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DETERMINING THE RELATIONSHIP BETWEEN HAPPINESS AND HUMAN DEVELOPMENT: MULTIVARIATE STATISTICAL APPROACH

Dilek MURAT*

Sevda GÜRSAKAL†

Uludağ University, Bursa

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Abstract

It has been understood that it is not enough to consider just certain macro-economic indicators to determine the development level of countries. Human Development Index (HDI), which is a part of the Human Development Report (HDR) published by United Nations Development Programme (UNDP) is a complex index prepared for this end with a focus on education and health as well as income. Yet, once it was realized that this index had certain limitations, some other indices were created. Happy Planet Index (HPI), which was first used by New Economic Foundation (NEF) in 2006, is one of these indices. In this study, canonical correlation analysis, a multivariate statistical method was applied to examine the relation between HDI and HPI calculated for 150 countries. The empirical findings of the study have revealed that there is a very strong and meaningful canonical relation between HDI and HPI.

Keywords: Human Development Index, Happy Planet Index, Multivariate Statistical Method, Canonical Correlation Analysis

Jel Code: C01, C40, I20, I30

* dilekm@uludag.edu.tr (Corresponding author)
† sdalgic@uludag.edu.tr

MUTLULUK VE İNSANİ GELİŞMİŞLİK ARASINDAKİ İLİŞKİNİN BELİRLENMESİ: ÇOK DEĞİŞKENLİ İSTATİSTİKSEL YAKLAŞIM

Özet

Ülkelerin gelişmişlik düzeylerinin belirlenmesinde yalnızca belirli makro-ekonomik göstergelerin dikkate alınması yeterli olmadığı anlaşılmıştır. Birleşmiş Milletler Kalkınma Programı (UNDP) tarafından yayımlanan İnsani Gelişmişlik Raporu (HDR)'de yer alan İnsani Gelişmişlik Endeksi (HDI) bu amaçla geliştirilen gelirin yanı sıra eğitim ve sağlık verilerini de göz önüne alan bileşik bir endekstir. Ancak bu endeksin belirli sınırlılıklarının fark edilmesiyle birlikte farklı bir takım endeksler hesaplanmaya başlanmıştır. Yeni Ekonomi Kurumu (NEF) tarafından ilk kez 2006 yılında hesaplanan Mutlu Gezegen Endeksi (HPI) bu endekslerdendir. Çalışmada seçilen 150 ülke için hesaplanan HDI ve HPI arasındaki ilişkiler çok değişkenli istatistiksel yöntemlerden kanonik korelasyon analizi ile araştırılmıştır. Çalışma sonucunda elde edilen ampirik bulgulardan HDI ve HPI arasında oldukça anlamlı ve güçlü bir kanonik ilişki olduğu saptanmıştır.

Anahtar Kelimeler : İnsani Gelişmişilik endeksi, Mutlu Gezegen Endeksi, Çok Değişkenli İstatistiksel Metod, Kanonik Korelasyon Analizi.
Jel Kodu : C01, C40, I20, I30

1. INTRODUCTION

For a long period after the World War II, the development levels of countries were determined via certain macro-economic parameters. In this period, economists mostly concentrated on income and production growth. However, after 1960s, it was understood that a high increase in the national income of countries was an insufficient indicator for development. Thus, economists started to handle the concept of development in a broader framework without limiting the term to growth. This made it necessary to redefine the concept of development. Development was to be interpreted not only through economic growth but also using different measurement techniques. Even today it is hard to provide an accurate definition for development, but the literature offers diverse indicators to measure it (Gökdemir and Veenhoven, 2014: 340-341).

Amartya Sen, who was awarded the Nobel Prize in economics in 1998, developed the capability approach, on which Human Development Index (HDI) was based. This index was further improved by United Nations Development Programme (UNDP) and it has, thus, been calculated since 1990. HDI is formed on a very minimal listing of capabilities, with a special focus on reaching a basic quality of life, which can be calculated through available statistics, in a way that the Gross National Product (GNP) or Gross Domestic Product (GDP) failed to obtain (Sen, 2005: 159). In fact, recent UNDP reports have been diverting attention away from mechanical indicators like GNP or GDP and concentrating on measurements that reflect the well-being and freedom levels of countries more realistically. With its imperfect data, HDI tries to reveal a complex reality in a compact way. It has its own limitations, though (Anand and Sen, 1995: 1). In order to overcome the limitations of HDI, other indices such as Gender Inequality Index (GIE), Inequality Adjusted Human Development Index (IHDI) and Multidimensional Poverty Index (MPI) have been developed, too.

