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Article

Applying Logarithmic Transformation, Sine Wave and Amplitude: An Emerging Global Pattern of Economic Growth and Human Development

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Abstract: The complex adaptive systems (CAS) research study investigates into the theoretical link of a sustained economic growth as a critical pathway to lift people out of poverty and improve their quality of life. The results show a left-skewed global behavior of an economy-driven human development of 189 countries with 20% or 27 countries obtaining low human development; 80% or 162 countries obtaining medium to very high human development of which 21.16% or 39 countries with medium HDI, 53 or 28.04% or 53 countries with high HDI, and 31.22% or 59 countries with very high HDI. Using the Log (GDP) for visual transformation, closer investigation into the scatterplot diagram reveals that there are also bimodal patterns where countries in the high amplitude and low amplitude groups obtained different human development outcomes despite less or more on economic growth variances mirror on the government policy priorities resulting in four differentiating conditions. Very few countries experience virtuous cycles where both growth and human development are successful; few countries with vicious cycles where both are weak; and many countries with lopsided conditions where the economy is strong but human development is weak, or conversely ones where human development is strong but the economy is weak. The global pattern of economy and human development illustrated by an upward sinusoid or sine wave refutes the conventional linear approach. Uniquely and most importantly, the sinusoidal wave illustrates a decreasing amplitude and decreasing periods as countries manifest apparently complex behaviors that emerge as a result of often nonlinear spatio-temporal interactions among a large number of component systems at different levels of organizations and governments leading to an emergence of a behavior characterizing of a complex adaptive system.

Keywords: human development index; education index; health index; standard of living index; gross domestic product; complex adaptive systems; logarithmic transformation; sine wave; amplitude

Introduction

There is a surge of international studies exploring interactions between economic growth and global measures for human development leading to strategic foresight on policy and mechanisms to ensure the sustainability of humanity. The Sustainable Development Goals (SDGs), also known as the Global Goals, serve as an imperative universal call to action to ensure the sustainability of humanity characterized by decent living and poverty alleviation, planet and environment care and disaster mitigation. Among these conditions, the study focuses on economic conditions measured by the gross domestic product (GDP).

Corollary, the call to action for human capital and human development has been emphasized as a critical determinant of economic development. A sustained economic growth remains a critical pathway out of poverty and a core driver of human development. In fact, there is overwhelming evidence that growth has been the most effective way to lift people out of poverty and improve their quality of life (Schwab, 2019). In addition, it exerts a significant influence on social and political issues, such as fertility, the education of children, and democracy (Barro, 2012).

The United Nations Development Programme reported that the world is off-track to achieve the health-related SDGs. With progress uneven in both between and within countries resulting to a 31-year gap between the countries with the shortest and longest life expectancies. On education, the

universal primary education drop-out rates decreasing by 50% and increase in total enrolment to 91% indicate remarkable successes in achieving inclusive and quality education. However, where there is intense ongoing armed conflict and wide economic disparities, there is the belief that education is one of the most powerful and proven vehicles for sustainable development remains weak and futile. On decent work and economic growth, milestones include a “bulging middle”, the middle class making up for 34% of total employment, still there is more than 204 million people were unemployed (International Labor Organization, 2015) and ongoing effective measures eradicating forced labor, slavery and human trafficking.

With the issues articulated above, research compels studies on assessing the impact outcomes of the global economic measures on human development. This paper probes into an overview of the main arguments linking economic development and sustainable humanity. To this end, this paper investigates on the research question on economic development as an engine of human development considering the following:

1. the trend dynamics of human development among countries
2. a correlation of GDP and Human Development among countries
3. an emerging global GDP-HDI pattern

Framework of the Study

Complex Adaptive System (CAS). The complex adaptive systems has been coined in the 1980s at the interdisciplinary Santa Fe Institute, a New Mexico think tank. CAS as dynamic systems are able to adapt and evolve with a changing environment. Complex Adaptive Systems (CAS) is a framework for studying, explaining, and understanding systems of agents that collectively combine to form emergent, global level properties (Carmichael et al., 2019). A complex adaptive system is a system made up of many individual parts or agents following simple rules (HBR, 2011). Premised with no leader or individual coordinating the action of others; through the interactions of the agents, emergent patterns are generated. When the environmental elements of the system are altered, the system demonstrate behavioral change, i.e., may evolve, adapt or react. Many natural systems such as ecologies, societies and countries are characterized by apparently complex behaviors that emerge as a result of often nonlinear spatio-temporal interactions among a large number of component systems at different levels of organization (Buckley et al., 2008). The analysis of CAS is done by a combination of applied, theoretical and experimental methods (e.g., mathematics and computer simulation). The 189 countries included in this study comprise the complex adaptive systems with interactions between and among countries not limited to economic or trade. The interaction between the human development index and the gross domestic product of the countries emerges a pattern for analysis.

Human Development. Multidisciplinary researches in the literature on Human Development place strong emphasis on the conceptual shift and alternative policy options that create a balance between economic growth and protection of the interest of poor and marginalized members of society became imperative (Gaye, 2011). Human development concerns on the improvement of lives and wellbeing at any age by enhancing their human abilities through positive relationships, experiences, and opportunities. For young people, human development involves nurturing abilities that help them decide what matters most in life and encouraging them to determine and navigate their own paths. It is about facilitating meaning and purpose, rather than using grades and test scores as the sole measurement of self-worth. For adults, human development involves fostering abilities that give people the opportunity to live lives they value rather than using income as the sole measurement of success or wellbeing.

