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COMPARISON OF THE ACCURACY OF THE HUMAN DEVELOPMENT INDEX WITH A DISCRIMINANT ANALYSIS IN THE MEASUREMENT OF HUMAN DEVELOPMENT

The present study aims to evaluate the success of the classification made in the Human Development Report (HDR) by means of a discriminant analysis. The report, prepared in the framework of United Nations Development Programme (UNDP), reflects the socio-economical development level of countries worldwide. The results based on the data provided in the HDR (2006) indicate that a classification done by a discriminant analysis has a great success rate.

JEL: O15

I. Human Development Index

“Development” and “progress” are related by different terms. These two concepts are among the most frequently used indicators in the comparison of countries. Before 1970s these two concepts were equated with the increase in national income and were expressed in terms of per capita income. However, the developments in 1960s have emphasized the inadequacy of this approach, and in 1970s the term has needed to be redefined. The new approach proposes a broader definition of the term “progress” by taking into account humanitarian, social, cultural, environmental, political and local variables. As a result, in addition to economic progress, poverty, unemployment, inequalities in the distribution of income and regional inequalities have been integrated into the definition of progress, which has resulted in a multidimensional and very inclusive concept.

Today the concept of progress is sometimes used synonymously with the terms “modernization”, “westernization”, “industrialization” and “urbanization”, but neither of these converges with its meaning. When developed and underdeveloped countries are compared, it appears that a level of progress satisfactory for one country is not sufficient for another country. That is why the terms poverty-wealth,

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progress, development varies from country to country and from society to society not only in terms of definition, but perception and its effects on the way of life.³

High per capita income alone is not sufficient to consider a country developed or progressed. It has been observed that in many developed countries social problems have not been completely resolved. As a consequence of this, it has become evident that the relationship between economic development and human progress should be redefined. For this purpose, United Nations Development Programme (UNDP) has published the Human Development Report (HDR) based on the Human Development Index (HDI) which reflects the level of socio-economic development of the countries at the global level in 1990 for the first time and has continued to do so each year since then. The report includes different number of countries each year and has global as well as regional and national dimensions.⁴

The HDI takes into account basic human needs such as living a long and healthy life, being educated and having a decent standard of living. Accordingly, the level of socio-economic development is measured in terms of the following indicators:⁵

- a) Prosperity Standard: Measured by purchasing power parity, PPP, income.
- b) Educational Standard: The second indicator used in the HDI is the level of education in a country. The measurement of the educational indicator is based on the following factors:
 - Adult literacy rate
 - Average length of education (Schooling Index)
- c) Health Standard: It is measured by average life expectancy.

In the HDR human progress is defined as a process of increasing individuals' options. These options could be infinite or variable. However, in all stages of progress three indicators have received prominence. These are living a long and healthy life, knowledge and being educated and having the necessary resources to live a decent life. Other options include political freedom, guaranteed human rights and personal honour. In this approach despite its importance per capita income alone has not been considered as a good indicator of human progress. In sum, in the measurement of Human Development Index the three indicators used are prosperity standard, educational standard and health standard.⁶

³ Erol Tümertekin, Nazmiye Özgüç, "Ekonomik Coğrafya. Küreselleşme ve Kalkınma", Çantay Kitabevi, İstanbul, 1999, s. 88

⁴ Birleşmiş Milletler Kalkınma Programı İnsani Gelişme Endeksi ve Türkiye Açısından Değerlendirme, <http://ekutup.dpt.gov.tr/ekonomi/gosterge/demirs/insanige.pdf>Demir

⁵ UNDP, Human Development Report, 2001, <http://hdr.undp.org/reports/global/2001/en/>

⁶ Birleşmiş Milletler Kalkınma Programı İnsani Gelişme Endeksi ve Türkiye Açısından Değerlendirme <http://ekutup.dpt.gov.tr/ekonomi/gosterge/demirs/insanige.pdf>Demir

The method of measurement used in the HDI has undergone many changes since its first publication in 1990. This was done for the purpose of measuring human development more accurately.

