jamaica's, which fell 42 places from 63 to 105.

The coefficient of variation of HLI, calculated as the sample standard deviation divided by the sample mean, can be used to assess the extent to which global inequality in well-being changed over time. If the coefficient of variation decreases, then (sigma) convergence takes place and cross-country inequality decreases (see, for example, Kufenko et al., 2020; Young et al., 2008). The results are displayed in Table 2 and Fig. 3. We observe that the coefficient of variation decreased substantially between 1990 and 2019 for the subsample of 155 countries for which we have the data in both periods. Thus, overall, sigma convergence of well-being took place over that period.

To get an additional measure for the change in inequality of global well-being in terms of HLI, we calculated the ratio between the median HLI and the mean HLI (median of HLI/mean of HLI) and traced it over time (see also Table 2 and Fig. 3). A higher ratio implies that well-being is more equally distributed because outliers at the upper end of the distribution affect the mean but not the median. Table 2 shows that the ratio increased overall and, thus, its inverse mimicked the evolution of the coefficient of variation. Thus, the results are consistent with the

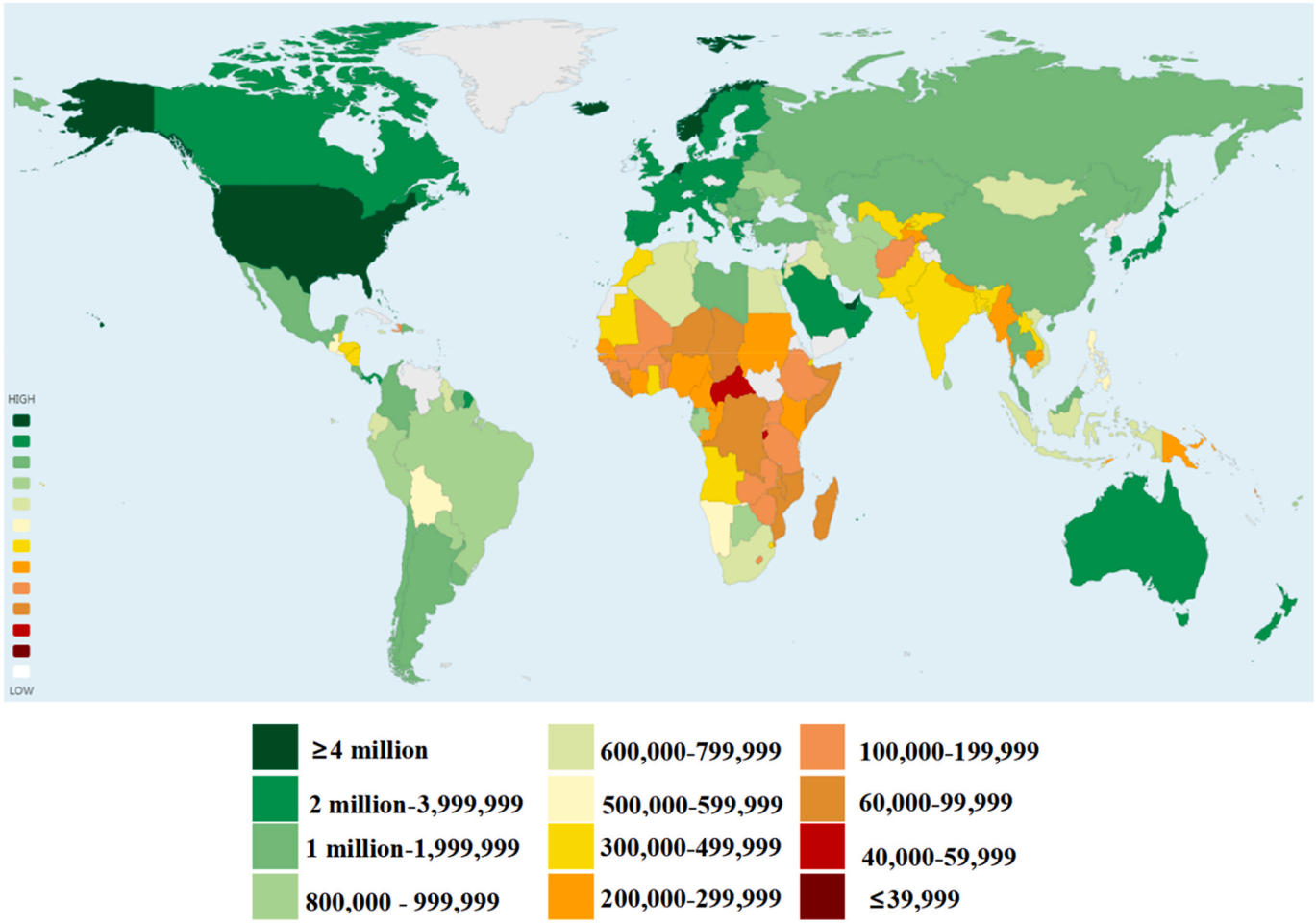

Fig. 1. HLI values in 2019 of 183 countries **Note**: HLI values are in 2017 INT$. Countries without available data remain gray.

finding of sigma convergence described above, i.e., overall inequality of countries in terms of well-being decreased over time.

In terms of World Bank regions (Table 3 and Figure A8), starting in 1990, North America exceeds Europe and Central Asia in terms of HLI by more than INT$ 1 million in all time periods considered. Considerably below these regions, we find the Middle East and North Africa group, starting at INT$ 625,786 and ending at INT$ 1,069,959, running parallel to and aligned with Latin America and Caribbean, starting