Happy Planet Index (HPI) is one of the indices that have been developed to make up for the limitations and deficiencies of HDI. HPI was first introduced by the New Economic Foundation (NEF) in 2006 as an index of human well-being and ecological efficiency (Marks et al., 2006: 2). What HPI measures is not the happiness, development, or environmental friendliness of a nation. It rather combines all three to measure the "provision of long-term well-being without exceeding the limits of equitable resource consumption". Essentially, HPI measures the ecological efficiency with which nations deliver human well-being (Marks et al., 2006: 8). A relatively new indicator, HPI has been the subject of few academic studies. So far, most research has centered on the link between HPI and conventional economic, social and political indicators as well as any lead-lag relationship it may have with other indicators (Abidin et al., 2013: 1236). In fact, HPI has been examined only in a few academic papers as opposed to HDI, which has been studied by many scholars. The studies that handle HDI and HPI simultaneously are not so common, either. This paper covers some of the limited number of studies, which have looked into HDI and HPI together.

Lang (2012) used three different measures of national happiness to build three regression models. In this study, life satisfaction, which is used as the dependent variable in these three models, was measured according to HPI, World Database of Happiness and Satisfaction with Life Scale. The independent variables in this study are GINI index values (GINI), HDI, Ethnic Group Diversity Percentages (Ethnic), Corruption Perceptions Index Values (Corruption), Unemployment Values (Unemploy) and Average Precipitation Values (AvgPre). All three models have pointed out that plentiful precipitation is a contributing factor in happiness. Two of the models have indicated that low corruption, a high HDI, and low unemployment are also important factors. One model has found out a positive relationship between national happiness and a more equal income distribution. All three models have shown that there is a linear and positive relation between HDI and life satisfaction.

Pillarisetti and Van Den Bergh (2013) have attempted to identify sustainable nations from five aggregate indices in their paper. For this purpose, they examined some index data including HDI and HPI using various graphical techniques and statistical correlation analysis. Their analysis revealed that there is a significant and positive correlation between HDI and HPI.

Focusing on EU countries, Gonda and Rozborilova (2013) carried out a study to identify the problems related to the long term revaluation of the importance of economic growth, and underestimation of the importance of prosperity as well as the comparison of the values of indicators of economic growth and prosperity. Their purpose is to justify the need for modifications to their perception, specify their interdependence and find out the primary determinants that might play a positive role in ensuring sustainable economic growth rate, and increase the level of prosperity existing difficult conditions. The 28 EU countries examined to this end were listed based on their Legatum Prosperity Index, HPI and HDI scores.

Schepelmann et al. (2010) emphasize that "Economic performance is generally being measured through GDP (Gross Domestic Product), a variable that has also become the de facto universal metric for "standards of living". However, GDP does not properly account for social and environmental costs and benefits". Therefore, one must move beyond GDP so as to measure "progress, wealth and well-being" effectively. Such an effective measurement necessitates clear and multidimensional indicators which show the links among a community's economy, environment and society. In line with this purpose, some alternative progress indicators including but not limited to HDI and HPI have been examined. Several alternative progress indicators have been examined in this study with the help of SWOT analyses. In fact, SWOT analyses make it possible to assess the internal strengths and weaknesses in addition to external opportunities and threats of each indicator, which is eventually necessary to go beyond GDP.

The aim of this study is to determine the relation between HPI, which is a part of the HDR published by UNDP and the HPI in the report published by NEF. To that end, 2012 data collected for 150 countries were analyzed using canonical correlation analysis, which is one of the multivariate statistical techniques. It has been observed there are only a few studies that have focused on the analysis of these two important indices through multivariate statistical analyses. Therefore, it is thought that this study will contribute to the literature.

1.1. Human Development Index (HDI)

The Human Development Index was first introduced in 1990 as an alternative to GDP. The reason for creating such an alternative index is that income level itself does not suffice to fully understand the concept of human development. HDI specified the term human development and operationalized it combining health, education and income under a composite index (Aguna & Kovacevic, 2011: 1). HDI was rapidly welcomed by most countries, which shows that all over the world there was a desire to understand whether, how and why people are doing better (Human Development Report, 2014: 27). HDI has been an important measure of progress. It is a complex index of life expectancy, years of schooling and income.

Human Development Report presents HDI values for 187 countries and global HDI was 0.702 in 2014. All countries included in the HDI are classified into one of four clusters of achievement in human development. HDI classifications are based on HDI fixed cut-off points, which are obtained from the quartiles of distributions of component indicators. In low human development, the cut-off points are less than 0.550. In medium human development 0.550–0.699, in high human development 0.700–0.799, and the cut-off points are 0.800 or greater in very high human development (Human Development Report, 2014: 156). In 2014, the lowest regional HDI values were found to be in Sub-Saharan Africa (0.502) and South Asia (0.588), and the highest was found to be in Latin America and the Caribbean (0.740), closely followed by Europe and Central Asia (0.738) (Human Development Report, 2014: 33).

