Measuring Under-achievements in Livelihood Space: Search for sustainability index and influencing factors through artificial neural network

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Abstract- Ensuring a sustainable livelihood to the larger counts of the population is the most challenging agenda of any developing economy. So this work wants to quantify the level of under achievements of different economies in the field of sustainable livelihood. The contribution of influencing variables of under-achievement and contributing variables to achievement in the construction of under achievement livelihood space is also determined under this work. The interaction between these two types of variables and their juxtaposed effects are evaluated through the use of artificial neural network. Finally this method of artificial intelligence is used to achieve a self-sustained monotonic high rate of development. The whole work is presented through a set theoretic approach which is followed by the testing of the same. It is expected that the application of neural network in the process of self-sustained growth of sustainable livelihood is unique in academic discourses.

Keyword: Sustainable Livelihood, Underachievement Space, Artificial Neural network.

1. INTRODUCTION

A person's livelihood refers to their means of securing the basic necessities like food, water, shelter and clothing. Human livelihood comprises of the capabilities, assets and activities required for a decent living. This livelihood is sustainable when it becomes capable to cope with and to recover from stresses and shocks(DFID, 2000). This very idea of Sustainable Livelihood constitutes the basis of different Sustainable Livelihood Approaches and has been adapted by different development agencies such as the Department for International Development, UK (DFID). The DFID has developed a 'Sustainable Livelihood Framework' (SLF) which is one of the most widely used livelihood frameworks(www.gov.uk, 1997). Petersen et.al.(Elsemarie Kappel Petersen, 2010)has discussed about sustainable livelihood framework to eradicate poverty. The sustainable livelihood thinking began to influence development practices since 1990's. United Nation Development Programme (UNDP, 2017) is one of the early participants as well as contributors of this conceptual framework. This Livelihood framework encompasses the skills, assets (both material and social) and the approaches which are used by individuals and communities to survive.

The term sustainable livelihood started to surface in the academic literature with the works of Chambers and Conway (Robert Chambers, 1992). Since 1991 a voluminous research appeared following this. Subsequently, Lasse Krantz developed an approach of sustainable livelihood (SL) for poverty reduction (Krantz, 2001). This study has attempted to go beyond the conventional definitions and approaches to poverty eradication. The basic idea of the SL approach is to start with a broad and open-ended analysis of the constraints in (poor) people's current livelihoods. Leigh Anderson et.al. (C.LeighAnderson, 2002) have presented a conceptual scheme for understanding the impact of common pool resources on sustainable livelihood. They have observed that impacts on common pool resources are posited to occur through changes in household production and consumption. They have also observed that enhanced human and social capital can improve sustainable livelihood through better environmental outcomes.

But it appears that quantification of sustainable livelihood indicators as well as components are very inadequate. Agenlen et.al.(Arild Angelsen, 2012) have discussed that research on livelihood in developing countries suffer from proper methods and problems in implementations. The results do not reflect the ground realities. This vacuum in livelihood research can easily be covered through the concept of artificial intelligence (AI). Nilson et.al. have tried to provide a better understanding of the role of human and Artificial Intelligence (Nilsson, 2005) in the organization decision making process. Here authors have tried to apply Artificial Intelligence as a rooted decision tree for many possibilities. Tin Miller (Miller, 2017) has applied Artificial Intelligence in social sciences. This study has produced outcomes that can design and implement intelligent agents those are truly capable of providing explanation to people.

On the basis of the existing studies it appears that the research on sustainable livelihood has failed to deliver desired results due to the absence of proper research methods. Naturally the policies to mitigate the human hardship is also failing increasingly. This problem in the academic discourses can well be solved through the ideas of artificial intelligence as developed as the tools of soft computing. The artificial intelligence techniques optimize the decisions about sustainable livelihood in a multi-dimensional framework. The modern computational techniques as discussed here will also help to achieve sustainable development goals as well as sustainable livelihood. This new technique may help us to explain the differential outcomes of different economies in achieving sustainable livelihood. These techniques can help us to understand the spatial, geographical, historical reason in the existence of acute resource constraints. In this respect modern computer aided technology can create a conducive atmosphere show the correct path. Thus, the specific objectives of this study are.