at INT$ 637,365 and ending at INT$ 1,056,054. These regions are just above the world average until after 2015 when their gains flatten, and the world average surpasses them in 2019 at INT$ 1,080,991. Between 2005 and 2010, East Asia and Pacific rises quickly to join and finally surpass the world average. Soon after, East Asia and Pacific also surpasses Latin America and Caribbean and Middle East and North Africa, gaining INT$ 199,255 in only five years from 2005 to 2010. On the lowest rung of this ladder, we find South Asia and Sub-Saharan Africa, which follow a similar trend until 2005 when South Asia begins to climb, gaining INT$ 200,312 between 2005 and 2019. Sub-Saharan Africa had the least gains of any region by INT$ 78,549 over 29 years. The Sub-Saharan Africa group's HLI in 2019 peaks at only INT$ 212,534. The annual growth rate for each region is as follows: 4.77% (East Asia and Pacific), 4.71% (South Asia), 2.34% (World), 1.87% (Middle East and North Africa), 1.76% (Latin America and Caribbean), 1.65% (Europe and Central Asia), 1.62% (North America), and 1.55% (Sub-Saharan Africa).

As Table 3 and Figure A9 show, over 29 years, the high-income group has consistently had an HLI much higher than the world average. The difference is more than INT$ 2 million after 2005, finally reaching INT$ 3,464,578 in 2019. Furthermore, the upper-middle-income group diverges considerably from the lower-middle-income group, reaching a difference of INT$ 715,403 in 2019. The upper-middle-income group also surpasses the world average in 2015, reaching INT$ 1,158,440 in 2019. The lower-middle-income group shows gains over the whole period, more than doubling from INT$ 173,045 in 1990 to INT$ 443,037 in 2019. While these gains are substantial, they pale in comparison with the absolute gains made by the higher income groups. The annual growth rate for each income group is 4.12% (upper-middle income), 3.29% (lower-middle income), 2.11% (low income), and 1.79% (high income).

