An Analysis of Poverty - A Ridge Regression Approach

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ABSTRACT

A High–Level Panel of the UN Secretary General identified the economic and social threats, in particular, poverty, infectious diseases, and environmental degradation as one of the six clusters of existing or anticipated threats to peace and security. This paper attempts to identify the socioeconomic determinants of the poverty component of the threat mentioned above by analyzing national level data of 68 countries collected from the World Population Data Sheet, 2006, and other international sources.

The dependent variable is the level of poverty, measured as the percentage of population living below US $2 per day. The technique used to analyze data is the multiple regression, while variance inflation factors and the ridge regression technique have been used to detect interrelation among the internal components of the regression model.

The analysis shows that the gross national income is the most influential variable in lowering the level of poverty, followed by the percentage of urban population, and the percentage of females enrolled in secondary school in that order.

The need for an even distribution of resources is emphasized and other policy implications are discussed. The paper suggests additional research before implementing policy based on the intuitively appealing formula: more resources = less poverty.

Keywords*:* Poverty, Ridge Estimator, OLS Rregression, Multicollinearity, Variance Inflation Factors

1. INTRODUCTION

The September 2005 World Summit of the United Nations General Assembly had in its consideration, among other documents, the report of the Secretary General's High-Level Panel of Threats, Challenges, and Change [12]. The panel identified the economic and social threats, in particular, poverty, infectious diseases, and environmental degradation as one of the six clusters of existing or anticipated threats to peace and security. In their report the panel of experts mentioned that although the per capita income of the developing countries witnessed an increase of an average of 3 percent annually since 1990, there has been an increase in the number of people living in extreme poverty by more than 100 million people in some regions, the average per capita income decreased in at least 54 countries over the same period, and global inequality and income inequality in many poor countries increased concomitantly along with the increasing poverty. As an example, they also wrote that the richest twenty percent of the households in some parts of Latin America have their income which is thirty times greater than the poorest twenty percent of the households.

In this paper we are concerned with the poverty component of the threat mentioned above. There is a considerable variability in the poverty level across countries of different socioeconomic levels. The intent is to identify the socioeconomic correlates of poverty that contribute towards the variations in poverty level across a number of countries by analyzing aggregate level data. The importance of this study derives from the fact that it is necessary to identify these correlates so that efforts can be made for the reduction of poverty through changes in government policies and redistribution of resources.

2. DATA AND METHODS

Data and Variables

The source of data in this analysis is the 2006 World Population Data Sheet and the individual country information [22], as well as, the Corruption Perception Index, 2005 [23].

The dependent variable to be analyzed is the poverty level (PL:Y) measured as percentage of population living below US $2 per day. The World Bank uses a common unit across countries: $1 per day (extreme poverty) and $2 per day (poverty) to estimate poverty level worldwide, and this measure has been used in the World Population Data Sheet. The percentage of population living below $2 per day varies from lows of less than 2 in Azerbaijan, South Korea, Belarus, Czech Republic, Hungary, Poland, Croatia, Macedonia, Portugal, and Slovenia to highs of 90 in Tanzania, 91 in Mali, 92 in Nigeria, and 94 in Zambia among the countries for which data on this variable and other relevant variables are available. The explanatory variables used are: Gross national income per capita (GNI: X1) which is based on the amount of goods and services one could buy in the United States with a given amount of money; Energy use per capita 2002 (kg oil equivalent) (ENG X2); Total fertility rate defined as the number of children a woman would have if she survived to the end of her reproductive period and experienced a given set of age-specific birth rates (TFR: X3); Percentage of the total population living in urban areas (URBAN: X4); Population density per square mile (DEN: X5); Percentage of the dependent population defined as the sum of the percentages of population aged less than 15 years and more than 65 years (DEP: X6); Percentage of the economically active females aged more than 15 years (EAF: X7); Females enrolled in secondary school as percentage of school-age enrollment (SSF: X8); and Corruption Perception Index, 2005 which relates to perceptions of the degree of corruption as seen by business people and country analysts, and ranges from 0 (most corrupt) to 1 (least corrupt) (CPI: X9). Details of the variables and their measures can be found in their sources mentioned above. Data for all the above ten variables are available only for 68 countries which form the basis of this analysis.

Theoretical reasoning and the availability of data are the guiding principles for selecting the explanatory variables. One common measure of general standards of living is the per capita income which may be used as a measure of income growth and has been found to be strongly negatively related to poverty [15, 18]. The link between poverty and income growth has garnered a great deal of research attention over the years [1, 2, 5, 6, 8]. However, if the benefit of income growth does not reach the low-income group, the overall positive impact of the income growth can well be mitigated by the income inequality which affects the pattern of poverty. Poverty in a society is likely to increase if only a select few can derive the benefits of income growth.

Energy consumption is another factor associated with poverty. The region of the world that includes the poverty-stricken countries has the lowest per capita energy consumption [14]. In this paper the author has divided the world into five regions – A (U.S., Canada, Australia, New Zealand), B (Soviet Union, Eastern Europe), C (European members of OECD (excluding Turkey and Japan), D (China excluding Taiwan), and E (all other countries), and calculated the per capita energy consumption for each region. The per capita energy consumption in region A is more than sixteen times higher than that in region E (7.51 versus 0.46) while the world per capita energy consumption (1.54) is more than three times higher than that in region E. The Gini index also shows the degree of inequality in per capita energy consumption between the world regions. If all regions of the World’s population had the same per capita energy consumption the index would be zero; the index would be almost one if a few percent of the world’s population consumed practically all the energy. The value of the Gini index was 0.55 in 1985 and is projected to decline to 0.45 in 2020. Whether the decline will continue until the development gap between industrialized and agrarian regions disappears is yet to be seen.