The Human Development Index (HDI) was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country and not economic growth alone. The Human Development Index (HDI) is a summary composite index that measures a country's average achievements in three basic aspects of human development, namely, a long and healthy life, being knowledgeable and having a decent standard of living (income). The HDI is the geometric mean of normalized indices for each of the three dimensions. The HDI sets a

minimum and a maximum for each dimension, called goalposts, and then shows where each country stands in relation to these goalposts, expressed as a value between 0 and 1.

The Health dimension, *Long and Healthy Life*, is assessed by life expectancy at birth which indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. The index is globally accepted in multiple researches and government reports to reflect the overall mortality level of a population. It summarizes the mortality pattern that prevails across all age groups - children and adolescents, adults and the elderly.

The Education Index, *Knowledge*, has been one of the most integral drivers and outcomes of global development. The provision of education is now viewed in most parts of the world as a basic right – with pressure on governments to ensure high-quality education for all. The Education Index premises that education is a broad measure of the overall level of preparedness of a country or region for a knowledge economy (World Bank Institute, 2008). Knowledge capital could determine the ability to build effective knowledge economies that deliver equitable and sustainable development (UNDP-MBRE, 2020). In this study, the Education dimension, Knowledge, is measured by expected years of schooling for children of school entering age and mean years of schooling for adults aged 25 years (Education Index). Mean years of schooling gives an indication of human capital formation in a country while expected years of schooling gives an indication of the number of years of schooling that a child of school entrance age can expect to receive if prevailing patterns of age specific enrolment rates were to apply

The Standard of Living dimension, *A Decent Standard of Living*, is measured by gross national income per capita (GNI Index). The Gross National Income, GNI, formerly referred to as gross national product (GNP) measures the total domestic and foreign value added claimed by residents at a given period in time, usually a year, expressed in international dollars using purchasing power parity rates (WHO). GNI comprises GDP plus net receipts of primary income (compensation of employees and property income) from nonresident sources. GNI provides an aggregate measure of income. An international dollar is defined as the currency unit that has the same purchasing power over GNI as the US dollar in the United States. For HDI, the GNI data are those estimated by the World Bank from the corresponding ones in the United Nations systems of National Accounts, expressed in domestic currency (World Bank). Purchasing power parity conversion factors are estimated by the World Bank based on data collected by the International Comparison Programme (ICP), which is coordinated by the United Nations regional economic commissions and other international organizations (ADB, 2007). Per capita figures are based on the World Bank's population estimates and projections (WHO).

Overall, for the Human Development Index, the United Nations Development Programme's (UNDP) has created the country classification system for the purpose of characterizing the progress of development primarily for policy decisions for better governance and shifting global attention and activity in improving inequities in countries, societies and communities. The classification system takes into account the multifaceted nature of development. HDI is a composite index of three indices measuring countries achievement in longevity, education and income. It also recognizes other aspects of development such as political freedom and personal security. In the classification system, developed countries are countries in the top quartile of the HDI distribution (Very High Human Development with HDI values between 0.800 to 0.953); developing countries consists of countries in the high group (HDI percentiles 51-75; High Human Development, 0.700 to 0.798); medium group (HDI percentiles 26-50; Medium Human Development with HDI values between 0.477 to 0.699), and the low group with bottom quartile HDI (Low Human Development: 0.354 to 0.546).

Gross Domestic Product is a measure developed by an economist Simon Kuznets in the early 1930s. The Gross Domestic Product (GDP) is widely accepted as the primary indicator of macroeconomic performance. The GDP, as an absolute value, shows the overall size of an economy, while changes in the GDP, often measured as real growth in GDP, show the overall health of the economy. The GDP consists of four components, namely: consumption, investment, government expenditure and net exports. The GDP Product (GDP) of an economy is a standard measure of total

production, the value of both of goods and services, produced by a country during a period has been established as a basic determinant of how the economy fares (OECD, 2009). By allocating total production to each unit of population, the extent to which the rate of individual output contributes to the development process can be measured. It indicates the pace of per capita income growth and also the rate that resources are used up. As a single composite indicator of economic growth, it is a most powerful summary indicator of the economic state of development in its many aspects. Among governments, GDP is one of the most comprehensive and closely watched economic statistics to prepare government budget, formulate monetary policy, used as indicator of economic activity in stock exchange centers, and data reference to prepare forecasts of economic performance that provide the basis for production, investment, and employment planning (McCulla et al., 2015).

Global organizations on economic growth group countries into three classifications on the basis of the GDP, namely the Developing, Transition, Developed, and least developed.

Gross Domestic Product and Human Development. Research studies pursue the theoretical or conceptual link between economic growth and human development. The GDP concept relates directly to welfare, or more specifically to a somewhat narrower concept that of the “aggregate economic well-being” which may exclude factors that are very far outside the scope of GDP, such as the quality of the environment (Dynan & Sheiner, 2018). Government spending is expected to improve the Human Development Index (HDI) in order to increase public welfare. Theoretically, if the number of government expenditure is increasing then the Human Development Index (HDI) will be higher as well. Economic theories support that countries with lower GDP have poor human development; and most of the countries with higher GDP have better human development. There is also literature contrary to the theory that higher income usually associated with high human development. On the basis of the correlation between economic growth and human development, it is estimated that sustained per capita economic growth would indeed reduce conditions of low human development. These estimates lead this study to investigate empirical data to establish that countries cannot depend on economic growth alone to reduce the human development divide.