2. OBJECTIVES

- Firstly, to construct an under-achievement index in the sustainable livelihood space.
- Secondly, to cluster the economies on the basis of their under-achievements to find the under-lying histro-geographical patterns of economy wise under-achievements.
- Thirdly, to locate the direct as well as indirect effects of influencing factors as well as component variables on the composite under achievement space with the help of artificial intelligence.
- Fourthly, to find a self-sustained process to maintain and develop sustainable development.

3. METHODOLOGY

This work is based on secondary data published by different reputed institutions like World Bank, UNDP etc. Sustainability of livelihood is defined by the ability to cope with and to recover from stresses and shocks related to livelihood space. Sustainable livelihood is determined through the domains like Human Capital, Social Capital, Physical Capital, Financial Capital and Natural Capital as published by Department of Foreign and International Development, UK. It is assume here that the benchmarked or expected level of domain specific sustainability is 100%. So, any deviation from this benchmark of 100% is treated here as under achievement in sustainability with respect to the concern variable of domain. Eventually the economies within the livelihood space are clustered on the basis of their under-achievements. These clusters are used to determine the spatial and histological influences on the intensities of under-achievements. Multiple regression analysis is used to trace the significance of different influencing variables which may have influence on the under achievement index. Simple statistical tools are used to quantify the extent of influence of influencing as well as component variables. Then the significance of influencing factors are statistically tested. Finally the influence of different influencing factor on the cluster are determined and presented diagrammatically. The idea of Artificial Neural Network has been used to come to the conclusion.

4. MODEL

The Artificial Neural Network as used in this model is assumed to have i layers where set of layers $L=\{l_1, l_2, l_3, \ldots . l_i\}$. It is assumed that there are m key elements to achieve sustainable developments. Each element with the said key elements have j components and these components correspond to n economies. Here l_1

consists of m x j components subsets where J denotes the set of m x j elements of n economies. Thus
J = {m x j_i } where i=1,2,3,….n. Now if there are 215 economies and
m_i= $\{j_p^i\}$ where p=1,2,3,4….215
In layer 2 the achievement of the n economies are determined through
l_2={●} → O_p
Where O_p = { d_{p1}^*, d_{p2}^*, d_{p3}^*…..d_{pn}^*}
Where O_p is a n dimensional radar representation, and p=1,2,3,4….215, i=1,2,3,4….n and p≠ i.
d_{p1}^* is the achievement of the p^{th} economy in the 1^{th} key element.
Let A_p is the area of polygon of the p^{th} perspective formed through d_{pi}^*. Naturally A_p is the achievement space as demonstrated by p^{th} economy.
Subsequently in layer 3 under achievement space U_p is developed where
[O^* - O_p] → U_p
This U_p is distributed over C, where C={C_g}, g=1,2,3,4…n and C_g can be expressed as clusters constructed on the basis of some exogenous considerations.
In the under achievement space of a particular economy gets matched with the interval as defined by the cluster wise boundaries. So U_p correspond to C_g.
In other words [O^* - O_p] → U_p → C_g
The next layer V is formed where V={V_h }, h= 1,2,3,4….p.
These V_h are some arbitrary selected influencing variables which may have significant relationship with U_p. To find the significance of these influencing factors Ordinary Least Square regression can be applied with error α.
Let, V^* is the set of significant variable influencing U_p . Thus $V^* \subseteq V$.
Finally Z is formed where Z = { Z_q }, where Z_q shows the relative position of different economies with respect to the significant influencing factors towards sustainable livelihood. Thus integrated network structure can create instance help to the policy maker to achieve sustainable livelihood by simply imputing the observation about the influencing variables.
Alternatively, I_i is the set of relative importance of d_i over p perspective.
Where $I_{ip} = \frac{d_{ip}}{U_p}$
Thus in C_g the relative importance if i th domain is