The countries included in the HDI are divided into three categories according to their level of development. In the first group labelled “Low Human Development” we have countries with 0-0,499 HDI value, in the second group called “Mid Human Development” are countries with 0,500-0,799 HDI value, and in the third group called “High Human Development” countries with 0,800-1 HDI value are included.⁷ Therefore, the HDI values of 0,500 and 0,800 are critical in the classification of countries.

For example, a country with 0,800 HDI value is classified as a “High Human Development” country whereas a country with a 0,799 HDI value is classified as a “Mid Human Development” country. The same could be said for the 0,500 HDI value. It could be argued that if a classification is involved, it is natural to have a critical value. However, in some cases, especially when the values are very close to the critical value, it may have negative consequences. For a more accurate classification particularly in such situations it may be useful to apply some other analytical methods. The present study proposes that the accuracy of the classification in such cases can be tested by the use of a discriminant analysis.

The present study aims to test the accuracy of the human development classification made in the HDR published in 2006 by a discriminant analysis. Another aim of the study is to start a discussion about the positive and negative consequences of the use of discriminant analysis for such a purpose.

II. Discriminant Analysis and its Application

Discriminant, or discriminant function, analysis is a parametric technique used to determine which weightings of quantitative variables or predictors best discriminate between two or more groups of cases and do so better than chance. The weightings of variables form a new composite variable, which is known as a discriminant function and which is a linear combination of the weightings and scores on these variables. The maximum number of such functions is either the number of predictors or the number of groups minus one, whichever of these two values is the smaller. For example, there will only be one discriminant function if there are either two groups or one predictor. There will be two discriminant functions if there are either three groups or two predictors. Where there is more than one discriminant function, the discriminant functions will be unrelated or orthogonal to each other. Each function will consist of all predictors, although their weight will not be the same on

⁷ D., SIRMA, *Birleşmiş Milletler Kalkınma Programı İnsani Gelişme Endeksi ve Türkiye Açısından Değerlendirme*, <http://ekutup.dpt.gov.tr/ekonomi/gosterge/demirs/insanige.pdf>, s.10.

all the discriminant functions. The accuracy of the discriminant functions in classifying cases into their groups can be determined⁸.

There are three ways of entering predictors into a discriminant analysis as there are in multiple regression. In the standard or direct method, all predictors are entered at the same time, although some of these predictors may play little part in discriminating between the groups. In the hierarchical or sequential method, predictors are entered in a predetermined order to find out what contribution they make⁹.

The data used in the analysis consist of the four indicators used in the measurement of HDI. These are:

- Life expectancy at birth,
- adult literacy rate,
- combined gross enrolment ratio,
- GDP per capita.

The 2004 values of 177 countries in total are provided in Appendix 1. The data were obtained from the HDR (2006) web site¹⁰. The reason for the use of the 2004 data is the fact that in the measurement of HDI two years earlier data are used. Therefore, in the 2006 HDR the 2004 values have been used. The data were loaded into the SPSS 13.0 statistical package and a discriminant analysis was performed.

In the discriminant analysis the stepwise method was used. In the stepwise method the variables which significantly reduce Wilk Λ are taken into the model. In each step the variable which minimises the discriminant function of Wilk Λ is considered a candidate to be taken into the model. For the inclusion of a variable in the discriminant function the p value of the F statistics should be maximum 5 %. On the other hand, for the exclusion of a variable from the discriminant function the p value of the F statistics should be minimum 10 %. In any step if no variable has been included in the discriminant function and no variable has been excluded, it means that the discriminant function has been determined.¹¹

Table 1 shows the variables included in the analysis according to the stepwise method.

⁸ Cramer, D., *Advanced Quantative Data Analysis*, Berkshire, , GBR: McGraw-Hill Education, 2003. p 203.

⁹ Cramer, D., *Advanced Quantative Data Analysis*, Berkshire, , GBR: McGraw-Hill Education, 2003. p 204.

