

# Comparing Quality of Life by Human Development Category: Parametric vs. Nonparametric Approaches

*Katherine M. Prioli*

*December 20, 2018*

## Abstract

**BACKGROUND** Increasing globalization has generated interest in comparing countries by key quality of life (QoL) measures such as life expectancy, gender equality, and happiness, among others. When considering how countries compare by QoL, it is vital to understand how the measures are related, if at all, and in what ways the statistical tests chosen affect the results. **METHODS** A dataset containing country names and selected QoL measures for 2016 was explored through descriptive statistics and sensible univariate and bivariate visualizations. Six sets of hypotheses pertaining to relationships within the data were generated and tested with both nonparametric methods and their parametric equivalents, and results of these paired analyses were compared. **RESULTS** Text goes here **CONCLUSION** text goes here

## Background

With increasing economic globalization, a natural topic of interest is how the world's nations compare with respect to quality of life (QoL). Several organizations monitor global QoL indicators and report single-dimension or aggregate values for indicators of interest. For example, the World Bank reports Gross Domestic Product (GDP), which is a single-dimension indicator often strongly predictive of QoL in a given country (The World Bank (2018)). Additionally, the World Health Organization reports infant mortality rate, life expectancy at birth, and life expectancy at 60 years of age (World Health Organization (2018b), World Health Organization (2018a)).

Other quality of life measures represent compound scores or indices based on several inputs. For example, the United Nations calculates an annual Human Development Index (HDI), representing the developmental level of each country on a scale of zero to one based on several factors, including life expectancy at birth, years of schooling, and per-capita income (The United Nations Development Programme (2018b)). The HDI also categorizes countries into four levels of development (low, medium, high, and very high). Similarly, the Social Progress Imperative publishes the Social Progress Index (SPI), ranging from 0 to 100, and comprising over 50 dimensions in three broad categories: basic human needs (e.g., nutrition, safety), foundations of wellbeing (e.g., basic knowledge, environmental quality), and opportunity (e.g., personal rights, freedoms) (Social Progress Imperative (2018b)). The World Economic Forum's Global Gender Gap Index reports a gender equality index, scaled from 0-1, based on measurements of gender-related gaps in such dimensions as economic participation, level of education, health and survival, and political offices held (World Economic Forum (2016b)). Finally, the World Happiness Report calculates a score from 0-10 by considering per-capita GDP, healthy life expectancy, social support, freedoms, and perception of corruption, among others (Helliwell, Layard, and Sachs (2018)).

The objective of this analysis is to explore the distributions of and relationships between key QoL indicators using both nonparametric and parametric methods, and to assess the appropriateness of each method used.

## Methods

The dataset used in this analysis, titled `alldata`, was generated for the MAT 8790 course (Prioli (2018b)). It consists of country-level variables for calendar year 2016 as described in Table 1.

**Table 1.** `alldata` dataframe contents.

Source	Variable Name	Description
countrycode package	country	Country names
Social Progress Imperative (2018a)	SPI	Social Progress Index value (scale of 0:100)
The World Bank (2018)	GDP_USD_2018	2016 Gross Domestic Product (valued in \$US 2018)
The United Nations Development Programme (2018a)	HDIrank	Human Development Index ranking
The United Nations Development Programme (2018a)	HDIindex	HDI index value (scale of 0:1)
The United Nations Development Programme (2018a)	HDI_cat	HDI index category (5 levels)

Source	Variable Name	Description
Helliwell, Layard, and Sachs (2018)	<code>happiness</code>	World Happiness Score (scale of 0:10)
World Economic Forum (2016a)	<code>genderequality_index</code>	Gender Equality Index (scale of 0:1)
World Health Organization (2018b)	<code>infantmort</code>	Infant mortality rate
World Health Organization (2018a)	<code>birth_MF</code>	Life expectancy at birth, males & females
World Health Organization (2018a)	<code>sixty_MF</code>	Life expectancy at 60 years, males & females

All variables pertain to the calendar year 2016. Missing values were omitted from the dataset to ensure that the tests of interest could be performed.

For each variable except `country`, descriptive statistics were run and a sensible visualization was generated, following which a correlation matrix was produced to examine pairwise relationships between continuous variables.

Based on the data exploration results, several formal hypotheses were generated about the data, and sensible nonparametric tests and their parametric equivalents were performed to assess these hypotheses. Results of these parallel tests were compared in the context of the data and assumptions needed.