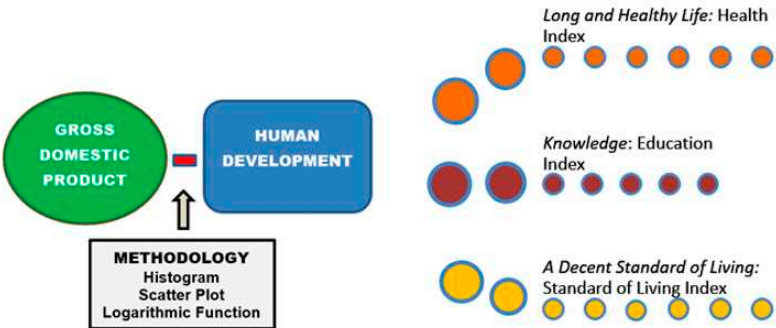


Figure 1. Schematic Diagram showing the operational framework of the study.

Methodology

Data Collection: Human Development Index and the Gross Domestic Product (UNDP). The research study employs the non-experimental quantitative inferential design on the quantitative data for the Human Development Index and the Gross Domestic Product regularly published by the United Nations Development Programme (UNDP).

The Human Development Index (HDI) of 189 countries provides a single index measure to capture three key dimensions of human development with the four key metrics. To assess the dimension on long and healthy life, the metrics on life expectancy at birth is used; to assess access to knowledge, the metrics on the expected years of schooling for the young generation and the average years of schooling for the older generation; and to assess the standard of living, the gross national income (GNI) per capita.

The HDI first forms indices for each of the four metrics where the values of each metric are normalized to an index value of 0 to 1. The dimension index is therefore 1 in a country that achieves the maximum value and it is 0 for a country that is at the minimum value.

With the actual value for a given country, and the global maximum and minimum, the dimension (indices) value for each metric is calculated as:

$$\text{Dimension Index} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}}$$

Second, the four metrics are aggregated to calculate the HDI. The HDI is calculated as a geometric mean of the three components by taking the cube root of the product of the normalized component scores; i.e. the geometric mean (equally-weighted) of life expectancy, education, and GNI per capita, as follows:

$$\text{HDI} = (\text{IHealth} * \text{IEducation} * \text{IIncome})^{1/3}$$

The Health Index to assess *Life Expectancy* uses long-run estimates of life expectancy across the world are shown in the visualization. For countries where historical records are available, such as the UK, estimates can extend as far back as 1543 – click on the UK to see this long-run perspective. Global and regional estimates extend back to the year 1770. This dataset is based on a combination of data from the Clio Infra project, the UN Population Division, and global and estimates for world regions from James Riley (2005).

The Education Index to assess *Knowledge* is the arithmetic mean of the two education indices. The two metrics are access to education which is measured by expected years of schooling of children at school-entry age; and the mean years of schooling of the adult population. Mean years of schooling estimates the average number of years of total schooling adults aged 25 years and older have received. This data extends back to the year 1870 and is based on the combination of data from Lee and Lee (2016); Barro-Lee (2018); and the UN Development Programme. Expected years of schooling measures the number of years of schooling that a child of school entrance age can expect to receive if the current age-specific enrollment rates persist throughout the child's life by country (Gaye, 2011).

The Standard of Living Index to assess *A Decent Standard of Living* uses the purchasing-power-adjusted per capita Gross National Income (GNI). The GNI includes remittances and foreign assistance income, for example, providing a more accurate economic picture of many developing countries. Gross National Income per capita which is adjusted for price changes over time, and price differences between countries is measured in international US\$. The GNI per capita (PPP \$) is calculated with the total income of a country's economy generated by its production and its ownership of factors of production, less the incomes paid for the use of factors of production owned by the rest of the world, converted to international dollars using purchasing power parity (PPP) rates, divided by midyear population. The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI. The scores for the three HDI dimension indices are then aggregated into a composite index using geometric mean.

The *Gross Domestic Product* (GDP) is the standard measure of the value of final goods and services produced by a country during a period (OECD, 2009). GDP measures the size of an economy by adding the market value of all final goods and services produced in a country in a given period. Using the expenditure approach, GDP is the consumption, gross investment, government spending, and imports against exports. More precisely, it is the monetary value of all final goods and services produced within a country or region in a specific time period. The current price estimates of GDP are adjusted to GDP at constant prices with the use of price deflators. Population estimates enable the conversion of total GDP to per capita levels, while exchange rates and other conversion factors are used to arrive at values based on a common unit of currency. Real GDP is derived by extrapolating total value-added in the base year with production indicators in physical terms or by deflating current price values by a price deflator.

In addition, the GDP per capita, purchasing power parity (PPP) (current international \$) is the GDP divided by the midyear population, where GDP is the total value of goods and services for final use produced by resident producers in an economy, regardless of the allocation to domestic and foreign claims. It does not include deductions for the depreciation of physical capital, or the depletion

and degradation of natural resources. PPP indicates the rate of exchange that accounts for price differences across countries, allowing for international comparisons of real output and incomes. An international dollar has the same purchasing power in the domestic economy as the US dollar has in the United States. PPP rates allow for standard comparisons of real prices among countries, just as conventional price indexes allow for comparisons of real values over time. The use of normal exchange rates could result in overvaluation or undervaluation of purchasing power.