¹⁰ Human Development Report 2006, <http://hdr.undp.org/hdr2006/statistics/>.

¹¹ Ünsal, E., Güler, H., *Türk Bankacılık Sektörünün Lojistik Regresyon ve Diskriminant Analizi İle İncelenmesi*, <http://www.ekonometridernegi.org/bildiriler/o14s2.pdf>, s.9.

Table 1 shows that in the first step the variable GDP per capita, in the second step life expectancy at birth, and in the third step adult literacy rate has entered the function. It can also be seen that the variable combined gross enrolment ratio has not entered the function. This situation is revealed in a more detail in Table 2.

Table 1
Variables included in the analysis according to the stepwise method

Step		Tolerance	F to Remove	Wilks' Lambda
1	kb_GSYIH	1.000	101.075	
2	kb_GSYIH	.997	49.814	.377
	dyb	.997	45.630	.363
3	kb_GSYIH	.984	44.314	.271
	dyb	.983	22.326	.212
	yoyo	.972	18.382	.201

Table 2
Variables excluded from the analysis according to the stepwise method

Step		Tolerance	Min. Tolerance	F to Enter	Wilks' Lambda
0	dyb	1.000	1.000	94.863	.377
	yoyo	1.000	1.000	74.846	.434
	boo	1.000	1.000	71.288	.446
	kb_GSYIH	1.000	1.000	101.075	.363
1	dyb	.997	.997	45.630	.201
	yoyo	.985	.985	40.495	.212
	boo	.911	.911	28.983	.240
2	yoyo	.972	.972	18.382	.152
	boo	.858	.858	9.657	.172
3	boo	.606	.606	.961	.149

When Table 2 is examined carefully, it can be seen that the only variable excluded from the analysis in the final third step is combined gross enrolment ratio. The Wilks' Lambda results of the variables that entered the function in each step are given in Table 3. If the p values in each step are examined, it can be seen that all are below 5%.

Table 3
Wilks' Lambda Results

Step	Number of Variables	Lambda	df1	df2	df3	Exact F			
						Statistic	df1	df2	p
1	1	.363	1	2	115	101.075	2	115.000	.000
2	2	.201	2	2	115	70.016	4	228.000	.000
3	3	.152	3	2	115	58.962	6	226.000	.000

Table 4 below shows the percentage of correct classifications obtained by the use of discriminant functions with stepwise method. The results in the table indicate that there is a high convergence between the original group membership and the predicted group membership. In other words, the percentage of correct classification is considerably high. In total, 86 % of the members in the original group have been classified correctly.

Table 4

Classification Result

		grup	Predicted Group Membership			Total
			1	2	3	
Original	Count	1	28	5	0	33
		2	2	55	10	67
		3	0	0	21	21
	%	1	84.8	15.2	.0	100.0
		2	3.0	82.1	14.9	100.0
		3	.0	.0	100.0	100.0

The results show that 84.8 % of the members in the first group, 82,1 % of the members in the second group and 100 % of the members in the third group have been correctly classified. In the predicted classification 5 members (i.e. countries) belonging to the first group have been included in the second group. On the other hand, 2 countries belonging to the second group have been included in the first group. All countries in the third group however have been classified correctly in the predicted classification.

The percentage of correct classifications in the second group is low in comparison to the other groups. This can be considered as a natural outcome of the existence of two critical (i.e. bottom-line and top-line) borderline values. This is because some countries in the second group appear close to the first group while some other countries appear close to the third group in the multidimensional space.

III. Discussion and Conclusions

The present study was aimed at the evaluation the success of the classification made in the Human Development Report (2006), prepared in the framework of UNDP and reflecting the socio-economical development level of the countries worldwide, by means of a discriminant analysis. With a discriminant analysis the percentage of correct classifications has been determined and the following conclusions were reached.

- There is a high convergence between the HDR and the results of the discriminant analysis. In total the percentage of correct classification is 86 %.
- The percentage of correct classification in the first group is 84.8, in the second group 82,1 and in the third group 100.