In Fig. 4 we plot the country ranking obtained using HLI against the country ranking obtained using IHLI for all countries for which we can compute the ranking based on both indicators. This shows that it does not make much of a difference for the rankings of the countries whether we compute the HLI or the IHLI (both described above). While IHLI includes considerations with regards to inequality, it demands more data and is therefore available for fewer countries. Typically the R^2 associated with the regression lines exhibits a value greater than 0.97. This means that more than 97% of the variation of the IHLI-based ranking of different countries is explained by the HLI-based ranking. Thus, in the tradeoff of omitting inequality versus maximizing the sample size, adding the Gini coefficient would not increase the available information substantially but would greatly reduce the number of countries for which the data are available.

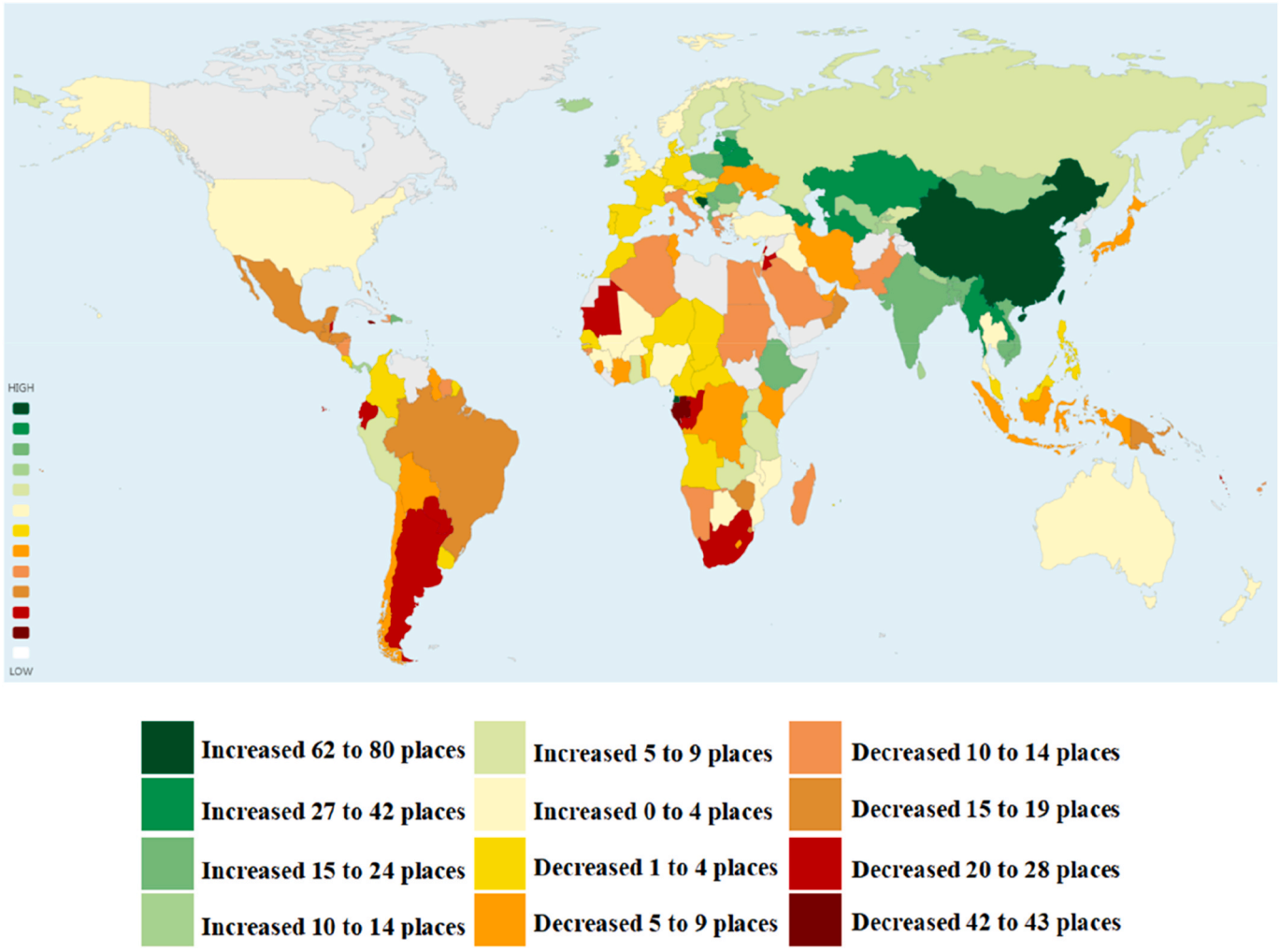

Fig. 2. Changes in country rank based on HLI between 1995 and 2019 **Note**: HLI values are in 2017 INT$. Countries without available data remain gray.

Table 2
World well-being equality and coefficient of variation in well-being from 1990 to 2019.

Year	Median HLI	Mean HLI	Equality of well-being	Standard deviation	Mean HLI	Coefficient of variation
1990	391,829	778,330	0.503	1,012,970	778,330	1.301
1995	370,997	816,589	0.454	1,069,680	816,589	1.310
2000	432,265	937,728	0.461	1,213,767	937,728	1.294
2005	507,176	1,048,872	0.484	1,291,621	1,048,872	1.231
2010	633,316	1,130,501	0.560	1,299,875	1,130,501	1.150
2015	749,046	1,228,029	0.610	1,374,026	1,228,029	1.119
2019	778,274	1,314,765	0.592	1,464,633	1,314,765	1.114

Source: Own calculations. Equality of well-being = Median of HLI / Mean of HLI. Coefficient of variation = Standard deviation of HLI / Mean of HLI

5. Discussion

5.1. Main findings