Data Analysis: Complex Adaptive System (CAS), Histogram, Scatter Plot, Logarithmic Transformation & Amplitude. A complex adaptive system has three characteristics. The first is that the system consists of a number of heterogeneous agents, and each of those agents makes decisions about how to behave. The most important dimension here is that those decisions will evolve over time. The second characteristic is that the agents interact with one another. That interaction leads to the third, something that scientists call emergence (Sullivan, 2011).

The study uses histograms as a visual representation of the data distribution of GDP and HDI. The histograms display the very large amounts of data and the frequency of the data values of the 189 countries; and the outliers and gaps in the data. The study uses the scatter plots to indicate values of individual data points and the patterns of the human development index (HDI) and the respective gross domestic product (GDP) of countries taken as a whole. The scatter plots show the relationships between variables, the HDI and the GDP of countries; describe possibly as positive or negative, strong or weak, linear or nonlinear. To visualize numerical data that range over several magnitudes, the research study uses the logarithmic transformation of the data for better visualization. The standard visualization technique to use in this study is the logarithmic transformation of data. Scatter plots with logarithmic axes are applied for the logarithmic transformation of HDI and GDP data whose range spans several orders of magnitude, yet still ensuring fidelity to the order of the observations while making outliers less extreme.

Results & Discussion

Histograms of HDI and GDP of 189 Countries. Figure 1 shows the distribution and frequency of the Human Development Index and the Gross Domestic Product of 189 countries. The differences across the world are very large, ranging from the highest values in North America, Europe, Japan, and Oceania to the lowest in central Africa.

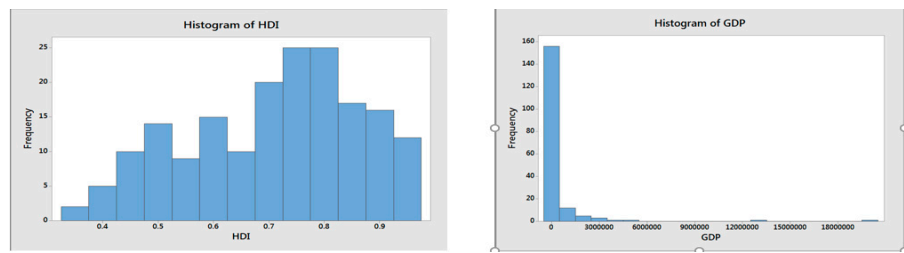


Figure 1. Histogram on the Distribution and Frequency of HDI & GDP of 189 Countries.

Figure 1 also shows both histograms with skewed distributions of HDI & GDP of 189 countries. The histogram for the GDP presents a very sharp "skewed right" distribution is one in which the tail is on the right side. This indicates that majority of the countries have relatively similar low to middle range of GDP and very few countries in the far right of the scatter plot diagram with very high GDPs; and these could be considered as outliers. The histogram for the HDI presents a slightly "skewed left" distribution with the tail on the left side indicating that majority of the 189 countries converge on middle to high human development indexes.

Tables 1 and 2 show the world views global human development in terms of four defined ranges Tables 1 & 2 show that there are 59 countries or 31.22% of 189 countries with very high HDI; 53 countries or 28.04% with high HDI; 40 countries or 21.16% with medium HDI; and 37 countries or 19.58% with low HDI. From the raw data, among the top ten HDIs, 80% are countries in Europe; and the ten lowest HDIs are all experienced in countries in the African continent. Overall, 152 countries or 80.42% characterize with The HDI was created to emphasize that people and their capabilities are

priority criteria for assessing the development of their societies with better conditions in health, education and standard of living.

Table 1. Listing of Countries in the Four Classifications of Human Development.