A frequent change in the measurement of the HDI is a clear evidence of a lack of an ideal method of measurement. Therefore, as long as there is a change in the method of measurement the classification made according to HDI is likely to change. However, if there is no change in the relevant data the results of a discriminant analysis are unlikely to change. Therefore, comparing the HDIs published in different years with a discriminant analysis would be easier and clear.

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Appendix 1: 2004 Human Development Data

High human development

country	grup	dyb*	yoyo*	boo*	GSYIH*	hdi*
Norway	1	79.60	.	.	38454	.965
Iceland	1	80.90	.	96.00	33051	.960
Australia	1	80.50	.	113.00	30331	.957
Ireland	1	77.90	.	99.00	38827	.956
Sweden	1	80.30	.	96.00	29541	.951
Canada	1	80.20	.	93.00	31263	.950
Japan	1	82.20	.	85.00	29251	.949
United States	1	77.50	.	93.00	39676	.948

Switzerland	1	80.70	.	86.00	33040	.947
Netherland	1	78.50	.	98.00	31789	.947
Finland	1	78.70	.	.	29951	.947
Luxembourg	1	78.60	.	85.00	69961	.945
Belgium	1	79.10	.	95.00	31096	.945
Austria	1	79.20	.	91.00	32276	.944
Denmark	1	77.30	.	101.00	31914	.943
France	1	79.60	.	93.00	29300	.942
Italy	1	80.20	98.40	89.00	28180	.940
United Kingdom	1	78.50	.	93.00	30821	.940
Spain	1	79.70	98.00	96.00	25047	.938
New Zealand	1	79.30	.	.	23413	.936
Germany	1	78.90	.	89.00	28303	.932
Hong Kong	1	81.80	.	77.00	30822	.927
Israel	1	80.00	97.10	90.00	24382	.927
Greece	1	78.30	96.00	93.00	22205	.921
Singapor	1	78.90	92.50	87.00	28077	.916
Korea	1	77.30	98.00	95.00	20499	.912
Slovenia	1	76.60	.	95.00	20939	.910
Portugal	1	77.50	92.00	89.00	19629	.904
Cyprus	1	78.70	96.80	79.00	22805	.903
Czech Republic	1	75.70	.	81.00	19408	.885
Barbados	1	75.30	97.00	89.00	15720	.879
Malta	1	78.60	87.90	81.00	18879	.875
Kuwait	1	77.10	93.30	73.00	19384	.871
Brunei Darussalam	1	76.60	92.70	77.00	19210	.871
Hungary	1	73.00	.	87.00	16814	.869
Argentina	1	74.60	97.20	89.00	13298	.863
Poland	1	74.60	.	86.00	12974	.862
Chile	1	78.10	95.70	81.00	10874	.859
Bahrain	1	74.50	86.50	85.00	20758	.859
Estonia	1	71.60	99.80	92.00	14555	.858
Lithuania	1	72.50	99.60	92.00	13107	.857
Slovakia	1	74.30	.	77.00	14623	.856
Uruguay	1	75.60	.	89.00	9421	.851
Croatia	1	75.20	98.10	73.00	12191	.846
Latvia	1	71.80	99.70	90.00	11653	.845
Qatar	1	73.00	89.00	76.00	19844	.844
Seychell	1	72.70	91.80	80.00	16652	.842
Costa Rica	1	78.30	94.90	72.00	9481	.841
U. Arap Emirates	1	78.30	.	60.00	24056	.839
Cuba	1	77.60	99.80	80.00	.	.826
St. Kitts and Nevis	1	70.00	97.80	80.00	12702	.825
Bahamas	1	70.20	.	66.00	17843	.825
Mexico	1	75.30	91.00	75.00	9803	.821
Bulgaria	1	72.40	98.20	81.00	8078	.816
Tonga	1	72.40	98.90	80.00	7870	.815
Oman	1	74.30	81.40	68.00	15259	.810
Trinidad	1	69.80	.	67.00	12182	.809
Panama	1	75.00	91.90	80.00	7278	.809
Antigua	1	73.90	85.80	69.00	12586	.808
Romania	1	71.50	97.30	75.00	8480	.805
Malaysia	1	73.40	88.70	73.00	10276	.805
Bosnia Herzogovina	1	74.30	96.70	67.00	7032	.800
Mauritania	1	72.40	84.40	74.00	12027	.800