### *Hypotheses*

Data exploration led to six hypotheses, as presented in Table 2.

**Table 2. Hypotheses of Interest**

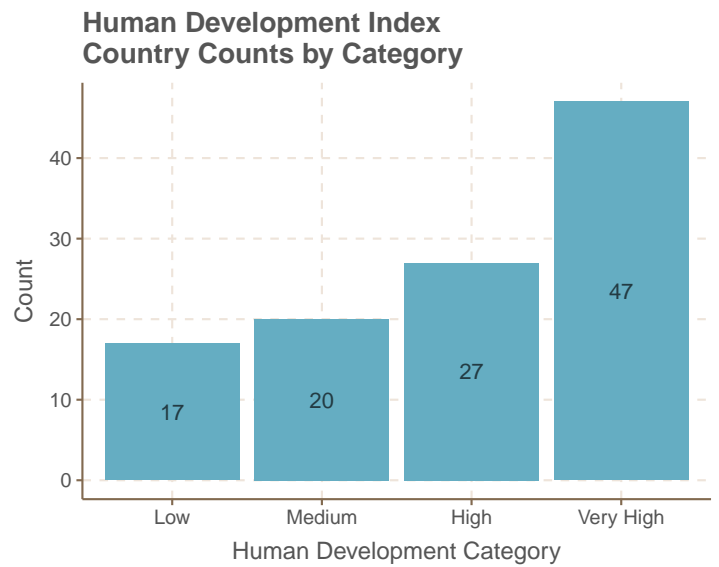
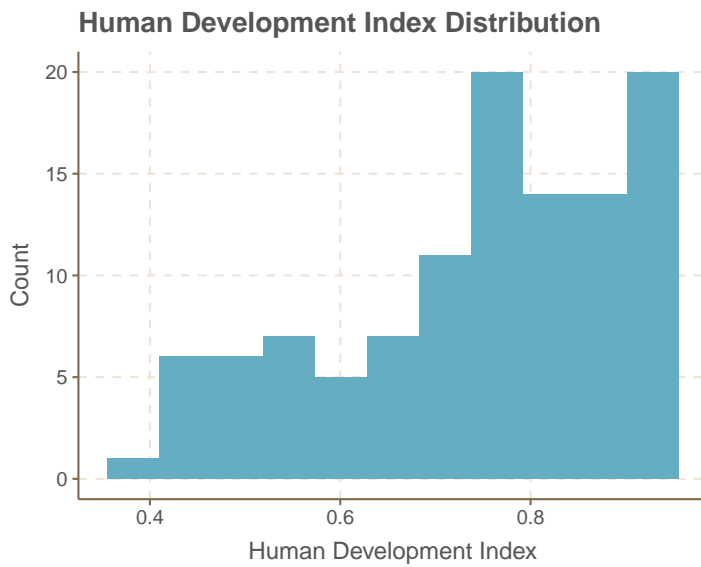
Test	Null Hypothesis	Alternative Hypothesis	Nonparametric Test	Parametric Test
1	The sample median is equal to its mean	The sample median differs from its mean	One-Sample Sign Test	One-Sample t-Test
2	Social progress and human development are not associated	Social progress and human development are correlated	Kendall's Tau	Pearson's Correlation Test
3	There is no relationship between log(GDP) and infant mortality	There is a relationship between log(GDP) and infant mortality	Hoeffding's Test	Pearson's Correlation Test
4	Happiness is normally distributed	Happiness is not normally distributed	One-Sample Kolmogorov-Smirnov Test	Shapiro-Wilk Test
5	Gender equality and adjusted social progress index have the same spread	Gender equality index and adjusted social progress index differ in spread	Ansari-Bradley Test	Levene's Test
6	Infant mortality rate is the same across levels of human development	Infant mortality rate differs by level of human development	Permutation F-Test	ANOVA

All tests were performed at level  $\alpha = 0.05$  in R. The dataset, full code, and this report are available in an online repository (Prioli (2018a)).