Healthy lifetime income (HLI) offers a different perspective than other commonly used indicators of well-being such as per capita GDP or the HDI. Per capita GDP does not reflect population health, and HDI has several inherent weaknesses as discussed in the introduction. IHLI is useful but requires more data than HLI. HLI incorporates similar information as IHLI, but with lower data requirements, which increases the coverage across countries and over time substantially. While some country-specific decreases and increases in HLI have occurred, the world at large has made steady progress toward higher well-being and a more equal global distribution thereof. We have illustrated this trend using the concept of sigma convergence (a decrease in the coefficient of variation of HLI across countries) and by computing the ratio of the median HLI to the mean HLI in a sample of 155 countries.

To compare regions of the world, we used the World Bank's regions and calculated HLI in five-year intervals from 1990 to 2019. North America had the highest HLI, averaging INT$ 3,334,384, followed by Europe and Central Asia, averaging much lower at INT$ 1,848,001. Latin America and Caribbean, the Middle East and North Africa, and East Asia and Pacific come next, with an average HLI of INT$ 858,583, INT$ 854,286, and INT$ 678,437, respectively. The bottom two regions were South Asia and Sub-Saharan Africa, averaging INT$ 212,424 and INT$ 167,527, respectively. As for the HLI increase among World Bank regions, East Asia and Pacific showed a remarkable climb starting in 2005, first by surpassing the world average in 2015 and then by

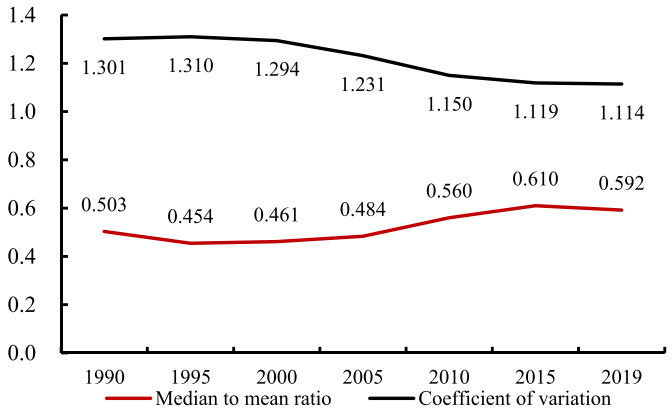

Fig. 3. World well-being equality and sigma convergence in terms of HLI in 155 countries from 1990 to 2019. **SOURCE**: Authors' own calculation. **NOTE**: A higher median to mean ratio implies well-being is more equally distributed because outliers at the upper end of the distribution affect the mean but not the median. We can see that the relationship between the coefficient of variation and the median to mean ratio is inverse. The sample size is constant for both lines.

surpassing two other regions, Latin America and Caribbean and Middle East and North Africa, in 2019.