COUNTRY	Very HDI	COUNTRY	Very HDI	COUNTRY	High HDI	COUNTRY	High HDI	COUNTRY	Medium HDI	COUNTRY	Low HDI
1 Norway	0.95	30 Estonia	0.871	60 Iran	0.798	86 China	0.752	113 Philippines	0.699	152 Solomon	0.546
2 Switzerland	0.94	31 Greece	0.870	60 Palau	0.798	86 Ecuador	0.752	113 South Africa	0.699	153 Papua New	0.544
3 Australia	0.93	32 Cyprus	0.869	62 Seychelles	0.797	88 Ukraine	0.751	115 Egypt	0.696	154 Tanzania	0.538
4 Ireland	0.93	33 Poland	0.865	63 Costa Rica	0.794	89 Peru	0.750	116 Indonesia	0.694	155 Syrian	0.536
5 Germany	0.93	34 United Arab	0.863	64 Turkey	0.791	90 Colombia	0.747	116 Viet Nam	0.694	156 Zimbabwe	0.535
6 Iceland	0.93	35 Andorra	0.858	65 Mauritius	0.790	90 Saint Lucia	0.747	118 Bolivia	0.693	157 Nigeria	0.532
7 Hong Kong	0.93	35 Lithuania	0.859	66 Panama	0.789	92 Fiji	0.741	119 Palestine	0.686	158 Rwanda	0.524
7 Sweden	0.93	37 Qatar	0.856	67 Serbia	0.787	92 Mongolia	0.741	120 Iraq	0.685	159 Lesotho	0.520
9 Singapore	0.93	38 Slovakia	0.855	68 Albania	0.785	94 Dominican	0.736	121 El Salvador	0.674	159 Mauritania	0.520
10 Netherlands	0.93	39 Brunei	0.853	69 Trinidad & Tobago	0.784	95 Jordan	0.735	122 Kyrgyzstan	0.672	161 Madagascar	0.519
11 Denmark	0.92	39 Saudi Arabia	0.853	70 Antigua & Barbuda	0.780	95 Tunisia	0.735	123 Morocco	0.667	162 Uganda	0.516
12 Canada	0.92	41 Latvia	0.847	70 Georgia	0.780	97 Jamaica	0.732	124 Nicaragua	0.658	163 Benin	0.515
13 United States	0.92	41 Portugal	0.847	72 Saint Kitts & Nevis	0.778	98 Tonga	0.726	125 Cabo Verde	0.654	164 Senegal	0.505
14 United	0.92	43 Bahrain	0.846	73 Cuba	0.777	99 Saint Vincent & Grenadines	0.723	125 Guyana	0.654	165 Comoros	0.503
15 Finland	0.92	44 Chile	0.847	74 Mexico	0.774	100 Suriname	0.720	127 Guatemala	0.650	165 Togo	0.503
16 New Zealand	0.91	45 Hungary	0.838	75 Grenada	0.772	101 Botswana	0.717	127 Tajikistan	0.650	167 Sudan	0.502
17 Belgium	0.91	46 Croatia	0.831	76 Sri Lanka	0.770	101 Maldives	0.717	129 Namibia	0.647	168 Afghanistan	0.498
17 Liechtenstein	0.91	47 Argentina	0.825	77 Bosnia and	0.768	103 Dominica	0.715	130 India	0.640	168 Haiti	0.498
19 Japan	0.90	48 Oman	0.821	78 Venezuela	0.761	104 Samoa	0.713	131 Micronesia	0.627	170 Cote	0.492
20 Austria	0.90	49 Russian	0.816	79 Brazil	0.759	105 Uzbekistan	0.710	132 Timor-Leste	0.625	171 Malawi	0.477
21 Luxembourg	0.90	50 Montenegro	0.814	80 Azerbaijan	0.757	106 Belize	0.708	133 Honduras	0.617	172 Djibouti	0.476
22 Israel	0.90	51 Bulgaria	0.813	80 Lebanon	0.757	106 Marshall Islands	0.708	134 Bhutan	0.612	173 Ethiopia	0.463
22 Korea (Rep)	0.90	52 Romania	0.811	80 Yugoslav	0.757	108 Libya	0.706	134 Kiribati	0.612	174 Gambia	0.460
24 France	0.90	53 Belarus	0.808	83 Armenia	0.755	108 Turkmenistan	0.706	136 Bangladesh	0.608	175 Guinea	0.459
25 Slovenia	0.89	54 Bahamas	0.807	83 Thailand	0.755	110 Gabon	0.702	137 Congo	0.606	176 Congo	0.457
26 Spain	0.89	55 Uruguay	0.804	85 Algeria	0.754	110 Paraguay	0.702	138 Vanuatu	0.603	177 Guinea-Bissau	0.455
27 Czechia	0.88	56 Kuwait	0.803			112 Moldova	0.700	139 Lao	0.601	178 Yemen	0.452
28 Italy	0.88	57 Malaysia	0.802					140 Ghana	0.592	179 Eritrea	0.440
29 Malta	0.87	58 Barbados	0.800					141 Equatorial Guinea	0.591	180 Mozambique	0.437
		58 Kazakhstan	0.800					142 Kenya	0.590	181 Liberia	0.435
								143 Sao Tome & Principe	0.589	182 Mali	0.427
								144 Eswatini	0.588	183 Burkina Faso	0.423
								144 Zambia	0.588	184 Sierra Leone	0.419
								146 Cambodia	0.582	185 Burundi	0.417
								147 Angola	0.581	186 Chad	0.404
								148 Myanmar	0.578	187 South Sudan	0.388
								149 Nepal	0.574	188 Central African	0.367
								150 Pakistan	0.562	189 Niger	0.354
								151 Cameroon	0.556		
Very High Human Development: 59 countries			High Human Development: 53 countries			Medium Human Development: 39 countries			Low Human Development: 37 countries		

Table 2. Summary of Countries in the Four Classifications of Human Development.

Classifications of Human Development	Number of Countries	Percentage	Cumulative Frequency Percentage	Human Development Index Range
Very High Human Development	59 countries	31.22	31.22	.800 to .953
High Human Development	53 countries	28.04	59.26	.700 to .798
Medium Human Development	39 countries	21.16	80.42	.477 to .699
Low Human Development	27 countries	19.58	100.00	.354 to .546
Total	189 countries	100.00		

Figure 2 presents that histograms of the distribution of countries belonging to each of the 4 classifications of HDI. Closer investigation into shows that there are distinguishing observations into the distribution of HDI in each of the four classifications. For the 59 countries with very high HDI, conditions for human development are relatively similar, i.e., welfare services and benefits are being provided and experienced equitably well. However, there are distinct differences for the other three classifications. The scatter plots show distributions with relatively two peaks. The bimodal distribution indicates that two highest main ranges. The two peaks mean that there are two groups in the frequency table that has the most frequency of occurrence. This also means that the data is showing two modes in the measures of central tendency. Many coverage in low-high and middle-high HDI; low-medium and upper-medium; and middle-low and upper-low HDI.

