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Welfare and GDP across Countries: 2007-2017

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Abstract: *This paper is designed to assess the changes of GDP and welfare across countries over the period 2007 to 2017. The conceptual framework of the paper is based on Jones and Klenow (2016). The welfare numbers of 2007 are updated and work out the welfare results of 2017. After analyzing the results, it can be found that during the period, the growth in GDP per capita is often the driving reason for the rise in the level of welfare. However, the extent to which income increase brings up welfare increase depends.*

Keywords: *Level of wealth; GDP per capita; life expectancy; consumption; leisure; consumption inequality*

1. Introduction

GDP comparisons are regularly used to describe the welfare differences across countries, but there are many limitations to consider. It is interesting to assess to what extent GDP-per-capita changes over the period 2007 to 2017 provide an accurate picture of welfare changes over the same period, using the broader concept of economic welfare that includes all forces mentioned above. In doing so, this work employs the conceptual framework developed in Jones and Klenow (2016).[1] Their analysis ends in 2007. In this paper, the evolution of welfare and GDP across countries in the period 2007 to 2017 will be discussed.

The standard economics of expected utility is used to measure economic welfare which combines data on consumption, leisure, inequality and mortality. In the work, expected lifetime utility is computed to quantify economic welfare. An additive decomposition of the forces contributing to welfare will be provided, by determining welfare in country i in 2007 and 2017 relative to the United States in 2007, which was used as a benchmark. Economic welfare includes four parts: life expectancy, consumption, leisure and consumption inequality. Like Krueger et al. (2010)[2], which describe an impressive set of recent papers tracking inequality in earnings, consumption, income, and wealth over time in 10 countries.

The data in this work are based on the Penn World Table 9.1[3] and 11 countries from the dataset were selected to do some comparison. The 11 countries include the United States, Brazil, China, France, India, Indonesia, Italy, Mexico, Russia, Spain, and the United Kingdom. 11 countries are chosen according to the 13 countries which are chosen in Jones and Klenow (2016). Because Malawi data is not recorded in the Penn World Table 9.1 version and South Africa lacks data on average annual hours worked per capita, the remaining 11 countries are chosen for analysis. These data were used to find the changes that have taken place over the period 2007 to 2017. These data are used to compute changes in the consumption per capita, the annual hours worked per person, working hours, the leisure share and the expenditure-side real GDP. And the data from World Health Organization in 2016[4] is used to illustrate the life expectancy across countries.

Since data on consumption inequality is not available for 2017, the contribution from changes in this component over the period 2007 to 2017 cannot be accessed, even if the 2007 differences across countries has been taken into account.

There are many limitations when using the welfare expressions to discuss the results. First, a particular standard for measuring GDP and welfare of different countries is used, which assumed common preference across countries. Second, morbidity will be ignored when using life expectancy, which is an imperfect measure of health. Third, the welfare computations assume that consumption growth will be set to a constant rate across all countries and the leisure will be constant across ages. Fourth, the social capital, political freedom, the natural environment, emissions, security and urban

ISSN 2522-3488 Vol. 5, Issue 1: 5-14, DOI: 10.25236/IJNDES.2021.050102

disamenities will not be considered in this paper.

In this work, the main findings can be summarized as follows.

1) GDP per capita and the average working hours per capita are negatively correlated. While an increase in GDP per capita leads to an increase in life expectancy, which causes a higher welfare level;

2) In most cases, income growth will increase welfare to a large extent, but due to the difference in income growth and consumption growth and the contribution of other components to welfare, the relation between income and welfare growth is non-linear.

2. Theory

Comparing GDPs across countries and the welfare of different countries requires a standard to measure. A common set of prices is needed for the GDPs across countries. And a common specification for preferences needs to be set for the welfare across countries.

For a fictitious person who lives in a particular country and has these preferences, he has no idea what his life will be like. He does not know whether his life is rich or poor, industrious or leisurely, and whether he will die of a fatal disease during his lifetime.

The following discussion is based on these assumptions, and consumption-equivalent, which follows in the tradition of Lucas (1987)[5], who calculated the welfare benefits of eliminating business cycles versus raising the growth rate, measure is referred to as "welfare". In the discussion that follows, utilitarian expected utility calculation giving equal weight to each person will be focused.