To compare income groups across the world, we used the World Bank's income groups (low income, lower-middle income, upper-middle income, and high-income) and calculated their HLI values in five-year intervals from 1990 to 2019. The gaps between the group averages is sizeable. The annual growth rates for each income group were 4.12% (upper-middle income), 3.29% (lower-middle income), 2.11% (low income), and 1.79% (high income).

HLI treats countries with high income levels but poor health less favorably than per capita GDP does. This can be illustrated using the United States and Saudi Arabia. In 2010, the United States had a per capita GDP of INT$ 54,136 (adjusted to 2017 INT$) and ranked ninth (out of 181 countries). However, when the calculations are made using HLI, the United States only ranked 12th, falling three places. This also happened with Saudi Arabia, which had a per capita GDP of INT$ 44,037 in 2010 and ranked 23rd (out of 181 countries). However, when using HLI, it only ranked 27th, falling four places.

5.2. Strengths and limitations

HLI has several strengths: it only requires easily accessible data for its construction, it has an immediate economic interpretation, it is not bounded between specific values like the HDI, and it reasonably reflects the progression of well-being in different countries by including income and health components. In terms of limitations, HLI is a mixed measure of an instrumental and an intrinsic goal. Thus, it inherits also the limitations of its subcomponents. Other limitations of HLI are that it does not include inequality or other aspects of well-being such as education, and it only captures environmental aspects via the effect of pollution on healthy life expectancy.

5.3. Examples of high performers

Some countries consistently perform well in HLI comparisons, meaning they are highly ranked or stable, or they show steady growth. China is a particularly interesting example of rapid rank increases. China, which belongs to the East Asia and Pacific group and the upper-middle-income group, has experienced rapid growth, as its HLI values over time show. In 1990, China had an HLI of INT$ 86,118. In 2019, we observe a value of INT$ 1,094,894. This reflects an increase by a factor of almost 13.

5.4. Policy implications

As far as policy implications are concerned, government investment in health is essential because it can increase well-being substantially even if it comes at the expense of economic growth (Baldanzi et al., 2019; Chen et al., 2021, 2022b; Jones and Klenow, 2016; Kuhn and Prettner, 2016). Longevity, generally associated with good health, is important for well-being, but standard approaches tend to disregard this aspect. The amount that a government should spend on healthcare is difficult to gauge, but Chen et al. (2021) show that almost all of the countries they consider (with the exception of the United States) invest less than optimally in healthcare.

Some factors have a negative impact on longevity worldwide and thereby limit the rise in HLI. One factor is tobacco consumption, leading to various noncommunicable diseases such as cardiovascular diseases and cancer. Reducing noncommunicable diseases could yield substantial economic benefits at a comparatively low cost. Taxing tobacco sales and investing in health screening are examples of effective policies in this regard (Bloom et al., 2011; Chen et al., 2019a, 2019b, 2021; Zhou et al., 2022; Sudharsanan et al., 2020). Thus, these policies could go a long way in helping to improve overall well-being. Another factor that reduces the level of population health is inequality (Dickman et al., 2017; Subhani et al., 2021). In unequal societies, particularly the poor do not have good access to healthcare and education, are often not able to afford high-quality food, and often have physically more demanding jobs than the rich. Thus, having a functioning social security system with sufficient benefits for those in need is very important in this context. Potential policies along these lines could include an expansion of the earned income tax credit in the United States, the establishment of means-tested basic income schemes as they are in place in many

Table 3
Healthy lifetime income by World Bank region and country income group in five-year intervals from 1990 to 2019, 2017 INT$.