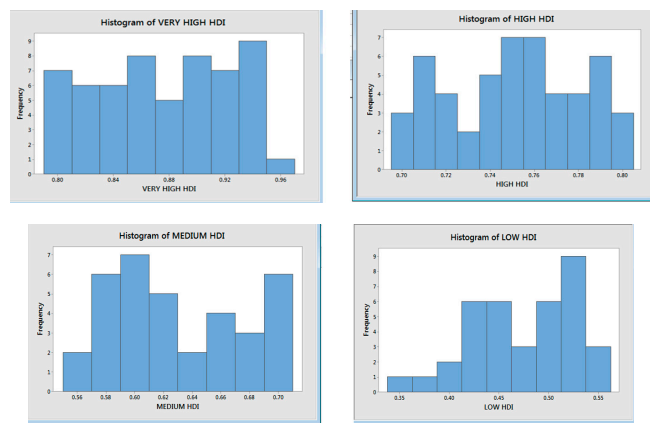


Figure 2. Histograms on the Classifications of Human Development Indexes of 189 Countries.

Figure 3 shows the scatter plot diagrams of the HDI and GDP. The results of the above four (4) scatterplot diagrams consistently show most of the HDI-GDP data points very closely converging near 0 point. In this case, the current scatter plots make it difficult for determination and analysis. To visualize those observations without losing information about these majority of countries, the study requires transformation that distributes the data more uniformly within the plot.

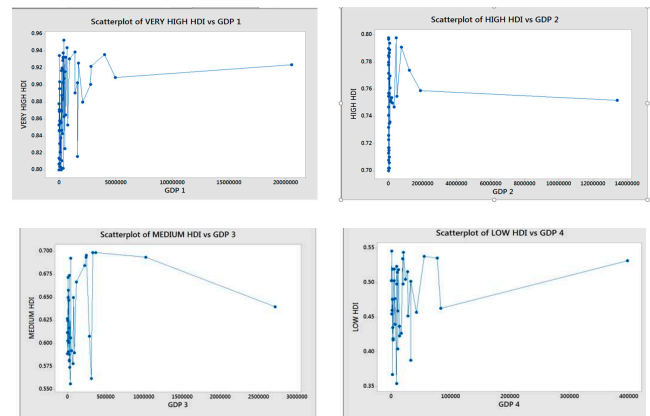


Figure 3. Scatter Plot Diagrams of HDI and GDP of 189 Countries.

Where all the four scatterplot diagrams of GDP and HDI yield relatively a behavior with very close plotting as shown in Figure 3, the Log of GDP is computed. Figure 4 is the scatter plot diagram with the log(GDP) and HDI showing the logarithmic transformation of data used as a standard visualization technique. When data whose range spans several orders of magnitude, the study considers a log transformation to enhance the visualization. A logarithmic transformation preserves the order of the observations while making outliers less extreme. Another reason, a logarithm transformation can change a highly skewed variable (as shown in Figure 3) into a more normalized distribution. In this attempt to linearize the relationship, the GDP is frequently approximated in log form.

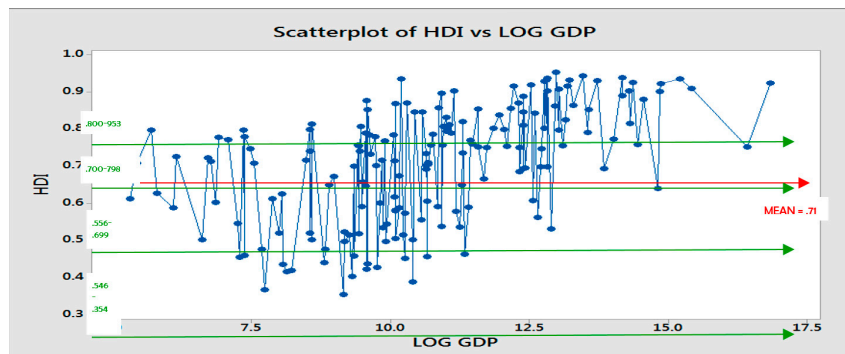


Figure 4. Scatter Plot Diagrams with Logarithmic Transformations of HDI and GDP Data of 189 Countries.

Figure 4 shows interesting observations. First, there is more distribution of data points above the mean of HDI=.71(High HDI .700 to .798). The mean is very close to the published global HDI value of 0.728. This also further supports the earlier finding that the many countries (60%) have obtained high to very high HDIs. Second, instead of expecting the hypothetical linear pattern, the diagram presents an erratic pattern of high and low points of GDP and HDI refuting that global economy and human development behaviors are directly correlated or positively linear. It can be inferred from the scatterplot diagram that the human development of countries has a non-linear upward trend.

Pursuing this argument, Finland, with a GDP of only 1.34% of US GDP, has obtained an HDI of 0.920 which is relatively the same of US. Other similar cases also be observed where differences exist and argues about the direct influence GDP on HDI. Given two or a few countries with the same gross domestic product, the countries could not achieve a relatively the same measure of human development. Other countries with higher GDPs yield lower HDIs; countries with lower GDPs yield higher HDIs. These striking contrasts can directly stimulate further investigation into HDI profile analysis per HDI dimension and per country more specific debate about government policy priorities.

Table 2 intends to identify the outlier countries in the logarithm transformation shown in Figure 4. Table 2 lists the countries with the top ten GDPs. among the top ten GDP countries, eight (8) countries achieved the Very High HDI, two (2) with High HDI, but one (1) with only a Medium HDI. China with the second highest GDP is able to provide its people with a High HDI. For India, its high GDP have not provided more opportunities or there could be only few mechanisms that impact improvement in health, education and income. It is also interesting to note that Canada, with the 10th highest GDP and just 8.33% of the GDP of United States (having the highest GDP) has obtained a relatively the same very high human development index. China which has the 2nd highest GDP has obtained only a high HDI.