2.1 The Main Setup

First, the computational formula of the expected lifetime utility, U is given. In the formula, S(a) is the probability an individual survives to age a, β is time discount factor which is limited between 0 and 1, u denotes the flow utility in a specific year and E denotes expectations operator which applies to the uncertainty about consumption and leisure. Let C denote an individual's annual consumption and ℓ denote leisure plus time spent in home production. Then the expected lifetime utility, U, is

$$U = E\sum_{a=1}^{100} \beta^a u(C_a, \ell_a) S(a) \quad . \tag{1}$$

If $\beta = 1$, and it is shown that

$$Cov(x, y) = E\left[x - E(x)\right]E\left[y - E(y)\right] \tag{2}$$

is equivalent to

$$E(x \cdot y) = E(x)E(y) + Cov(x, y) . \tag{3}$$

Because C_a and ℓ_a are independent of each other, which means $Cov(u(C_a, \ell_a), S(a)) = 0$. Then

$$U = E\sum_{a=1}^{100} u(C_a, \ell_a) \cdot E\sum_{a=1}^{100} S(a) + \sum_{a=1}^{100} Cov(u(C_a, \ell_a), S(a)) \quad , \tag{4}$$

$$U = E\sum_{a=1}^{100} u(C_a, \ell_a) \cdot E\sum_{a=1}^{100} S(a) . \tag{5}$$

In order to realize welfare calculation, let $U_i(\lambda)$ denote expected lifetime utility in country i if consumption is multiplied by a factor λ at each age,

ISSN 2522-3488 Vol. 5, Issue 1: 5-14, DOI: 10.25236/IJNDES.2021.050102

$$U_i(\lambda) = E_i \sum_{a=1}^{100} \beta^a u(\lambda C_{ai}, \ell_{ai}) S_i(a). \tag{6}$$

If this fictitious person mentioned above to live in the United States and in some other country i without difference, his consumption should be adjusted by the factor λ_i. Then it should satisfy

$$U_{us}(\lambda_i) = U_i(1). \tag{7}$$

2.2 An Illustrative Example

Now some assumptions need to be made. First, assume that flow utility for that fictitious person is

$$u(C, \ell) = \bar{u} + \log C + v(\ell), \tag{8}$$

where $v(\ell)$ captures the utility from leisure and home production. Assuming utility from leisure takes a form that implies a constant Frisch elasticity of labor supply. And labor supply is $1-\ell$, Frisch elasticity is ε, the utility weight on leisure or home production is θ, and the intercept in flow utility is $\bar{u}$. Then

$$v(\ell) = -\frac{\theta\varepsilon}{1+\varepsilon}(1-\ell)^{\frac{1+\varepsilon}{\varepsilon}}. \tag{9}$$

Let w denote the real wage and τ denote the marginal tax rate on labor income. And then it can get the weight on the disutility from working, θ,

$$\theta = \frac{w}{c}(1-\tau)(1-\ell)^{-\frac{1}{\varepsilon}}. \tag{10}$$

Let arithmetic mean is c_i, and a variance of log consumption is σ_i^2. It is supposed that consumption in each country obeys logarithmic normal distribution across people at a point in time, independent of age and mortality. It is shown that

$$E(\log C) = \log c - \frac{\sigma^2}{2}. \tag{11}$$

Assuming that consumption grows at a constant rate g, and for now that leisure is constant across ages and certain. Then the expected lifetime utility, U_i^{simple}, under these assumptions, is

$$U_i^{simple} = \left[\sum_a \beta^a S_i(a)\right] \cdot (\bar{u} + \log c_i + v(\ell_i) - \frac{\sigma^2}{2}) + g \cdot \sum_a \beta^a S_i(a). \tag{12}$$

Let $\beta = 1$ and $g = 0$. And in this special case, lifetime utility= the product of life expectancy × expected flow utility from each year, which is equivalent to

$$U_i^{simple} = e_i(\bar{u} + \log c_i + v(\ell_i) - \frac{\sigma^2}{2}), \tag{13}$$

and $e = \sum_a S(a)$.