Medium human development

country	grup	dyb*	yoyo*	boo*	GSYIH*	hdi*
Libya	2	73.80	.	94.00	7570	.798
Russian	2	65.20	99.40	88.00	9902	.797
Macedonia	2	73.90	96.10	70.00	6610	.796
Belarus	2	68.20	99.60	88.00	6970	.794
Dominica	2	75.60	88.00	83.00	5643	.793
Brazil	2	70.80	88.60	86.00	8195	.792
Colombia	2	72.60	92.80	73.00	7256	.790
Saint Lucia	2	72.60	94.80	76.00	6324	.790
Venezuela	2	73.00	93.00	74.00	6043	.784
Albania	2	73.90	98.70	68.00	4978	.784
Thailand	2	70.30	92.60	74.00	8090	.784
Samoa	2	70.50	.	74.00	5613	.778
Saudi Arabia	2	72.00	79.40	59.00	13825	.777
Ukraine	2	66.10	99.40	85.00	6394	.774
Lebanon	2	72.20	.	84.00	5837	.774
Kazakhstan	2	63.40	99.50	91.00	7440	.774
Armenia	2	71.60	99.40	74.00	4101	.768
China	2	71.90	90.90	70.00	5896	.768
Peru	2	70.20	87.70	86.00	5678	.767
Ecuador	2	74.50	91.00	.	3963	.765
The Philippines	2	70.70	92.60	82.00	4614	.763
Grenada	2	65.30	96.00	73.00	8021	.762
Jordan	2	71.60	89.90	79.00	4688	.760
Tunisia	2	73.50	74.30	75.00	7768	.760
St. Vincent	2	71.30	88.10	68.00	6398	.759
Suriname	2	69.30	89.60	72.00	.	.759
Fiji	2	68.00	.	75.00	6066	.758
Paraguay	2	71.20	.	70.00	4813	.757
Turkey	2	68.90	87.40	69.00	7753	.757
Sri Lanka	2	74.30	90.70	63.00	4390	.755
Dominican Republic	2	67.50	87.00	74.00	7449	.751
Belize	2	71.80	75.10	81.00	6747	.751
Iran	2	70.70	77.00	72.00	7525	.746
Georgia	2	70.60	.	75.00	2844	.743
Maldives	2	67.00	96.30	69.00	.	.739
Azerbaijan	2	67.00	98.80	68.00	4153	.736
Occupied	2	72.70	92.40	81.00	.	.736
El Salvador	2	71.10	.	70.00	5041	.729
Algeria	2	71.40	69.90	73.00	6603	.728
Guyana	2	63.60	96.50	76.00	4439	.725
Jamaica	2	70.70	79.90	77.00	4163	.724
Turkmenistan	2	62.50	98.80	.	4584	.724
Cape Verde	2	70.70	.	67.00	5727	.722
Syria	2	73.60	79.60	63.00	3610	.716
Indonesia	2	67.20	90.40	68.00	3609	.711
Vietnam	2	70.80	90.30	63.00	2745	.709
Kyrgyzstan	2	67.10	98.70	78.00	1935	.705
Egypt	2	70.20	71.40	76.00	4211	.702
Nicaragua	2	70.00	76.70	70.00	3634	.698
Uzbekistan	2	66.60	.	74.00	1869	.696
Moldova	2	68.10	98.40	70.00	1729	.694
Bolivia	2	64.40	86.70	87.00	2720	.692
Mongolia	2	64.50	97.80	77.00	2056	.691
Honduras	2	68.10	80.00	71.00	2876	.683