$RI_{ig} = \sqrt[i]{\prod^i \frac{d_{ip}}{U_p}}$

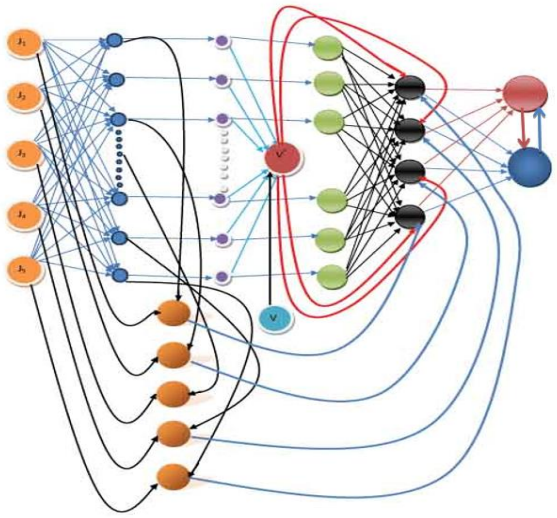
Or F_{ig} = log RI_{ig} =$\log_i \sum_i \frac{d_{ip}}{U_p}$

And F_j= $\sqrt[g]{\prod^g F_{ig}}$

And K = { F_j }

The above stated model is represented through the following neural network.

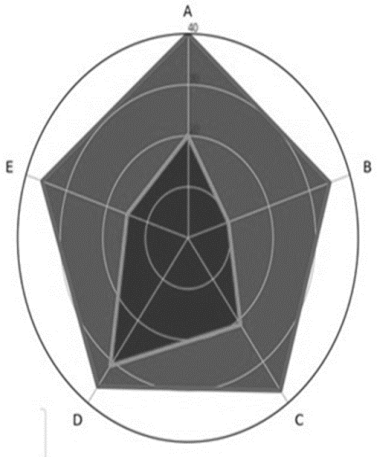
Chart I



5. TESTING

In a j dimensional sustainable livelihood space a j axis radar diagram will consist of 360^0. Through SAS method the inter domain triangles are determined and finally the area of the j dimensional radar is calculated. Here it is assume that the consecutive inter axis angles are equal. Here j is 5, so the radar is represented through a pentagon line one as represented bellow.