HDI is a summarized measure of achievements in key dimensions of human development. These are a long and healthy life, access to knowledge and a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions (Klugman, 2011: 168). HDI can be calculated in two steps. First, dimension indices are created. Minimum and maximum values (goalposts) are set to transform the indicators expressed in different units into indices between 0 and 1 (Technical Notes, 2014: 2). Equations for the dimension indices are calculated as follows:

$$I_H = \frac{le - le_{min}}{le_{max} - le_{min}} \tag{1}$$

$$I_E = \left(\left(\frac{mys - mys_{min}}{mys_{max} - mys_{min}} \right) \times \left(\frac{eys - eys_{min}}{eys_{max} - eys_{min}} \right) \right)^{1/2} \tag{2}$$

$$I_I = \frac{\ln(gni) - \ln(gni_{min})}{\ln(gni_{max}) - \ln(gni_{min})} \tag{3}$$

The Health dimension I_H is calculated using life expectancy (le). The Education dimension, I_E is based on mean years of schooling (mys) and expected years of schooling (eys). The Income dimension I_I is calculated using Gross National Income (gni). The HDI is calculated as the geometric mean of the three dimensional indices:

$$HDI = (I_H * I_E * I_I)^{1/3}$$

HDI is a summary measure of the average achievements in a country in three basic dimensions of human development. The criticism of HDI has mostly been about the more technical issues of data quality and the transformation processes. HDI has received some deeper criticism, too. For example, some point out that HDI has never covered an environmental or consumption-based component although the UNDP has sometimes suggested that such components be a part of HDP. In fact, UNDP has done more than mere suggestion. It has also investigated the possibility of doing so. Therefore, it can be said that HDI cannot be the only index of sustainable development in the same way as it is for the UNDP’s vision of human development (Morse, 2004: 7).

HDI overlooks the environment and in particular the relationship between environmental impact of country development and actual development of country. The Report of NEF (New Economics Foundation) and The (Un) Happy Planet Index (July 2006) are more advanced alternatives to HID (Codruta et al., 2011: 198).

1.2. Happy Planet Index (HPI)

Happy Planet Index (HPI) tells us how successful nations are in supporting their inhabitants to lead good lives while ensuring that next generations can do the same (sustainable well-being for all) in the future.

HPI is one of the first measures of sustainable well-being used worldwide. It uses global data on experienced well-being, life expectancy, and ecological footprint to produce an index showing which countries are best at offering long and happy lives for their inhabitants while maintaining the same conditions for future generations so that they can do the same (Abdallah, 2012: 3).

The HPI was created by Nic Marks, founder of the Centre for Well-being at the NEF. The HPI was first published in July 2006 by the NEF with its second edition in 2009 and the third in 2012 (Singh, 2014: 802). The HPI scores range from 0 to 100. High scores can only be achieved when all three targets mentioned in the index – high life expectancy, high life satisfaction, and a low ecological footprint- are fulfilled (Abdallah, 2009: 3). The HPI incorporates experienced well-being (measured based on happy life years, which is a result of life expectancy and life satisfaction multiplied together) and resource consumption (measured based on ecological footprint) (Mally, 2011: 73). HPI is calculated as follows:

$$HPI \approx \frac{wb \times \mathrm{le}}{\mathrm{fp}} \tag{4}$$

wb denotes experienced well-being, le expresses life expectancy and fp refers to ecological footprint in HPI equation. This simple headline indicator shows whether a society is heading in the right direction or not. It is a vital tool to ensure that fundamental issues are taken into consideration in crucial policy decisions.

When the HPI report was being prepared, national performance in each of the three component indicators (life expectancy, experienced well-being, and ecological footprint) and combined score of the components were mapped out in a way to highlight the top and bottom countries in 2012. The maps reveal that the warning lights are much brighter than ever before – no country can achieve bright green in the HPI map, which is an indicator of good performance in all three components. Indeed, there are only nine countries in the second-best category (light green). Eight of them are in Latin America and the Caribbean. Two are classified in very high development by the UN (Argentina and Chile), five in high development (Mexico, Costa Rica, Panama, Jamaica, and Belize), and two in medium development (Vietnam and Guatemala) (Abdallah, 2012: 10). Considering the overall HPI ranking, Costa Rica has the first highest (64.0) HPI scores while Vietnam has the second highest (60.4) HPI scores and Colombia has the third highest (59.8) HPI scores. Botswana (22.6), Chad (24.7) and Qatar (25.2) also have the lowest HPI scores respectively.