Then the following calculation procedure (14) and (15) can be calculated from the above formulas

ISSN 2522-3488 Vol. 5, Issue 1: 5-14, DOI: 10.25236/IJNDES.2021.050102

$$\begin{aligned} U_{us}(\lambda_i^{simple}) &= e_{us}(\bar{u} + \log(\lambda_i^{simple} C_{us}) + v(\ell_{us}) - \frac{1}{2}\sigma_{us}^2) \\ &= e_{us}(\bar{u} + \log \lambda_i^{simple} + \log C_{us} + v(\ell_{us}) - \frac{1}{2}\sigma_{us}^2) \\ &= e_{us} \log \lambda_i^{simple} + U_{us}^{simple} \\ &= U_i(1) \end{aligned} \quad , \tag{14}$$

$$\begin{aligned} e_{us} \log \lambda_i^{simple} &= U_i^{simple} - U_{us}^{simple} \\ &= U_i^{simple} - e_{us}(\bar{u} + \log C_{us} + v(\ell_{us}) - \frac{1}{2}\sigma_{us}^2) \\ &= U_i^{simple} - e_{us}(\bar{u} + \log C_{us} + \log C_i - \log C_i + v(\ell_{us}) + v(\ell_i) - v(\ell_i) \\ &\quad - \frac{1}{2}\sigma_{us}^2 + \frac{1}{2}\sigma_i^2 - \frac{1}{2}\sigma_i^2) \\ &= (e_i - e_{us})(\bar{u} + \log C_i + v(\ell_i) - \frac{1}{2}\sigma_i^2) + e_{us}(\log C_i - \log C_{us}) \\ &\quad + e_{us}(v(\ell_i) - v(\ell_{us})) - e_{us}\frac{1}{2}(\sigma_i^2 - \sigma_{us}^2) \end{aligned} \quad . \tag{15}$$

Then formula (16) can be found,

$$\begin{aligned} \log \lambda_i^{simple} = \frac{e_i - e_{us}}{e_{us}}(\bar{u} + \log c_i + v(\ell_i) - \frac{\sigma^2}{2}) \quad & \text{Life expectancy} \\ + \log c_i - \log c_{us} \quad & \textit{Consumption} \\ + v(\ell_i) - v(\ell_{us}) \quad & \textit{Leisure} \\ - \frac{1}{2}(\sigma_i^2 - \sigma_{us}^2) \quad & \textit{Inequality} \end{aligned} \quad . \tag{16}$$

This expression will be widely used in the following discussion.

3. Description of the Data

The data in this paper are used for the comparison of GDP and welfare between 2007 and 2017 is the Penn World Table 9.1, instead of Penn World Table 8.0, which is used in Jones and Klenow (2016). In this section, the data used in Jones and Klenow with the updated data set will be briefly compared.

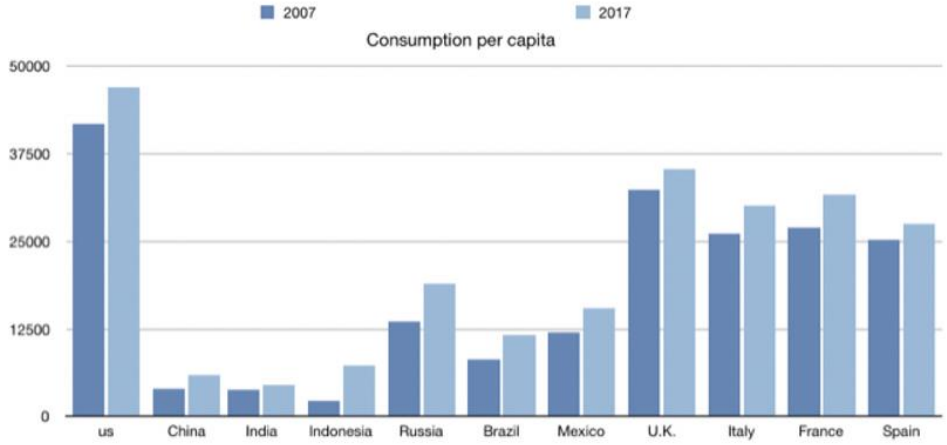

Figure 1. Consumption per capita comparison in Year 2011 USD

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The results in Jones and Klenow (2016) are mainly based on detailed micro datasets. They used household surveys for calculation of consumption inequality and welfare along three dimensions: consumption, leisure and inequality. (The calculation of consumption-equivalent welfare in various countries are based on equation (16) above.) Besides, 11 countries are chosen from the dataset, which include the United States, Brazil, China, France, India, Indonesia, Italy, Mexico, Russia, Spain, and the United Kingdom. They use data from the Penn World Tables 8.0 and the life tables from the World Health Organization.