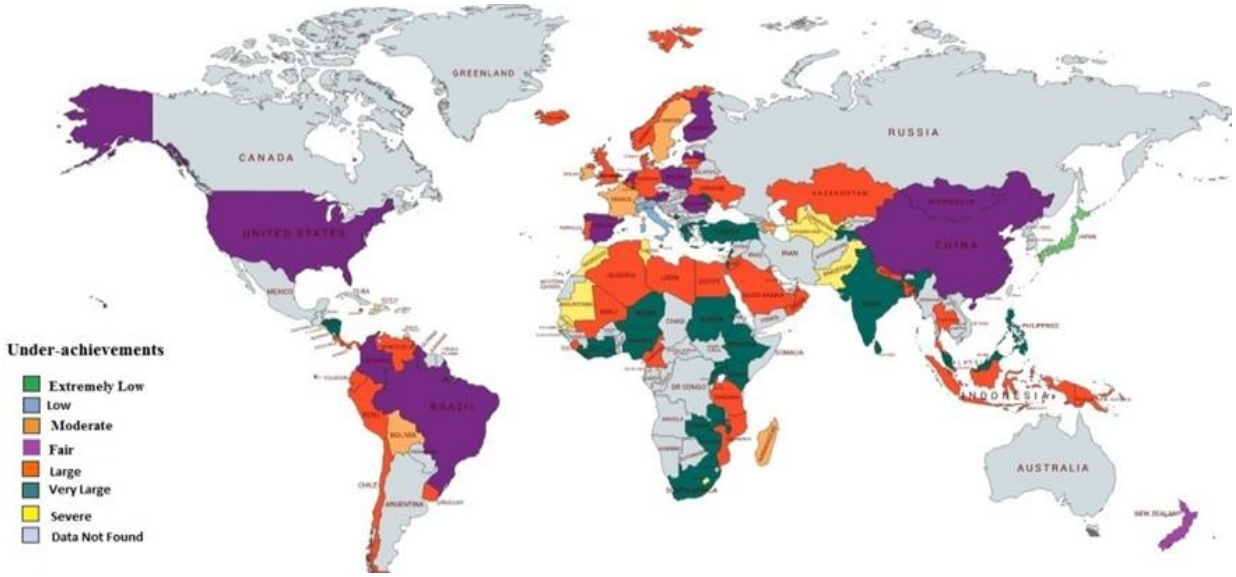
Chart - II



On the basis of the model it is observed that the lowest and highest levels of under achievement in the global livelihood space are 15893.2845 and 21507.327 respectively. This spread of data is distributed over 7 clustered with equal class intervals. These are depicted through tabular forms as Appendix - 1.

An interesting finding about the cluster wise distribution of geographical space is depicted through the following map.

Chart - III



Interestingly, no distinct geographical or historical pattern on the under-achievement has been observed. In the next layer these under achievement levels of all the economies are regressed over a set of explanatory variables. Other than the components of sustainable livelihood as accepted in this work. Thus the regression equation is represented through the following form.

U_P= 20013.77 – 19.93 FemLit** – 1.067 x 10 $^{-008}$ BOP** – 16.15 HumRight** + 22.76 CorrPer*

(1818.006) (9.289) (.000) (5.956) (13.565)

(.000) (.035) (.009) (.008) (.098)

Here FemLit means adult female literacy rate, BOP means balance of payment, HumRIght means human right and CorrPer means corruption perception index. The descriptive statistics of this regression analysis is presented in Appendix-2.

In the next step the importance of significant influencing variables on each cluster is determined. These levels of importance of each significant influencing variable in each cluster is determined through the geometric mean of the said influencing variables. The cluster wise importance of influencing variables is depicted bellow.