Amongst the top 40 countries listed by overall HPI score, only four countries have a GDP per capita of over $15,000.35. The highest ranking Western European nation, Norway is 29th just following New Zealand ranking 28th. The USA ranks 105th position out of 151 countries (Abdallah, 2012: 10).

HDI was calculated based on the data of 187 countries whereas HPI was calculated based on the data of 151 countries. Yet, to establish quantitative balance between these two sets of data, 37 countries, whose HPI values had not been calculated, were excluded from HDI calculations and 1 country, whose HDI value had not been calculated, was excluded from HPI calculations. As a result, the data of 150 countries were used in the analysis.

2. Data Sets and Method

This study is based on Human Development Index (HPI), which is a part of the Human Development Report (HDR) published by UNDP, and Happy Planet Index (HPI). Thus, the link between the sub-indices composing HDI -Life Expectancy at Birth (LEB), Mean Years of Schooling (MYS), Gross National Income (GNI)- and the sub-indices composing HPI- Well-Being (WB), Happy Life Years (HLY) and Footprint (FP)- was analyzed. The data are retrieved from UNDP’s 2012 data. The data of the 150 countries examined in this study are attached to this study. The variables which were subject to the analysis can be defined as follows:

Human Development Index (HDI): A composite index measuring average achievement in three basic dimensions of human development—a long and healthy life, knowledge and a decent standard of living.

Life expectancy at birth (LEB): Number of years a newborn infant could expect to live if prevailing patterns of age-specific mortality rates at the time of birth stay the same throughout the infant's life.

Mean years of schooling (MYS): Average number of years of education received by people aged 25 and older, converted from education attainment levels using official durations of each level.

Gross national income (GNI) per capita: Aggregate income of an 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 PPP rates, divided by midyear population.

Happy Planet Index (HPI): It is measured through the number of Happy Life Years achieved per unit of resource use. This is calculated approximately by dividing Happy Life Years by Ecological Footprint. ('Approximately' because there are some adjustments to ensure that all three components – experienced well-being, life expectancy and Ecological Footprint – have equal variance so that no single component dominates the overall Index).

Well-Being (WB): Experienced well-being is assessed using a question called the 'Ladder of Life' from the Gallup World Poll.23 This asks respondents to imagine a ladder, where 0 represents the worst possible life and 10 the best possible life, and report the step of the ladder they are currently standing on.

Happy Life Years (HLY): It has combined life expectancy and experienced well-being in a variation of an indicator called Happy Life Years, developed by sociologist Ruut Veenhoven.

Footprint (FP): This is a measure of how much land is available to produce the resources and services whose consumption is measured by the Footprint. Both the Ecological Footprint and bio capacity are measured in terms of global hectares (g ha), which represent a hectare of land with average productive bio capacity.

2.1. Canonical Correlation Analysis (CCA)

The method which assesses the bilateral relation between two variables (x and y) through r_{xy} correlation coefficient is called simple correlation analysis. The method which assess the relations between one dependent variable (y) and two or more independent variables ($x_1, \mathrm{x}_2, \ldots\ldots\ldots x_p$) is called multiple correlation analysis. Developed by Hotelling in 1936, CCA, however, can be defined as a multivariate method which assesses the relation between two sets of variables $(x_1, \mathrm{x}_2, \ldots\ldots\ldots x_p;\ \mathrm{y}_1, \mathrm{y}_2, \ldots\ldots\ldots y_q)$ that include two or more variables through linear combinations. In canonical correlation, one linear combination with maximum correlation and unit variance is obtained for each set of variables. After that, independent of this pair, another linear combination with maximum correlation and unit variance is obtained. This operation is continued until new linear combination pairs are obtained in the same number as the number of variables in the set with fewer variables (Tatlıdil, 2002: 217).

Most of the dependence methods are a special form of CCA, which is a holistic method. If CCA has only one dependent variable, CCA turns into *multiple regression analysis.* In other words, CCA is the generalized version of the multiple correlation analysis used in *multiple regron analysis* (Johnson, 1998: 494). If only one dependent and independent variable is used in the analysis, then it turns into *simple correlation analysis.* If the dependent variables are dummy variables representing multiple groups, the analysis is reduced to *multiple-group discriminant analysis.* If predictor variables are dummy variables representing the groups formed by various factors, the analysis is reduced to "*MANOVA analysis*" (Sharma, 1996: 409).