Figure 1 illustrates the consumption per capita changes between 2007 and 2017 in these countries (computed by adding csh_c and csh_g, multiplying the resulting sum by rgdpe, and dividing the result by the total population series pop). Consumption increased in every country during this ten-year period.

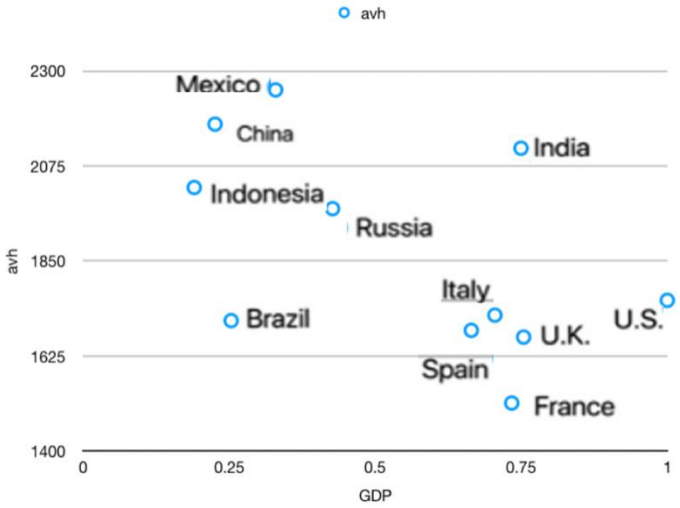

Figure 2. Average annual working hours per capita and GDP per capita

Figure 2 reports the annual working hours per person and GDP per capital levels in different countries (series Avh in the PWT 9.1). The GDP figures of all countries are normalized to the benchmark (US 2007 GDP per capita). As can be seen from the graph, countries with higher GDP level tend to have lower level of average working hours. In other words, the higher the GDP per capita, the lower the average working hours per person. This is one reason why GDP differences understate welfare difference across countries.

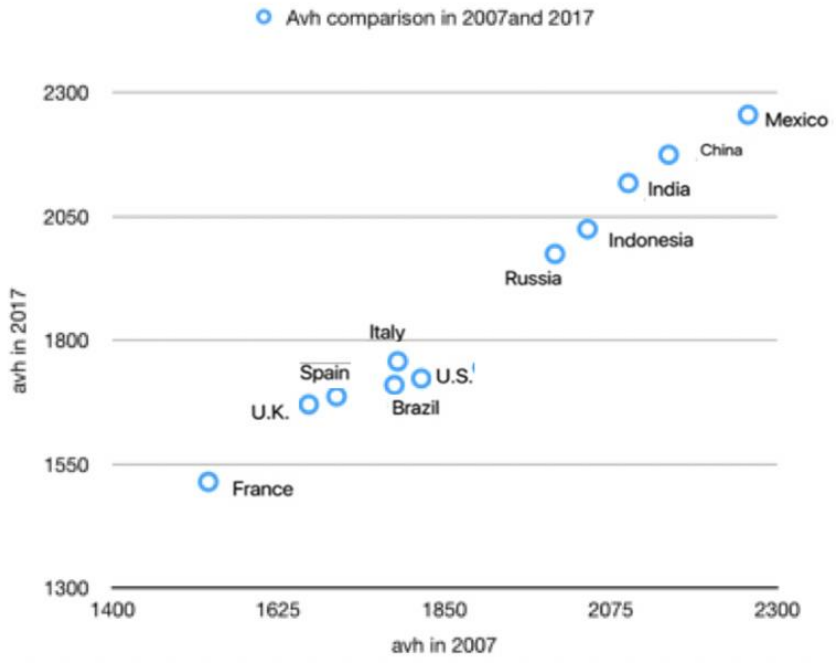

Figure 3. Avh comparison between 2007 and 2017

ISSN 2522-3488 Vol. 5, Issue 1: 5-14, DOI: 10.25236/IJNDES.2021.050102

Figure 3 shows the changes in average working hours across countries. From the graph, overall, the level of average working hours of all countries seems to remain at a similar place. It is obviously that the average working hours of China and Mexico in both years are much higher than those of other countries.