Guatemala	2	67.60	69.10	66.00	4313	.673
Vanuatu	2	68.90	74.00	64.00	3051	.670
Equatorial Guinea	2	42.80	87.00	58.00	20510	.653
South Africa	2	47.00	82.40	77.00	11192	.653
Tajikistan	2	63.70	99.50	71.00	1202	.652
Morocco	2	70.00	52.30	58.00	4309	.640
Gabon	2	54.00	71.00	72.00	6623	.633
Namibia	2	47.20	85.00	67.00	7418	.626
India	2	63.60	61.00	62.00	3139	.611
São Tomé & Príncipe	2	63.20	83.10	63.00	1231	.607
Solomon Islands	2	62.60	76.60	47.00	1814	.592
Cambodia	2	56.50	73.60	60.00	2423	.583
Myanmar	2	60.50	89.90	49.00	1027	.581
Botswana	2	34.90	81.20	71.00	9945	.570
Comoros	2	63.70	.	46.00	1943	.556
Laos	2	55.10	68.70	61.00	1954	.553
Pakistan	2	63.40	49.90	38.00	2225	.539
Bhutan	2	63.40	47.00	.	1969	.538
Ghana	2	57.00	57.90	47.00	2240	.532
Bangladesh	2	63.30	.	57.00	1870	.530
Nepal	2	62.10	48.60	57.00	1490	.527
Papua New Guinea	2	55.70	57.30	41.00	2543	.523
Congo	2	52.30	.	52.00	978	.520
Sudan	2	56.50	60.90	37.00	1949	.516
East Timor	2	56.00	58.60	72.00	.	.512
Madagascar	2	55.60	70.70	57.00	857	.509
Cameroon	2	45.70	67.90	62.00	2174	.506
Uganda	2	48.40	66.80	66.00	1478	.502
Swaziland	2	31.30	79.60	58.00	5638	.500

Low human development

country	grup	dyb ⁺	yoyo	boo ⁺	GSYIH ⁺	hdi ⁺
Togo	3	54.50	53.20	55.00	1536	.495
Djibouti	3	52.90	.	24.00	1993	.494
Lesotho	3	35.20	82.20	66.00	2619	.494
Yemen	3	61.10	.	55.00	879	.492
Zimbabwe	3	36.60	.	52.00	2065	.491
Kenya	3	47.50	73.60	60.00	1140	.491
Mauritania	3	53.10	51.20	46.00	1940	.486
Haiti	3	52.00	.	.	1892	.482
Gambia	3	56.10	.	50.00	1991	.479
Senegal	3	56.00	39.30	38.00	1713	.460
Eritrea	3	54.30	.	35.00	977	.454
Rwanda	3	44.20	64.90	52.00	1263	.450
Nigeria	3	43.40	.	55.00	1154	.448
Guinea	3	53.90	29.50	42.00	2180	.445
Angola	3	41.00	67.40	26.00	2180	.439
Tanzania	3	45.90	69.40	48.00	674	.430
Benin	3	54.30	34.70	49.00	1091	.428
Côte d'Ivoire	3	45.90	48.70	40.00	1551	.421
Zambia	3	37.70	68.00	54.00	943	.407
Malawi	3	39.80	64.10	64.00	646	.400
Congo,	3	43.50	67.20	27.00	705	.391
Mozambique	3	41.60	.	49.00	1237	.390
Burundi	3	44.00	59.30	36.00	677	.384

Ethiopia	3	47.80	.	36.00	756	.371
Chad	3	43.70	25.70	35.00	2090	.368
C.African Republic	3	39.10	48.60	30.00	1094	.353
Guinea-Bissau	3	44.80	.	37.00	722	.349
Burkina Faso	3	47.90	21.80	26.00	1169	.342
Mali	3	48.10	19.00	35.00	998	.338
Sierra Leone	3	41.00	35.10	65.00	561	.335
Niger	3	44.60	28.70	21.00	779	.311

- * dyb : Life expectancy at birth
- * yoyo : adult literacy rate
- * boo : combined gross enrolment ratio
- * GSYIH : GDP per capita