2.1.1. Covariance and Correlations of Data Sets

The shared data matrix of X(1) and X(2) sets will be a matrix of n serial and p+q column $(p \leq q)$ based on the assumption that there is an X(1) data matrix with p variables (px1) obtained out of n units and that there is an X(2) data matrix with q variables (qx1). X(1) μ_1 has an average vector and Σ_{11} covariance matrix, and , X(2) has an μ_2 average vector and Σ_{22} covariance vector. The covariance vector between X(1) and X(2) is calculated as follows:

$$\sum_{(p+q)\times(p+q)} = E(X-\mu)(X-\mu)'$$

$$= \begin{bmatrix} E(X(1)-\mu_1)(X(1)-\mu_1)' & E(X(1)-\mu_1)(X(2)-\mu_2)' \\ E(X(2)-\mu_2)(X(2)-\mu_2)' & E(X(2)-\mu_2)(X(2)-\mu_2)' \end{bmatrix}$$

$$= \begin{bmatrix} \underset{p\times p}{\Sigma_{11}} & \underset{p\times q}{\Sigma_{12}} \\ \underset{q\times p}{\Sigma_{21}} & \underset{q\times q}{\Sigma_{22}} \end{bmatrix} \tag{5}$$

(Johnson & Wichern, 1998: 588). In Equation one, $p \times p$ refers to the covariance matrix of the variables in Σ_{11} X(1) set; $p \times q$ refers to the covariance matrix of the variables in $\Sigma_{12} = \Sigma_{21}'$ X(1) and X(2) sets and $q \times q$ refers to the covariance matrix of the variables in Σ_{22} X(2) set. Similarly, the correlation matrix of the variables in X(1) is Σ_{11} while the correlation matrix of variables in X(2) set is Σ_{22} . As to the correlation matrix of the variables in X(1) and X(2), it is $\Sigma_{12} = \Sigma_{21}'$. Therefore, it is possible to calculate $1/2p(1-p)$ correlations in X(1), $1/2q(1-q)$ correlations in X(2) and $p \times q$ correlations between the two sets. Instead of interpreting these correlations, CCA aims to measure the relation between the variable sets by explaining $p \times q$ elements with fewer elements. To this end, two new variables are calculated for each set. These variables, which are called canonical variables, are calculated through linear combinations. It is through these variables that the canonical correlations are between the variables of the two sets are calculated (Özdamar, 2004: 424). Thus, CCA focuses on the correlation between the linear combinations of the variable sets in question (Johnson & Wichern, 1998: 587).

2.1.2. Canonic Variables and Canonical Correlations

The two sets of variables in question can be expressed with variables called canonical variables in linear combinations:

$$V = a'\,\mathrm{X}(1);\; W = b'\,\mathrm{X}(2) \tag{6}$$

In Equation 2, a and b refer to coefficient vectors. The variance and covariance of V and W canonical variables are as follows:

$$Var(V) = a'\ \mathrm{Cov\ X(1)\ a} = a'\ \Sigma_{11}\ a \tag{7}$$

$$Var(W) = b'\ \mathrm{Cov\ X(2)\ b} = \mathrm{b}'\ \Sigma_{22}\ b \tag{8}$$

$$Var(V,\ \mathrm{W}) = a'\ \mathrm{Cov\ (X(1), X(2))\ b} = a'\ \Sigma_{12}\ b \tag{9}$$

The canonical correlation between V and W canonical variables is calculated as follows:

$$r(V,\ \mathrm{W}) = \frac{a'\ \Sigma_{12}\ b}{\sqrt{(a'\ \Sigma_{11}\ a)\ (b'\ \Sigma_{22}\ b)}} \tag{10}$$

To maximize the correlations between V and W canonical variables, it is necessary to find the correlation coefficient in which a and b coefficient numbers are maximum. Canonical variable pairs which have unit variance are the values that maximize the correlation. The correlation between each canonical variable pair is called canonical correlation. The maximum number of canonical variable pairs that can be produced in CCA is equal to the lower of the variables (k=min(p, q)) in the two variable set (Yıldırım et al., 2011: 9).

2.1.3. The Importance of Canonical Correlations

Since one of the objectives of CCA is dimension reduction, it is necessary to identify how many of the canonical variable pairs are important. In other words, it is required to identify how many variable groups can be used. Therefore, before interpreting the canonical variables and canonical correlations, it is required to determine their statistical significance (Sharma, 1996: 402).

Although there are so many methods used to this end, the most common two methods are Wilks' Lambda (Wilks' Λ) and Roy's Eigenvalue, which are also known as Bartlett test. In Roy's Eigenvalue, which is based on the graphics developed by Heck, the graphics cannot be found in all sources and the critical values obtained from the graphics are not definite but approximate. Because of this, this technique is not so common (Tatlıdil, 2002: 227).