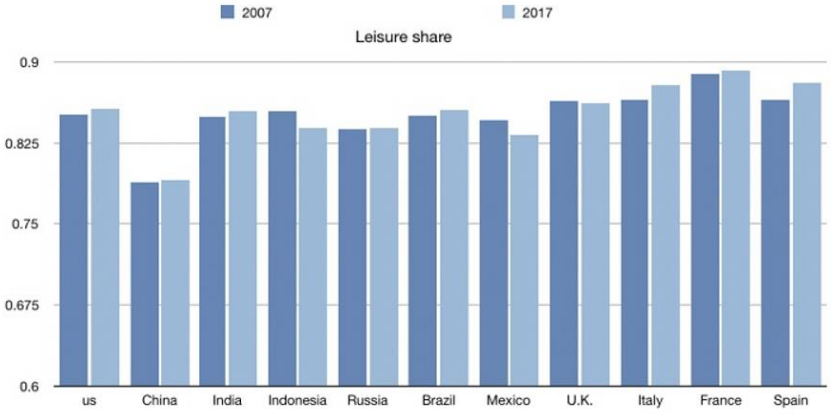

Figure 4. Leisure share

Figure 4 compares the leisure share of the 11 countries in both years. It shows that China has the lowest number of leisure share both in 2007 and 2017. It means the welfare level in China is adversely affected because of high numbers of working hours.

Table 1: Life expectancy 2016 versus 2007

Country	Life expectancy 2016	Life expectancy 2007
U.S.	78.5	77.8
China	76.45	72.6
South Africa	63.6	51
India	68.85	64.1
Indonesia	69.35	67.7
Russia	71.8	67.5
Brazil	75.15	72.1
Mexico	76.75	76
U.K.	81.45	79.4
Italy	82.7	81.3
France	82.9	80.8
Spain	83	80.9

Table 1 illustrates the life expectancy in every country in year 2016 and 2007, using data from the World Health Organization, which is the latest year for which this data is available. Countries like India, China, Russia and Brazil witness a dramatic increase in the life expectancy figures while the increase in other countries like the US is not as obvious. Overall, the table shows an increasing trend in life expectancy in all countries.

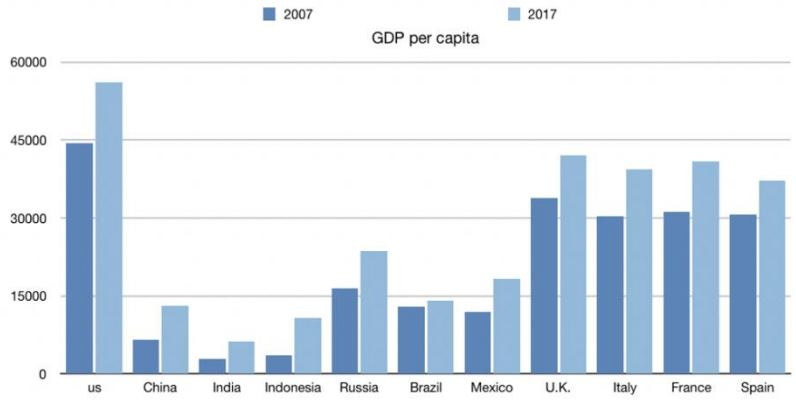

Figure 5. GDP per capita comparison

ISSN 2522-3488 Vol. 5, Issue 1: 5-14, DOI: 10.25236/IJNDES.2021.050102

Figure 5 demonstrates the expenditure-side real GDP comparison. It can be seen from the figure that the GDP per capita of each country has risen. The increase in the developing countries are the most significant. Their figures at least doubled during the 10 years. In comparison, GDP per capita of Brazil did not increase much. For the developed countries, their percentage increase in GDP per capita seems to be similar.