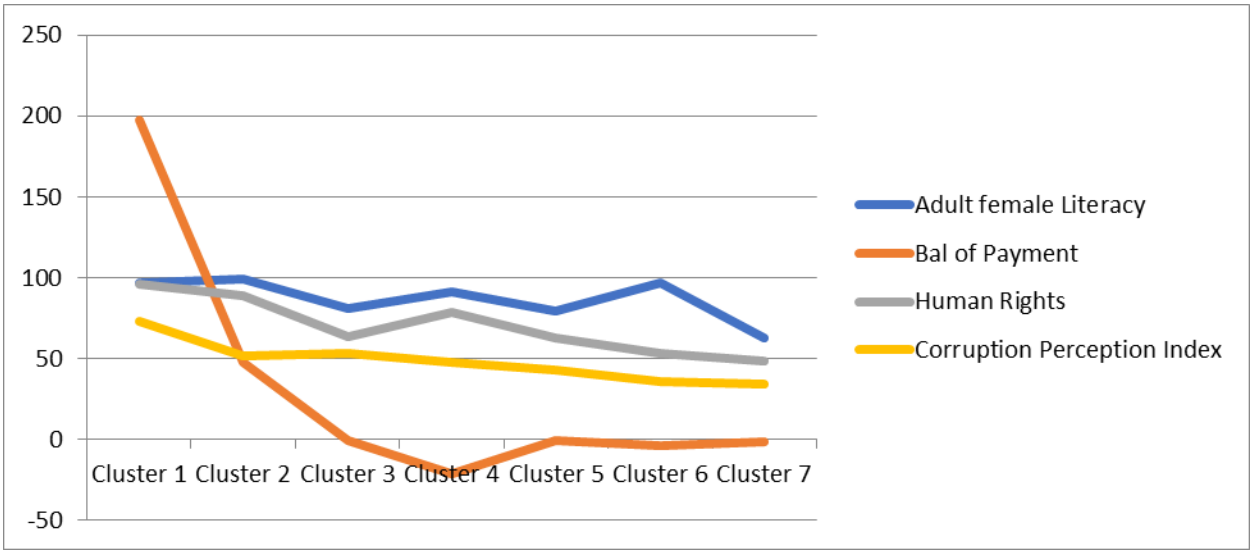
Table 1

Cluster wise importance of significance variables

	Adult Female Literacy	Balance of Payment	Human Right	Corruption Perception Index
Cluster 1	97	197.0493925	96	73
Cluster 2	99.0	47.51532892	89	52
Cluster 3	80.71428571	-0.307547435	63.57142857	53
Cluster 4	91.45454545	-21.02497627	78.73333333	47.90909091
Cluster 5	79.05128205	-0.507883278	62.88372093	42.69230769
Cluster 6	96.84615385	-3.458053112	53.12903226	35.5
Cluster 7	63	-1.573390124	48.77777778	34.44444444

This tabular information is represented through the following diagram.

Chart - IV



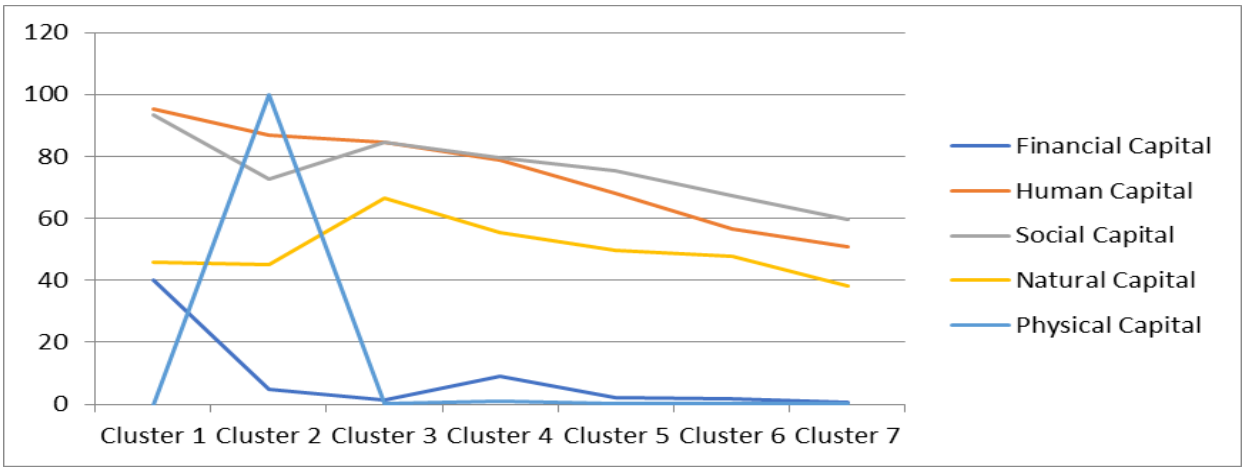
Again the same operation is undertaken to determine the cluster wise influence of component variables as accepted in this analysis to achieve sustainable livelihood. These importance of component variables are calculated through geometric mean using equal weight. The following table shows the findings.

Table 2
Cluster wise importance of component variables

	Financial Capital	Human Capital	Social Capital	Natural Capital	Physical Capital
Cluster 1	40.10034148	95.45828968	93.35467134	45.87803228	1.15E-05
Cluster 2	4.809070596	86.93611269	72.78792707	44.96469642	100.0000005
Cluster 3	1.475277435	84.49173952	84.43999359	66.58571348	0.032851938
Cluster 4	9.193782139	78.89840753	79.51696739	55.37841459	0.876136107
Cluster 5	1.991105373	68.27659083	75.32348837	49.51026213	0.089013955
Cluster 6	1.581317043	56.72295089	67.15063834	47.83878927	0.049534593
Cluster 7	0.585612461	50.8165497	59.48865134	38.245448	0.025516647

This is shown graphically as follows.