The most popular technique used for determining statistical significance is Wilks' Lambda. In this technique, in order to determine how many of the canonical correlation pairs can be considered significant, the following hypotheses are tested:

$H_0 : \Sigma_{12} = 0$ veya $\rho_1 = \rho_2 = ... = \rho_p = 0$

$H_a :$ En az bir $\rho_i \neq 0$

If the null hypothesis is rejected, the biggest coefficient is excluded from the hypothesis. These operations are repeated until the null hypothesis is accepted. Wilks' Λ test statistics used in the test is calculated as follows:

$$\Lambda = \prod_{i=1}^{p}(1-r_i^2) \qquad (11)$$

L test is calculated using this coefficient:

$$L = -\left[n-1-1/2\ (p+q+1)\right]\ \ln \Lambda \qquad (12)$$

L test shows a χ^2 distribution with $p \times q$ degrees of freedom. In Equation 6, n refers to sample size; p refers to the number of variables in the first set; q refers to the number of variables in the second set; r_i refers to canonical correlations and k refers to the number of canonical correlations (k=min(p, q)). If L test statistics is found significant when compared to $\chi^2_{(p\times q;\ \alpha)}$ value, in other words if the null hypothesis is rejected, the biggest canonical correlation is excluded from the test and the test is repeated with other canonical correlations (Özdamar, 2004: 430). In this situation, Wilks' Λ test statistics for i=2, 3,…,p is as follows:

$$\Lambda_1 = \prod_{i=2}^{p}(1-r_i^2) \qquad (13)$$

L_1 test statistics

$$L_1 = -\left[n-1-1/2\ (p+q+1)\right]\ \ln \Lambda_1 \qquad (14)$$

shows χ^2 distribution with $(p-1)\times(q-1)$ degrees of freedom. These operations are repeated until an insignificant L_i value is obtained. The significance of L_i statistics should without doubt be assessed based on the critical values of χ^2 distribution with $(p-1)\times(q-1)$ degrees of freedom.

2.1.4. Redundancy Analysis

Even small canonical correlations might be significant for large sample sizes. Besides, large canonical correlations might not always mean that the correlation between the variable sets is strong. The reason for this is that canonical correlation maximizes the correlation between the linear composites of variable sets rather than the amount of the variance explained by another variables set. Therefore, in order to determine the level at which a variable set is explained by another variable set, the redundancy measure (RM) suggested by Stewart and Love (1968) was used (Sharma, 1996: 404-405). RM can be calculated for each canonical correlation. RM is calculated in two steps in order to understand at what level the X (1) variables can explain the X(2) variables for RM_{V_i/W_i}, i. canonical relation ρ_i.

V_i value, which shows the average variance explication amount in X(2) variables and which is equal to the average of the squared loadings of X(2) variables, can be calculated as follows:

$$AV(X(2)/V_i) = \sum_{j=1}^{q} L_{ij}^2 / q \qquad (15)$$

$AV(X(2)/V_i)$ in Equation 15 shows the average variance explained by V_i canonical variable in X(2) variables and L_{ij} shows j. canonical loading of the X(2) variables on i. canonical variables. ρ_i^2 gives us the shared variance between V_i and W_i canonical variables. Therefore, based on average variance and shared variance, RM is calculated as follows:

$$RM_{V_i/W_i} = AV(X(2)/V_i) \times \rho_i^2 \qquad (16)$$

3. Results

In this study, in which primary data were used, the sub-indices of HDI were accepted as the first set while the sub-indices of HPI were accepted as the second set. In this part of the study, the canonical relation between the sets in question was examined. The data included in the analysis can be seen in Appendix 1. The descriptive statistical values calculated for the variables in the first stage are summarized in Table 1.

Table 1. Descriptive Statistics for the Variables

	Mean	Std. Dev.	Minimum	Maximum	Range
HDI	0.69	0.16	0.33	0.94	0.61
LEB	70.77	8.99	45.60	83.60	38.00
MYS	8.03	3.15	1.30	12.90	11.60
GNI	44.59	135.60	1.01	873.00	871.99
HPI	42.34	9.08	22.60	64.00	41.40
WB	5.41	1.17	2.80	7.80	5.00
HLY	45.61	11.61	24.30	66.50	42.20
FP	3.05	2.16	0.54	11.68	11.14

According to the findings, in the countries included in the study, Life Expectancy at Birth (LEB) is mean 70.77 year, Mean Years of Schooling (MYS) is mean 8.03 year, Gross National Income (GNI) per capita is mean 44.59 $, Well-Being (0-10) (WB) is mean 5.41, Happy Life Years (HLY) is mean 45.61 and Footprint (FP) is 3.05 gha/capita. It is striking that the standard deviation and range values of GNI, HLY and LEB variables are high. These show that GNI, HLY and LEB might greatly change from country to country. The countries included in the study are classified in four groups as very high human development, high human development, medium human development and low human development based on their HDI and HPI values. Given that, the findings are compatible with the expectations. HDI scores are in 0-1 range and HPI scores are in 0-100 range. In our country, the value for HDI is 0.759 and the value for HPI is 47.6. Turkey ranks 69th in the HDI list of 187 countries and is, thus, included in the high development group. In HPI list of 151 countries, however, it ranks 44th.