HLI								
By World Bank region	1990	1995	2000	2005	2010	2015	2019	Average
East Asia & Pacific	310,725	391,852	462,077	588,728	787,983	1,007,361	1,200,331	678,437
Europe & Central Asia	1,480,970	1,389,392	1,613,739	1,853,119	2,028,369	2,187,736	2,382,682	1,848,001
Latin America & Caribbean	637,365	703,461	780,310	842,665	948,155	1,042,074	1,056,054	858,583
Middle East & North Africa	625,786	664,832	761,255	862,852	968,422	1,026,893	1,069,959	854,286
North America	2,530,808	2,719,206	3,199,263	3,498,577	3,558,165	3,806,380	4,028,289	3,334,384
South Asia	101,112	119,486	144,994	184,017	240,527	312,506	384,329	212,424
Sub-Saharan Africa	139,819	126,359	131,191	155,965	188,456	212,534	218,368	167,527
By World Bank income group	1990	1995	2000	2005	2010	2015	2019	Average
Low income	63,556	57,186	62,666	75,565	92,773	106,005	116,605	82,051
Lower-middle income	173,045	178,655	200,707	249,046	312,798	378,191	443,037	276,497
Upper-middle income	359,367	370,378	446,345	578,664	790,879	995,789	1,158,440	671,409
High income	2,073,414	2,263,031	2,623,177	2,896,179	3,022,258	3,249,365	3,464,578	2,798,857
World	552,735	574,686	652,257	748,842	857,503	977,532	1,080,991	777,792