## **Results**

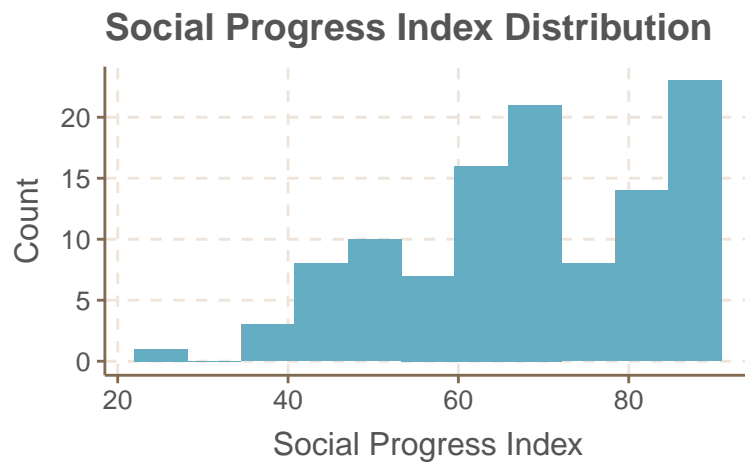
### *Descriptive Statistics and Visualizations*

First, exploring the Human Development Index variables:



minimum	q1	median	mean	q3	maximum	sd
0.4053	0.6527	0.7722	0.7446	0.8673	0.9512	0.15

Exploring the Social Progress Index data:



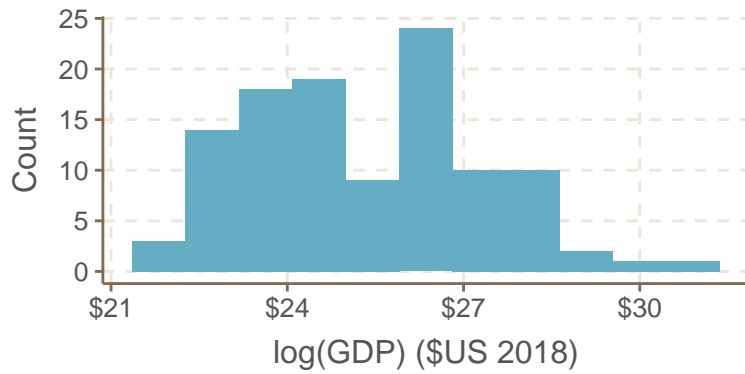
minimum	q1	median	mean	q3	maximum	sd
26.92	58.42	68.94	68.6235	82.37	89.62	15.3807

Next, exploring GDP by summary statistics:

minimum	q1	median	mean	q3	maximum	sd
2101	20228.98	73000.98	650859.6	380937.5	18624500	2138824

Taking the log transform and plotting:

## Gross Domestic Product Distribution, Log Transform



minimum	q1	median	mean	q3	maximum	sd
21.4657	23.7304	25.0137	25.3227	26.6656	30.5555	1.9419

Exploring the World Happiness Report data:

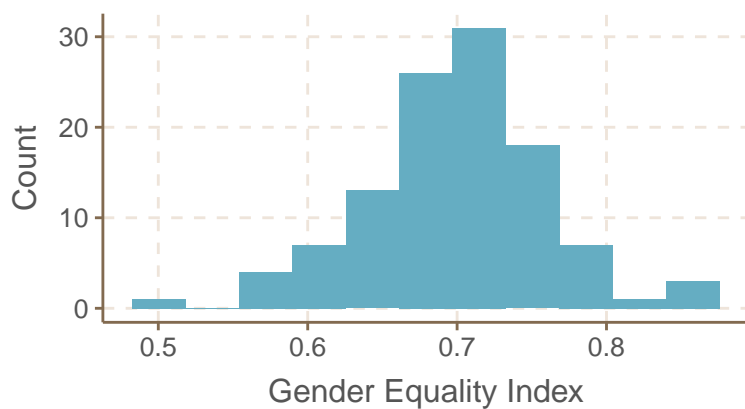
## Happiness Score Distribution



minimum	q1	median	mean	q3	maximum	sd
2.9027	4.6236	5.5778	5.5532	6.3388	7.6598	1.1395