4. Results

In order to compare welfare and real GDP growth across countries between 2007 and 2017, GDP and other related figures need to be measured using a constant price approach. Hence, the macro welfare numbers generated by Jones and Klenow (2016) need to be updated accordingly. Unlike Jones and Klenow who use output-side real GDP, expenditure-side real GDP is used to measure consumption because consumption is related more to expenditure instead of output. For countries that have no life expectancy figures or average annual working hours per person (avh), their results are not included in this paper. Also, some improvement is added to the original approach of measuring leisure share. The new formula of calculating leisure share is (5840-avh)/5840 * emp/pop + 1 * (1 – emp/pop), which Emp is employed and pop is population. The new formula not only takes the leisure share of the employed into account but the unemployed as well. In addition, due to a lack of data, the consumption inequality and the life expectancy figures in 2017 are unable to capture. Therefore, the consumption inequality numbers are assumed to remain constant during the 10-year period and the 2016 life expectancy figures are used to approximate the 2017 ones for a set of countries.

Table 2 is the original results of a set of countries in Jones and Klenow's paper. Table 3 shows the new results of the same selected countries. The new results are not substantially different from the old ones except for some minor changes. For example, in Table 2, China has a welfare of 0.056, while the number increases to 0.061 in Table 3 because of increased income. Overall, the new results remain consistent with the original ones.

Table 2: Welfare Measurement for Selected Countries in Jones and Klenow's[6]

				Decomposition				
	Welfare λ	Income	log ratio	Life exp.	C/Y	Leisure	Cons. ineq.	Leis. ineq.
US	100.0	100.0	0.000	0.000	0.000	0.000	0.000	…
(micro)	100.0	100.0	0.000	0.000	0.000	0.000	0.000	0.000
UK	87.4	75.2	0.150	0.088	0.009	0.010	0.044	…
(micro)	96.6	75.2	0.250	0.086	–0.143	0.073	0.136	0.097
France	86.4	67.2	0.251	0.164	–0.080	0.061	0.106	…
(micro)	91.8	67.2	0.312	0.155	–0.152	0.083	0.102	0.124
Italy	75.4	66.1	0.132	0.190	–0.148	0.025	0.065	…
(micro)	80.2	66.1	0.193	0.182	–0.228	0.078	0.086	0.075
Spain	73.0	61.1	0.178	0.136	–0.045	0.038	0.049	…
(micro)	73.3	61.1	0.182	0.133	–0.111	0.070	0.017	0.073
Mexico	22.0	28.6	–0.261	–0.085	–0.045	–0.008	–0.123	…
(micro)	21.9	28.6	–0.268	–0.156	–0.021	–0.010	–0.076	–0.005
Russia	20.9	37.0	–0.572	–0.507	–0.129	0.007	0.058	…
(micro)	20.7	37.0	–0.583	–0.501	–0.248	0.035	0.098	0.032
Brazil	11.2	17.2	–0.428	–0.227	–0.036	–0.007	–0.157	…
(micro)	11.1	17.2	–0.436	–0.242	0.004	0.005	–0.209	0.006
South Africa	6.7	16.0	–0.869	–0.499	–0.030	0.087	–0.427	…
(micro)	7.4	16.0	–0.771	–0.555	0.018	0.054	–0.283	–0.006
Indonesia	5.6	7.8	–0.340	–0.302	–0.091	0.039	0.015	…
(micro)	5.0	7.8	–0.445	–0.340	–0.178	–0.001	0.114	–0.041
China	5.6	10.1	–0.592	–0.141	–0.230	–0.066	–0.155	…
(micro)	6.3	10.1	–0.468	–0.174	–0.311	–0.016	0.048	–0.014
India	3.5	5.6	–0.470	–0.339	–0.170	0.052	–0.013	…
(micro)	3.2	5.6	–0.559	–0.440	–0.158	–0.019	0.085	–0.028
Malawi	1.1	1.3	–0.152	–0.184	0.074	0.033	–0.075	…
(micro)	0.9	1.3	–0.310	–0.389	0.012	–0.020	0.058	0.028

Notes: The first row for each country reports the welfare decomposition obtained using our macro data sources. The second row repeats the micro results provided earlier. The year varies by country and corresponds to the latest year for which we have household survey data.