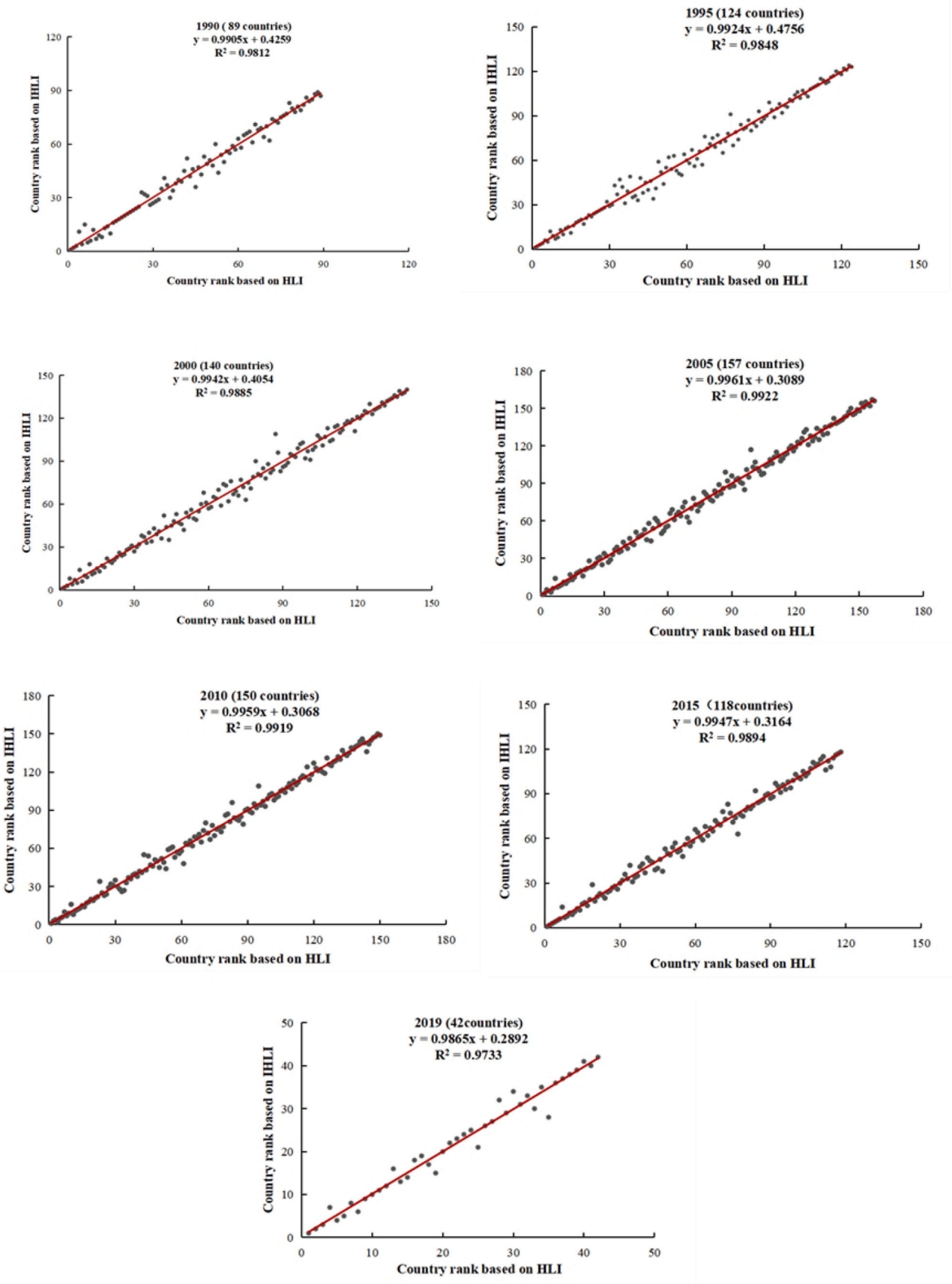

Fig. 4. Comparisons of HLI and IHLI rankings. **Note:** Regression lines are estimated by OLS. The slope is close to one for all years. The R^2 values provides the share of the variation of the IHLI-based ranking that is explained by the HLI-based ranking.

European countries, an expansion of funding for stipends and tuition-fee wavers for children of poorer parents in order for them to afford quality education, and general policies toward the reduction of unemployment. For a discussion of different aspects of social security systems that have the potential to reduce inequality see Prettner and Bloom (2020), chapter 7).

Another important aspect to consider in this context is the effect of climate change. Climate change is expected to impact the global economy in numerous ways, causing economic growth around the world to decline and potentially to turn negative. In addition, climate change can also lead to more premature deaths, e.g., due to heatwaves, droughts, or floods. As poorer countries are usually located closer to the equator and already now suffer severe weather extremes, they will be particularly strongly affected by the adverse effects of climate change on well-being. This would then result in a further increase in global inequality (Burke et al., 2015; Diffenbaugh and Burke, 2019). In this area, it is important that all countries over the world collaborate and pass the necessary laws to contain temperature rises in line with the Paris goals (Gazzotti et al., 2021). In addition, it would be helpful if richer countries provide sufficient funding for fostering a transition of poorer countries towards the use of clean technologies.

6. Conclusion

This study is the first to use HLI as a measure of well-being. Based on this measure, we provide a cross-country comparison of the evolution of well-being over the last 30 years. We show that HLI has advantages over other indicators and therefore recommend its use. Per capita GDP alone is too narrow and fails to capture the value of health, which is, arguably, one of the most important components of well-being. Therefore, policymakers should broaden their focus to include measures of health, such as HALE, that reflect the quality of life more directly.

Credit author statement

Junlai Zhang: Methodology, Investigation, Data Curation, Visualization, Writing - Original Draft. Klaus Prettner: Conceptualization, Methodology, Investigation, Writing - Original Draft, Supervision. Simiao Chen: Conceptualization, Methodology, Writing-Reviewing and Editing, Supervision. David E. Bloom: Conceptualization, Methodology, Writing-Reviewing and Editing, Supervision.

Declarations of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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