Chart V



At the end of this discussion it can be said that the under achievement in sustainable livelihood can be demonstrated through radar area. Quantification of this radar space can deliver the under-achievement index in the sustainable livelihood space. It is found that this under achievement indices of the available economies varied largely. Observed that the clustering of the economies on the basis of their under-achievement level delivered results according to our exceptions – the number of countries increased with

the downward movement in the hierarchy of clusters. A pictorial illustration of the cluster wise distribution of different economies though projected an interesting diagram but failed to depict any historical or geographical pattern. Regressing the under-achievement areas through some exogenously determined explanatory variables it appears that adult female literacy rate, balance of payment, human rights and perceptions about corruption have significant effects on under achievement in sustainable livelihood. Among the significant variables human rights, adult female literacy rate and balance of payment have negative relationship with under achievement in livelihood apace. But interestingly perception about corruption is positively related with under achievement index. It is quite expected that corruption leads to adverse selection and moral hazards which can ultimately ensure lower levels of sustainable livelihood. On the other hand, cluster wise determination of influence of component variables on under achievement found that human capital, social capital and natural capital played an important role over almost all the clusters to achieve sustainable livelihood. Interestingly it can be said without any hesitation that the achievement of sustainable livelihood needs simultaneously improvement of natural capital, social capital and human capital. These findings do not contradict with the findings of the influence of the exogenous causal variables. So finally, it can be said that a push on any set of variables, influencing variables or contributing variables can create both way causal movement and create infinite loop of development to sustain human livelihood. This whole process is depicted through a compact neural network in this work. The application of neural network like this analysis can open new dimensions in livelihood research.

Appendix – 1

Table 3	
Cluster 1(Value >=15000 to <=16000)	
Country Name	UA Space
Japan	15893.2845
Source: Calculated by the authors	

Table 4	
Cluster 2 (Value >16000 to <=17000)	
Country Name	UA Space
Italy	16703.37801
Source: Calculated by the authors	

Table 5	
Cluster 3 (Value >17000 to <=18000)	
Country Name	UA Space
Azerbaijan	17899.56027
Bolivia	17980.59823
France	17810.10294
Ireland	17579.01072
Madagascar	17336.99739
Qatar	17484.21204
Sweden	17579.71249
Source: Calculated by the authors	

Table 6	
Cluster 4 (Value >18000 to <=19000)	
Country Name	UA Space
Austria	18517.6245
Brazil	18289.44515
China	18037.96967
Colombia	18356.67086
Spain	18868.33659
Finland	18362.57887
Guyana	18110.46353
Latvia	18602.96225
Maldives	18377.15113
Mongolia	18585.39217
Netherlands	18352.99531
New Zealand	18597.09003
Poland	18821.4077
Romania	18929.64609
United States	18733.20449
Source: Calculated by the authors	

Table 7	
Cluster 5 (Value >19000 to <=20000)	
Country Name	UA Space
Belgium	19520.75779
Bangladesh	19862.45543
Chile	19150.2098
Cameroon	19894.74765
Costa Rica	19239.53215
Germany	19524.81352
Denmark	19191.38789
Algeria	19215.47477
Ecuador	19291.11174
Egypt, Arab Rep.	19951.75309
United Kingdom	19800.98274
Indonesia	19971.68245
Iceland	19130.28672
Jamaica	19369.73867
Jordan	19942.92856
Kazakhstan	19426.59461
Kuwait	19286.17881
Libya	19714.46295
Lithuania	19664.75385

Mexico	19693.5563
Mali	19078.90552
Malta	19846.69281
Mozambique	19922.1177
Mauritius	19794.31586
Norway	19057.26483
Nepal	19808.80084
Oman	19728.79619
Panama	19409.18858
Peru	19936.25008
Papua New Guinea	19287.39803
Portugal	19934.13248
Paraguay	19020.43684
Saudi Arabia	19853.04502
Singapore	19933.00835
Sierra Leone	19642.19405
Thailand	19465.32809
Timor-Leste	19223.18288
Tonga	19986.38129
Trinidad and Tobago	19846.45003
Tanzania	19826.63878
Ukraine	19504.19811
Uruguay	19037.36669
Venezuela, RB	19239.38856
Source: Calculated by the authors	