ISSN 2522-3488 Vol. 5, Issue 1: 5-14, DOI: 10.25236/IJNDES.2021.050102

Table 3: Welfare and Income for Selected Countries in 2007

Country	lambda	Income	logratio	life expectancy	consumption	leisure	inequality
us	1	1	0	0	0	0	0
France	0.921114949	0.705003761	-0.082170442	0.177350715	-0.435157136	0.0700745	0.1055615
U.K.	0.912594071	0.732980982	-0.091464107	0.096067552	-0.257141345	0.0259997	0.04361
Italy	0.840762327	0.693585808	-0.173446266	0.2017072	-0.468458304	0.0286233	0.0646815
Spain	0.778685133	0.672296004	-0.250148509	0.176599139	-0.502526939	0.0269178	0.0488615
Mexico	0.23054748	0.281222493	-1.467298451	-0.080325424	-1.253443684	-0.010523	-0.123006
Russia	0.202944256	0.365004401	-1.594823937	-0.498061068	-1.125572918	-0.028624	0.057434
Brazil	0.132299163	0.202282151	-2.022689538	-0.224215297	-1.638767774	-0.002076	-0.1576305
Indonesia	0.06797677	0.098496434	-3.164625022	-0.252752328	-2.933933762	0.0071916	0.0148695
china	0.061084184	0.14172846	-2.795502297	-0.147785581	-2.33307008	-0.158744	-0.1559025
India	0.037725642	0.063627963	-2.826693059	-0.434322767	-2.376204499	-0.003483	-0.0126825

Table 4 presents the welfare results in 2017 of the same selected countries as in table 3. Comparing table 3 with table 4, it is obvious that welfare numbers have changed significantly. For example, France, who had only 92 per cent of the US 2007 welfare, has now 124 per cent. Its life expectancy difference increased by nearly twofold. The consumption difference also decreased by approximately 16 per cent, with income rising by 9 per cent. Both life expectancy and consumption contributed substantially to the increase of welfare in France. The increase in leisure, however, is trivial. Also, due to the soaring income, the welfare number in Indonesia approximately doubled. This large decrease of about 118 per cent in consumption difference compensates for the 8 percent decrease in life expectancy difference. The change in leisure is also insignificant in Indonesia's case.

Table 4: Welfare and Income for Selected Countries in 2017

country	lambda	income	loglambda	life expectancy	consumption	leisure	inequality
France	1.23746434	0.792239	0.213064399	0.309634076	-0.277256483	0.075125307	0.1055615
US	1.188882221	1.085708	0.173013556	0.042368368	0.11879925	0.011845939	0
U.K.	1.124685524	0.814721	0.117503462	0.220618411	-0.168573096	0.021848147	0.04361
Italy	1.082262161	0.763156	0.079053444	0.290240202	-0.327414972	0.051546714	0.0646815
Spain	0.987506272	0.719884	-0.01257243	0.301341527	-0.418847833	0.056072376	0.0488615
Russia	0.341018498	0.455883	-1.075818555	-0.318184068	-0.786957428	-0.02811106	0.057434
Mexico	0.299608799	0.354993	-1.205277657	-0.051840948	-0.987619338	-0.04281137	-0.123006
Brazil	0.213997404	0.272791	-1.541791395	-0.118690101	-1.274197703	0.008726909	-0.157631
Indonesia	0.122214319	0.209621	-2.101979059	-0.337460118	-1.752947969	-0.02644047	0.0148695
china	0.099070674	0.252343	-2.311921802	-0.046274672	-1.957041009	-0.15270362	-0.155903
India	0.079264918	0.121451	-2.534959646	-0.303401667	-2.225878871	0.007003392	-0.012683

Table 5: Income, Consumption and Welfare Growth between 2007 and 2017 for Selected Countries

country	income growth	consumption growth	welfare growth
India	0.908774886	1.030038769	1.104387147
Indonesia	1.128206275	0.864991564	0.799288134
Russia	0.248979247	0.403003772	0.683305896
China	0.780467814	0.456489474	0.622969394
Brazil	0.348567605	0.439894822	0.619194467
France	0.12373717	0.171049848	0.345498947
Mexico	0.26231946	0.304505898	0.301930807
Italy	0.100305771	0.151474542	0.291354495
Spain	0.070783926	0.087279936	0.273048293
United Kingdo	0.111516612	0.09260882	0.23174301
United States	0.085707615	0.126143822	0.188882223

Table 5 shows the calculation of the income and welfare growth in the selected countries. Figure 6 presents a graph which illustrates the income and welfare movement of the same set of countries. In Figure 6, China, Indonesia, and India all have large increase in both income and welfare. From Table 5, it is interesting that India has a welfare growth figure larger than income growth figure while China and Indonesia have an opposite result. The reason why India has such a large welfare growth is mainly because of its increase in life expectancy, income and consumption level. Thus, it generates more increase in welfare than expected. The change in leisure difference has an effect of increasing welfare as well. Similar cases take place in Russia and Brazil, where consumption grows faster than income and where life expectancy has a significant increase. For China and Indonesia, although income increased significantly, consumption did not increase as much, hence contributing less to welfare than expected.