Table 2. Top Ten GDP Countries & HDIs.

Top Ten GDP Countries	Gross Domestic Product (US\$ million)	Human Development Index
United States	20,494,050	0.924
China	13,407,398	0.752
Japan	4,971,929	0.909
Germany	4,000,386	0.936
United Kingdom	2,828,644	0.922
France	2,775,252	0.901
India	2,716,746	0.640

Italy	2,072,201	0.880
Brazil	1,868,184	0.759
Canada	1,711,387	0.926

Tables 3 and 4 intend to characterize the normalized distribution in the logarithm transformation shown in Figure 4. Tables 3 & 4 specifically show the countries belonging to the two groups as described in the bimodal distribution in Figure 4. The two groups where many countries converge confirm an earlier observation on a bimodal distribution. Tables 3 and 4 also show an emerging pattern as illustrated by amplitudes. With the HDIs of the countries in each group are arranged from their respective group's range of lowest and highest values, the difference of the highest and lowest values, that is the peak deviation within the range, determines and characterizes the amplitude. Specifically, peak-to-peak amplitude (p-p) is the change between peak (highest amplitude value) and trough (lowest amplitude value).

Table 3 presents the 57 countries belonging to the group with high amplitude. With the HDIs are arranged from the highest value to the lowest, the group consists of countries with 10.0 to 12.0 Log(GDP) with HDIs widely ranging from Low HDI to Very High HDI. The range shows the lowest HDI at .388 (South Sudan) and the highest HDI at .935 (Iceland). The difference of these HDIs is almost p-p amplitude of 0.547; and where the differences from the low and high points are wider to characterize a high p-p amplitude. South Sudan and 5 other countries at the bottom of Table 3 have higher GDP values than Iceland and other 3 countries in the top 5 of Table 3. It could be inferred from this observation that countries of this group though of relatively within same GDP ranges, their country behaviors toward human development vary very widely; a distinct characteristic of complex adaptive systems with each agent making its own country decisions on how to behave in human capital and closing in inequities through varying national policy choices.

However, in Table 4, the other group consists of countries with 12.5 to 15.0 Log(GDP) with HDIs ranging from almost Medium HDI to Very High HDI. The range shows the lowest HDI at .562 and the highest HDI at .953. The difference of these HDIs is .391 which further presents a low p-p amplitude. The differences from the low and high points are narrower in this second p-p amplitude illustrated in Figure 4. The behavior could be attributed to another distinct characteristic of complex adaptive systems that these countries have made decisions evolving over time by interacting with one another to close in the human development divide among these countries in a higher GDP range.

Table 3. 57 Countries with High Amplitude.

COUNTRY	GDP	HDI	Log(GDP)	COUNTRY	GDP	HDI	Log(GDP)
Iceland	26684	0.935	10.191	Jordan	41869	0.735	10.642
Luxembourg	68993	0.904	11.141	Tunisia	41662	0.735	10.637
Slovenia	54969	0.896	10.914	Honduras	23835	0.715	10.078
Estonia	29527	0.871	10.293	Uzbekistan	43303	0.710	10.675
Cyprus	23963	0.869	10.084	Libya	43236	0.706	10.674
Lithuania	52468	0.858	10.867	Turkmenistan	42764	0.706	10.663
Slovakia	106585	0.855	11.576	Paraguay	41851	0.702	10.641
Latvia	34286	0.847	10.442	Bolivia	41833	0.693	10.641
Bahrain	39300	0.846	10.579	El Salvador	25833	0.674	10.159
Hungary	155703	0.838	11.955	Morocco	118309	0.667	11.681
Croatia	59971	0.831	11.001	Guatemala	79109	0.650	11.278
Oman	81682	0.821	11.31	Congo, Rep	42692	0.606	10.661
Bulgaria	63651	0.813	11.061	Ghana	51815	0.592	10.855
Belarus	56934	0.808	10.949	Kenya	89591	0.590	11.403
Uruguay	60933	0.804	11.017	Zambia	25778	0.588	10.157
Kuwait	141050	0.803	11.856	Cambodia	24141	0.582	10.091
Kazakhstan	170539	0.800	12.046	Angola	24141	0.581	10.092

Costa Rica	60816	0.794	11.015	Myanmar	71543	0.578	11.178
Panama	66031	0.789	11.097	Nepal	28813	0.574	10.268
Serbia	47564	0.787	10.769	Cameroon	38445	0.556	10.556
Trinidad & Tobago	23284	0.784	10.055	Tanzania	55645	0.538	10.926
Sri Lanka	92504	0.770	11.435	Syria	77460	0.536	11.257
Venezuela	96328	0.761	11.475	Uganda	27855	0.516	10.234
Azerbaijan	45592	0.757	10.727	Senegal	24240	0.505	10.095
Lebanon	56709	0.757	10.945	Sudan	33249	0.502	10.411
Ecuador	107511	0.752	11.585	Ethiopia	83836	0.463	11.336
Ukraine	124603	0.751	11.732	Congo	42692	0.457	10.661
Dominican Rep	81103	0.736	11.303	Yemen	28524	0.452	10.258
				South Sudan	33249	0.388	10.411

Table 4. 39 Countries with Low Amplitude.