Before canonical analyses, the correlation link between the sets was examined and the findings are given in Table 2. The sets are expected to produce meaningful correlations within themselves.

Table 2. The Correlations between the Sub-Indices of HDI and HPI Variables

	HDI (Human Development Index)			HPI (Happy Planet Index)		
	LEB	MYS	GNI	WB	HLY	FP
LEB	1.0000	0.7610*	-0.2606*			
MYS	0.7610*	1.0000	-0.2403*			
GNI	-0.2606*	-0.2403*	1.0000			
WB				1.0000	0.9358*	0.6714*
HLY				0.9358*	1.0000	0.7038*
FP				0.6714*	0.7038	1.0000

*Correlation is significant at the 0.01 level (2-tailed).

Table 2 shows that there are meaningful correlations at 0.01 significance level between the sub-indices of HDI and HPI variable, which is in line with the expectations. As it can be seen in the table, the correlations can be both negative and positive.

Table 3. Correlations Between HDI and HPI Variable Sets

	HDI (Human Development Index)			HPI (Happy Planet Index)		
	LEB	MYS	GNI	WB	HLY	FP
LEB	1.0000					
MYS	0.7610**	1.0000				
GNI	-0.2606**	-0.2403**	1.0000			
WB	0.7176**	0.6409**	-0.1270	1.0000		
HLY	0.9002**	0.7513**	-0.1952*	0.9358*	1.0000	
FP	0.6116**	0.6274**	-0.0397	0.6714**	0.7038**	1.000

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

The correlations between the sets can be seen in Table 3. According to the findings, there are meaningful and positive relations between the variable LEB and variables WB, HLY and FP and also between the variable MYS and variables WB, HLY and FP. While there is no meaningful relation between the variable GNI and variables WB and FP, there is a meaningful and negative relation between the variable GNI and the variable HLY.

Table 4. Canonical Correlations between HDI and HPI Variable Sets

Canonical Correlations	Wilk's Lambda	Chi-Square	df	Sig.
0.968	0.055	422.292	9.000	0.000
0.344	0.882	18.297	4.000	0.001
0.010	1.000	0.014	1.000	0.907

While determining the number of canonical correlations to be calculated, the number of the variables in each set is taken into consideration. The minimum number of variables in the sets gives us the maximum number of canonical correlations (k=min (p, q)). Because there are three variables in both sets, there are three canonical correlations. In order to interpret the canonical correlations, first the significance of the coefficients needs to be tested. The findings related to Wilk's Lambda approach to be used for this purpose and the canonical correlations already calculated are summarized in Table 4. Given the values in the table, it can be said that the first and second canonical correlations are statistically meaningful at 0.01 significance level.

Table 5. Redundancy Analysis

Proportion of Explained Variance of HDI				Proportion of Explained Variance of HPI			
by its own canonical variable		by opposite canonical variable		by its own canonical variable		by opposite canonical variable	
CV1-1	0.561	CV1-1	0.526	CV2-1	0.616	CV2-1	0.578
CV1-2	0.157	CV1-2	0.018	CV2-2	0.245	CV2-2	0.029
CV1-3	0.283	CV1-3	0.000	CV2-3	0.139	CV2-3	0.000

Before interpreting canonical correlations and canonical variables, their significance needs to be tested. In addition to this, a redundancy analysis is recommended in order to determine how well a variable set is explained by the other as mentioned in CCA. The results of the redundancy analysis are given in Table 5. According to the table, the CV1-1 canonical variable explains 56.1% of the total variance in the first set whereas the CV2-1 canonical variable explains 61.6 % of the total variance in the second set. Besides, the CV1-1 canonical variable explains 52.6% of the total variance of the variables in the second set while the CV1-2 canonical variable explains 1,8% of the total variance of the variables in the second set. CV2-1 canonical variable explains 57.8% of the total variance of the variables in the first set while the CV2-2 canonical variable explains 2.9% of the total variance in the first set. These findings mean that the first canonical correlation coefficient is meaningful both in statistical and practical terms. However, although the second canonical correlation coefficient is found to be statistically meaningful, it is understood to be more meaningful in practical terms compared to Table 5. Therefore, it was decided to take into consideration only the first of the three canonical variable pairs.