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Also, since the life expectancy increases in China and Indonesia are smaller than that in India, the welfare of China and Indonesia grow more slowly than that of India. The contribution of leisure differences is trivial compared with the former two composition. It is not surprising that the developed countries are all lined near the original point in Figure 6. Developed countries generally have slower growth in economy and better health care compared with developing countries. Therefore, the growth in welfare and income will not be as significant as that of the developing countries. The correlation between the two growth rates is 0.837, which means that welfare growth is highly connected to income growth. Although in most cases, welfare growth is largely driven by income growth, the two figures do not co move entirely with each other. Because income growth does not necessarily mean consumption growth due to different consuming preferences across countries, and because not only income growth, but growth in life expectancy and leisure time also contributes to the welfare growth, the relation between income and welfare growth is non-linear.

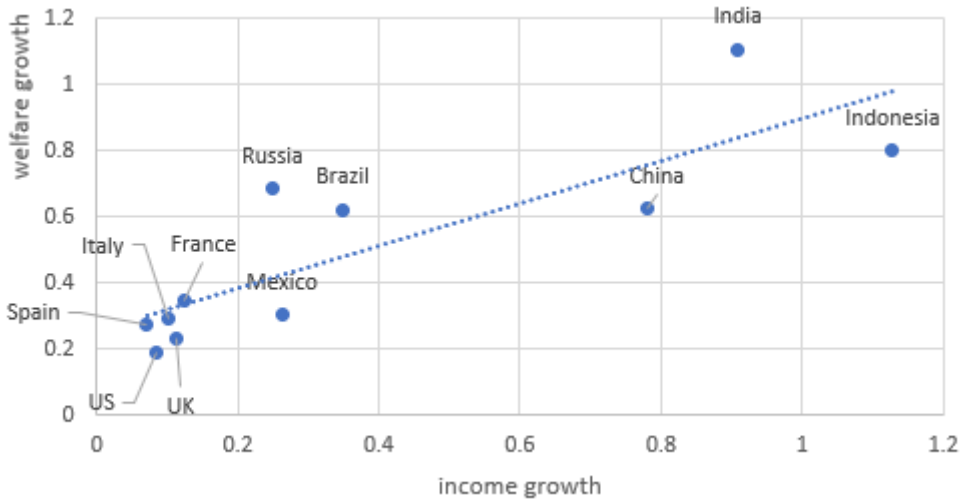

Figure 6: Income and Welfare Growth between 2007 and 2017 for Selected Countries

5. Conclusion

This study sets out to assess the evolution of welfare and GDP across countries from 2007 to 2017. The data on consumption, leisure, inequality and mortality are used to calculate welfare of various countries under a common set of prices and a common specification for preferences. The paper contributes to the understanding of the extent to which GDP-per-capita changes provide an accurate picture of welfare changes over the period 2007 to 2017. More specifically, the findings can be summarized as follows:

First, the growth of GDP per capita causes a higher level of welfare. A decrease in average working hours per capita is equivalent to an increase in leisure time. And growth in leisure time and life expectancy contribute to the welfare growth. Second, it is non-liner between income and welfare growth because of the gap between income and consumption growth. One reason for this is because different countries have different consuming preferences, the growth of income does not necessarily mean consumption growth. Another reason is that not only income growth, but growth in leisure time and life expectancy also contributes to the welfare growth.

The calculations of this paper are based on many assumptions. These assumptions and acquire more detailed data need to be refined, in order to generate a more accurate assessment. Also, the differences of the standard for measuring GDP and preferences over consumption and leisure across different countries should be considered when discussing the question. In addition, the natural environment, emissions, security and urban amenities, the results will be more appropriate in a variety of contexts, if the data and condition of the social capital, political freedom is considered.

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