Table 8

Cluster 6 (Value >20000 to <=21000)

Country Name	UA Space
Cote d'Ivoire	20058.20823
Cyprus	20332.86555
Ethiopia	20812.70805
Ghana	20023.49821
Greece	20004.46569
Honduras	20209.51651
India	20501.42434
Israel	20594.07224
Kenya	20635.79857
Lebanon	20542.22449
Liberia	20662.8181
Sri Lanka	20241.85726
Luxembourg	20054.91861
Moldova	20491.82608
Montenegro	20021.62795
Malawi	20806.39281
Malaysia	20464.07309
Namibia	20095.66848
Niger	20806.90824
Nigeria	20604.89678
Nicaragua	20471.02282
Philippines	20518.11469
West Bank and Gaza	20360.3111
Rwanda	20111.92945
Sudan	20330.65767
Solomon Islands	20497.36669
Tajikistan	20836.64433
Turkey	20281.14891
Uganda	20086.8169
South Africa	20976.6988
Zambia	20021.80961
Zimbabwe	20740.67971
Source: Calculated by the authors	

Table 9

Cluster 2 (Value >21000)

Country Name	UA Space
Haiti	21507.32749
Lesotho	21128.49092
Morocco	21289.83252
Mauritania	21364.39641
Pakistan	21187.75859
Senegal	21339.33984
El Salvador	21240.3925
Turkmenistan	21251.90849
Tunisia	21262.81464
Source: Calculated by the authors	

Appendix- 2

Descriptive Statistics

Table 10

	Mean	Std. Deviation	N
UAI	19808.0640	987.24089	86
SexR	1.0266	.26926	86
PCGDP	14595.0581	18091.50786	86
LifeExp	71.3698	7.13024	86
YearofSch	7.9605	2.63011	86
Colony	.5814	.49622	86
FemLit	79.6512	22.24821	86
BOP	732390186.5842	25452720840.48409	86
RiskInd	4.0233	1.48274	86
PolInst	-.3555	.81718	86
HumRight	55.1512	25.11644	86
CorrPer	38.5698	13.06773	86
KOF	62.3259	11.37657	86

Model Summary
Table 11

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.601[a]	.361	.256	851.31106

a. Predictors: (Constant), KOF, SexR, BOP, Colony, PolInst, FemLit, HumRight, LifeExp, CorrPer, RiskInd, YearofSch, PCGDP

ANOVA[a]
Table 12

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	29939461.444	12	2494955.120	3.443	.000[b]
Residual	52905328.080	73	724730.522		
Total	82844789.524	85			

a. Dependent Variable: UAI
b. Predictors: (Constant), KOF, SexR, BOP, Colony, PolInst, FemLit, HumRight, LifeExp, CorrPer, RiskInd, YearofSch, PCGDP

Table 13

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	20013.774	1818.006		11.009	.000
	SexR	-434.229	573.429	-.118	-.757	.451
	PCGDP	-.019	.013	-.350	-1.505	.137
	LifeExp	-11.527	22.429	-.083	-.514	.609
	YearofSch	89.419	81.383	.238	1.099	.275
	Colony	339.972	212.132	.171	1.603	.113
	FemLit	-19.934	9.289	-.449	-2.146	.035
	BOP	-1.067E-008	.000	-.275	-2.702	.009
	RiskInd	99.230	134.456	.149	.738	.463
	PolInst	57.560	198.130	.048	.291	.772
	HumRight	-16.153	5.956	-.411	-2.712	.008
	CorrPer	22.764	13.565	.301	1.678	.098
	KOF	26.665	19.179	.307	1.390	.169

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