Table 6. Canonical Loadings for HDI

	Canonical Loadings			Cross Loadings		
	CV1-1	CV1-2	CV1-3	CV1-1	CV1-2	CV1-3
LEB	-0.999	0.049	0.008	-0.967	0.017	0.000
MYS	-0.790	-0.524	-0.319	-0.765	-0.180	-0.003
GNI	0.246	-0.44	0.864	0.239	-0.151	0.008

As it is the case with conceptually meaningful factors generated with factor analysis and the discriminant functions produced in discriminant analysis, the canonical variables generated with CCA can also be interpreted. It is possible to comment on the canonical variables found to have statistical and practical significance. Canonical coefficients, canonical loadings and cross canonical loadings, which have been standardized for this purpose, can be used. In interpreting, cross canonical loadings is used the most (Hair et al., 1998: 454).

Table 7. Canonical Loadings for HPI

	Canonical Loadings			Cross Loadings		
	CV2-1	CV2-2	CV2-3	CV2-1	CV2-2	CV2-3
WB	-0.748	-0.371	-0.55	-0.725	-0.128	-0.005
HLY	-0.934	-0.199	-0.296	-0.905	-0.068	-0.003
FP	-0.645	-0.747	0.161	-0.625	-0.257	0.002

The correlations calculated between the canonical variables which are also called canonical loadings and which are produced through variables can be seen in Table 6 and 7. Table 6 shows that the correlation between the canonical variable CV1-1 and variables LEB, MYS are GNI are respectively -0.999, -0.790 and 0.246. Table 7 shows that the correlation between the canonical variable CV2-1, which is produced for HPI variables, and variables WB, HLY and FP are respectively -0.748, -0.934 and -0.645. An examination of canonical loadings and cross canonical loadings reveals that the most important variables to define the variable CV1-1 are respectively LEB, MYS and GNI while the most important variables to define the variable CV2-1 are respectively HLY, WB and FP. Based on these findings, it was decided to name the canonical variable CV1-1 as LEB and the canonical variable CV2-1 as HLY.

4. Conclusions

This study looked into the link between HDI and HPI indices in the Human Development Report. To this end, the sub-indices of the related variables were taken into consideration and the CCA technique was applied to the data. At the first stage, the correlations within the sets themselves were examined and it was observed that the variables in both sets produced meaningful correlations within themselves, which was in parallel with the expectations. Second, the correlations between the sets were calculated and it was seen that there was a meaningful and positive relation between the variable LEB and variables WB, HLY and FP as well as the variable MYS and variables WB, HLY and FP. Moreover, no meaningful relation was found between the variable GNI and variables WB and FP, but a meaningful and negative relation was found between GNI and HLY. Based on these findings, it can be deduced that if there is an increase in Life Expectancy at Birth (LEB) and Mean Years of Schooling (MYS) in the related countries, there will also be an increase in the Well-Being (WB), Happy Life Years (HLY) and Footprint (FP) variables. Likewise, there is no meaningful relation between the Gross National Income (GNI) and the levels of WB and FP. It has also been found that any increase in GNI would decrease HLY.

Three canonical correlation coefficients were calculated between HDI and HPI sets. The first two of these coefficients were found to be at 0.01 significance level. Yet, after the statistical and practical meaning of the coefficients was tested, it was found to be sufficient to interpret only the first coefficient. The analysis has revealed that there is a quite strong canonical relation between HDI and HPI sets, which is at 96.8% significance level.

An examination of canonical loadings and cross canonical loadings shows that the most important variables to define CV1-1 variable are respectively LEB, MYS and GNI while the most important variables to define CV2-1 are respectively HLY, WB and FP. According to these results, CV1-1 is called

Life Expectancy at Birth (LEB) and CV2-1 canonical variable is called Happy Life Years (HLY).

Redundancy analysis reveals that 56.1% of the total variance of the variables defining Life Expectancy at Birth (LEB) is explained by its own canonical variable and its 52.6% is explained by Happy Life Years (HLY). Similarly, 61.6% of the total variance of the variables defining Happy Life Years (HLY) is explained by its own canonical variable while its 57.8% is explained by Life Expectancy at Birth (LEB). Thus, it can be said that in both canonical variables, approximately 50% of the total variance is explained by the cross variable.

An overall examination of the data shows that there is a strong relation between HDI and HPI variables of the countries included in this study. It is observed that there is a positive relation between the development and happiness levels of the countries. The variables which contribute most to this relation are Life Expectancy at Birth (LEB) and Happy Life Years (HLY).

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