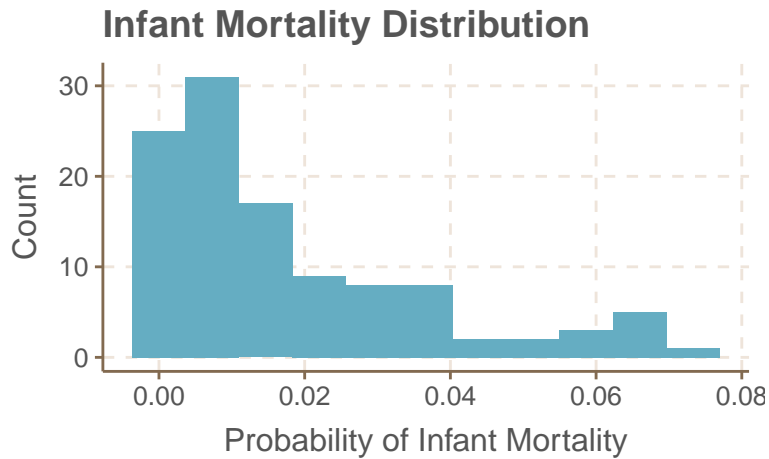
Exploring the gender equality index data:

## Gender Equality Index Distribution



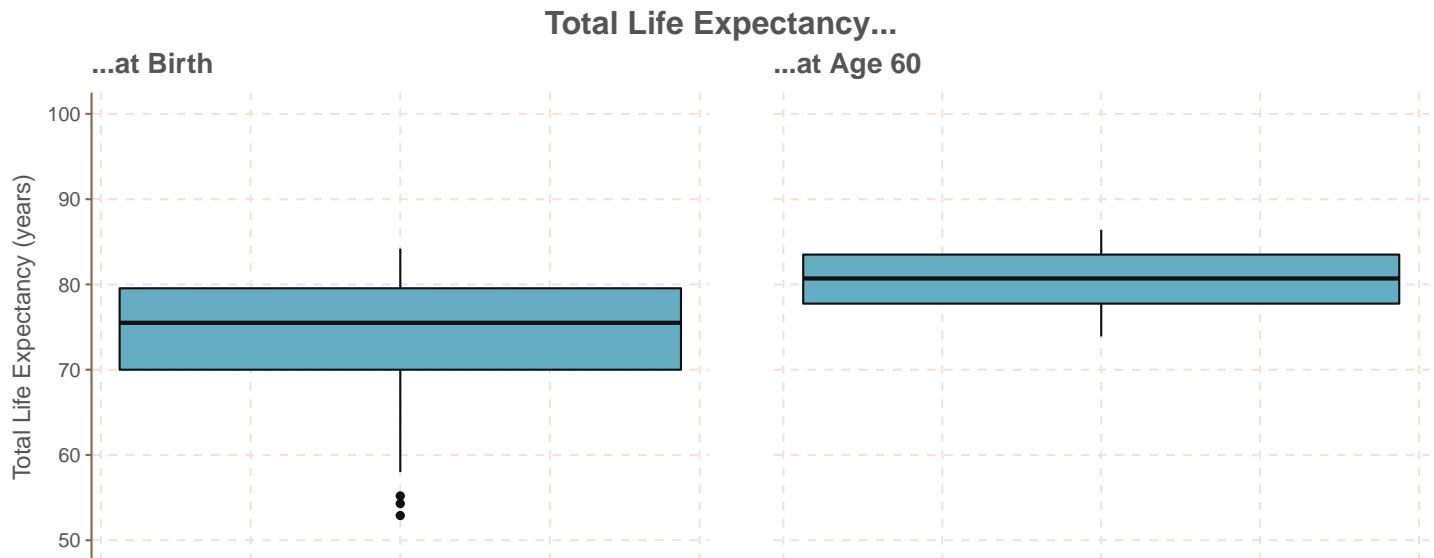
minimum	q1	median	mean	q3	maximum	sd
0.5162	0.6694	0.6999	0.699	0.7347	0.8737	0.0596

Exploring the WHO infant mortality rate data:



minimum	q1	median	mean	q3	maximum	sd
0.0017	0.0038	0.0108	0.0178	0.0273	0.075	0.0185

Exploring the WHO life expectancy data:

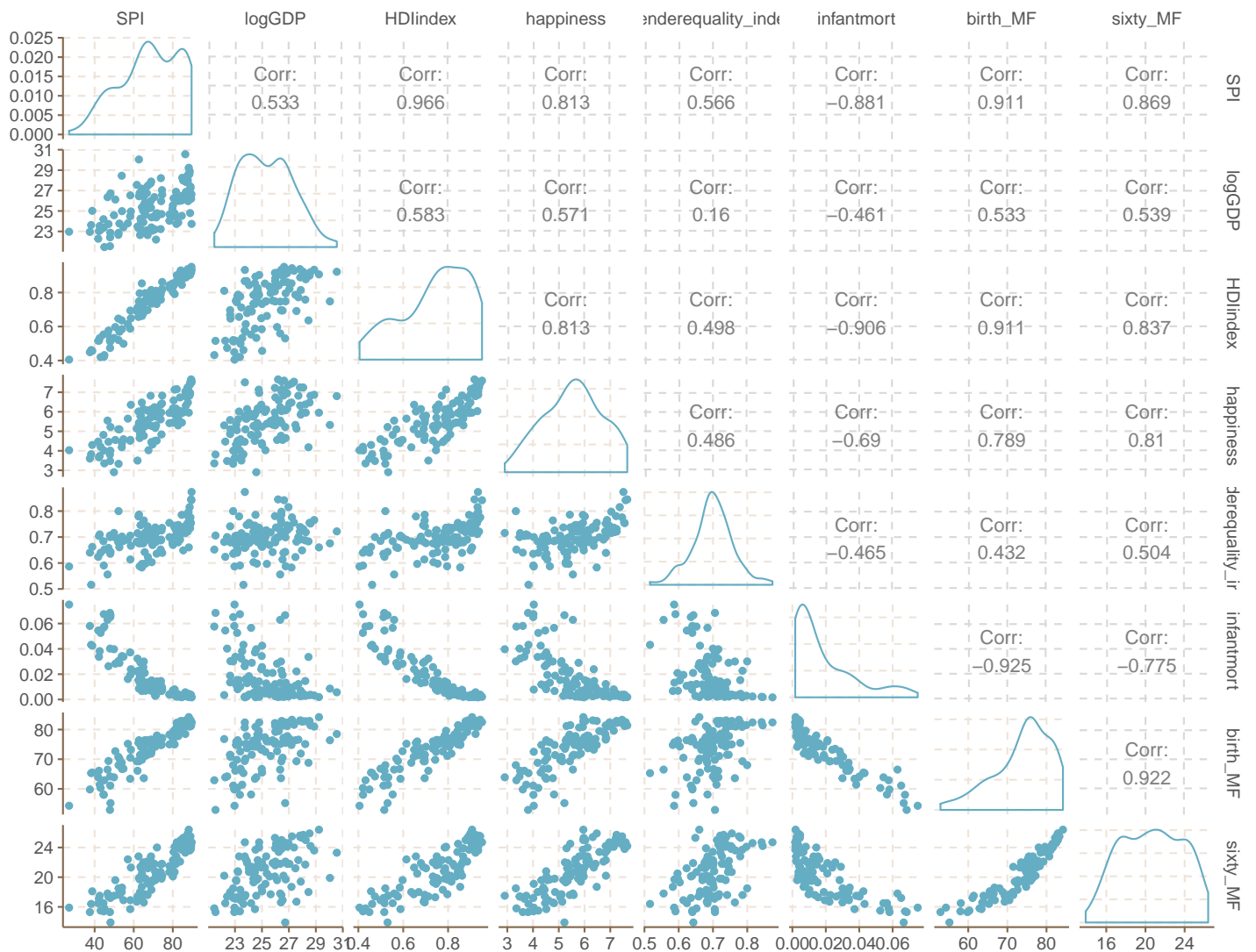


minimum	q1	median	mean	q3	maximum	sd
52.9	70	75.5	73.9586	79.55	84.2	7.2699

minimum	q1	median	mean	q3	maximum	sd
13.9	17.75	20.7	20.6622	23.5	26.4	3.107

Investigating pairwise relationships between continuous variables:

## Correlation Matrix, Continuous Variables



Strong positive linear relationships are seen between HDIindex and SPI, happiness, and birth\_MF; between SPI and happiness, birth\_MF, and sixty\_MF; and between happiness and sixty\_MF. Additionally, strong positive relationships that are possibly nonlinear are seen between HDIindex and sixty\_MF, and between birth\_MF and sixty\_MF.

Strong negative relationships are seen between infantmort and birth\_MF, between HDIindex and infantmort, and between SPI and infantmort, though the latter two of these may not necessarily be linear. A strong negative nonlinear relationship is seen between infantmort and sixty\_MF.

### *Hypothesis #1:*

## References

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