COUNTRY	GDP	HDI	Log(GDP)	COUNTRY	GDP	HDI	Log(GDP)
Norway	434937	0.953	13.000	Poland	586015	0.865	13.300
Switzerland	703750	0.944	13.500	United Arab Emirates	424635	0.863	13.000
Australia	1418275	0.939	14.200	Saudi Arabia	782483	0.853	13.600
Ireland	372695	0.938	12.800	Chile	298172	0.843	12.600
Sweden	551135	0.933	13.200	Argentina	518092	0.825	13.200
Hong Kong	363031	0.933	12.800	Russia	1630659	0.816	14.300
Singapore	361109	0.932	12.800	Malaysia	354348	0.802	12.800
Netherlands	912899	0.931	13.700	Iran	452275	0.798	13.000
Denmark	350874	0.929	12.800	Turkey	766428	0.791	13.500
Canada	1711387	0.926	14.400	Mexico	1223359	0.774	14.000
United Kingdom	2828644	0.922	14.900	Brazil	1868184	0.759	14.400
Finland	275321	0.920	12.500	Thailand	487239	0.755	13.100
Belgium	533153	0.916	13.200	Colombia	333114	0.747	12.700
Austria	457637	0.908	13.000	South Africa	368135	0.699	12.800
South Korea	1619424	0.903	14.300	Philippines	330846	0.699	12.700
Israel	369843	0.903	12.800	Indonesia	1022454	0.694	13.800
France	2775252	0.901	14.800	India	2716746	0.640	14.800
Spain	1425865	0.891	14.200	Bangladesh	287630	0.608	12.600
Italy	2072201	0.880	14.500	Pakistan	312570	0.562	12.700

Figure 4 and Tables 3 & 4 altogether explain the amplitude illustrating a sine wave, sinusoidal wave or a sinusoid explaining the variance in the behavior of countries in terms of their economic growth behavior and human development behavior. The study applies the sine wave concept based from the implications of the amplitudes that could refer to the extent of efforts that demonstrate government spending, investments and economic activities that are expected to improve the Human Development Index (HDI) that translates to increase public welfare and the improvement of the quality of life. Moreover, economists explain that economic activities are aimed ultimately to contribute to the quality of human development. Economic activities need to achieve the key dimensions of human development, namely, health, knowledge and income. Governments and society invest in providing their citizens more freedoms and opportunities to improve their well-being. Human development means that the people are able to live long, healthy lives, have access to functional and purposeful knowledge, and enjoy a decent standard of living.

Conclusion

The study articulates the following conclusions:

First, the study through advanced mathematical functions applied for an econometric analysis demonstrates lopsided distribution and frequency of countries' GDP and HDI; as well as establishes

strong links between economic growth and human development. Progress is not linear or guaranteed.

Second, the country performance of the 189 countries on their GDP and HDI can be characterized in four ways: virtuous cycles where both growth and human development are successful; vicious cycles where both are weak; and lopsided ones where the economy is strong but human development is weak, or conversely ones where human development is strong but the economy is weak. Countries obtaining different human development outcomes despite less or more on economic growth variances mirror on the government policy priorities.

Third, the global emergent behavior is manifested by the sine function of the GDP of the countries. The global pattern of economy and human development is an upward **sinusoid** or sine wave with a decreasing amplitude and decreasing periods. The sine wave refutes the conventional linear approach where the analysis for human development is restricted to only the four ranges of HDI. There is a series of high and low economy-driven human development conditions that the GDP is not the absolute precursor for human development.

Fourth, the analysis of the study especially in countries with high human development levels are obtained, remarkable successes or challenges however are pursued such as dramatic increases in longevity, quality of education (functional knowledge); wealth disparities among rural, urban poor, urban rich; age and gender inequities; and inequalities among regions.

Fifth, the economic growth and human development as a serious top agenda inclusive by most countries for the sustainability of humanity could eventually mitigate how inequalities and uncertainty drive polarization and escalated conflict.

Recommendation

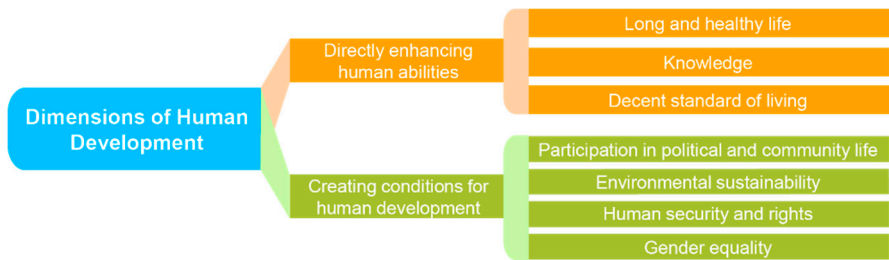


Figure 2. Schematic Diagram showing the recommendatory UNDP operational framework of the study.

The study recommends the following:

For governments and policy-makers to collaborate with the academe in pursuing regional and local researches to identify inequalities or inequities in micro-components of the HDI dimensions and their corresponding sector services; and capacitate grass root levels in monitoring and measuring granular impact of economic growth to human development.

For the private sector, governments and international coalitions, to set and operationalize a trajectory for social entrepreneurship that provides and utilize functional knowledge and futuristic patterns of behavior rather than dole-outs and other tangible give-aways.

For both the public and private sectors to intensify forums for citizen engagement and community empowerment in stimulating debates on national policy choices and policy priorities leading to impactful innovation.

For the private sectors to intensify forums for citizen engagement and community empowerment in stimulating debates on national policy choices and policy priorities.

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