In a high-fertility society, a family is more likely to use a given income on a larger number of members than in a low-fertility society. This may cause economic strains on low-income families that may eventually lead to poverty. A similar argument might show that the variable – dependent population – may also influence poverty. Urban areas are usually centers of political and economic power and offer more sources to earn better incomes compared to the rural areas. As a consequence, people in urban areas are generally economically better off than their rural counterparts, and hence are less likely to face poverty. Another factor that may influence poverty is the population density [7]. For example, in China, the highest-income area is the most densely populated (the coastal region) and the lowest-income area is the western region which is the least densely populated [19]. One reason may be that in a densely populated area people can run their businesses and other activities with a desirably greater number of potential consumers in a relatively smaller area and hence can earn better with less investment than in a sparsely populated area.

A female’s involvement in income generation raises the total income of the family and consequently the probability that the family may face material deprivation is lessened. Education plays a very important role in the reduction of poverty. A higher level of education enhances the probability of a higher level of knowledge that eventually leads to higher economic gains. As Johnson aptly states that if people are to be pulled out of poverty, the most appropriate way is to increase the level of their education [19]. Since the higher the level of education of the females the higher the likelihood that more females will be economically active, both variables – SSF and EAF are expected to contribute negatively to poverty.

In a society, people who are corrupt usually possess more wealth earned through illegal means at the expense of those who are not corrupt. When the scale of corruption is massive, it corrodes the economic vitality of a society and may entail poverty. Understandably, the scenario is more dismal for a low-income society.

Based on the above arguments we hypothesize negative relationships between PL and each of the variables GNI, ENG, URB, DEN, EAF, and SSF, and positive relationships between PL and each of the variables TFR, DEP, and CPI.

3. ANALYSIS

Fitting OLS Regression Model

The results of fitting the ordinary least squares (OLS) regression model

$$Y = \beta_0 + \sum_{i=1}^{9} \beta_i X_i + U \qquad (1)$$

(where β_0 is the intercept and β_is are the regression coefficients) connecting the poverty level and the nine explanatory variables X_1, X_2, ………..X_9 are shown in table 1.

The significance of the F value at a very low probability level shows that the variables chosen to explain poverty are valid explanatory variables [9]. Although the value of R^2 is large (0.795), it is not a guarantee of a good fit [3], nor that the model assumptions have not been violated [9]. However, the residual analysis did not show any evidence of model misspecification nor of any serious violations of model assumptions.

After properly specifying the model it is necessary to investigate the theoretically desirable but methodologically arduous presence of multicollinearity. The problem with interdependency or multicollinearity is that, as the multicollinearity increases the variances of the OLS estimates also increase rendering the estimates unstable. It is, therefore, important to judge whether the internal components of the regression model are themselves interrelated or not, and if they are, difficulties inherent in collinear systems must somehow be dealt with.

TABLE I. UNSTANDARDIZED AND STANDARDIZED COEFFICIENTS OF REGRESSION OF POVERTY LEVEL ON THE NINE

Variable	Unstandardized Coefficients	T Value	Standardized Coefficients
INTERCEPT	-18.090	-.647	
GNI: X_1	-.001	-1.892	-.226
ENG: X_2	-.001	-.487	-.039
TFR: X_3	-2.933	-.634	-.145
URB: X_4	-.303	-2.403	-.198
DEN : X_5	.010	1.983	.130
DEP: X_6	2.060	2.254	.443
EAF: X_7	.422	3.828	.240
SSF: X_8	-.185	-1.462	-.188
CPI: X_9	-.555	-.279	-.025
N= 68 R^2 = 0.795 F = 25.005			

Detection of Multicollineartiy

To this end, first the bivariate correlation table is examined. Two of the nine explanatory variables – total fertility rate and the percentage of the dependent population – are highly correlated (correlation coefficient r = -0.840). Also two of the nine possible R^2s from the regressions of each explanatory variable on all other explanatory variables – one from the regression of TFR (X_3), and the other from the regression of DEP (X_6) – are very large – 0.93 and 0.91 respectively. These values of r and R^2 indicate the presence of multicollinearity in the data.

In order to gauge how precise an OLS estimated regression coefficient is, we need to consider its variance which is proportional to the variance σ^2 of the residual term in the regression model, the constant of proportionality being termed variance inflation factor (VIF). The VIF for the coefficient b_i is given by $\frac{1}{R_i^2}$ where R_i^2 is the square of the multiple correlation coefficient obtained from the regression of the ith explanatory variable on all other explanatory variables. As R_i^2 approaches 1, indicating the presence of a linear relationship among the explanatory variables, the VIF for b_i tends to infinity. Usually, a VIF in excess of 10 is considered as an indication that multicollinearity may cause problems in estimating the parameters.

If there are p explanatory variables, the expected squared distance of the OLS estimators from their true values is given by [9]

$$L^2 = \sigma^2 \sum_{i=1}^{p} VIF_i \tag{2}$$

The smaller the distance, the more accurate are the OLS estimates. In case the explanatory variables are orthogonal, each VIF will be equal to 1 and $L^2 = p\sigma^2$. Hence the ratio

$$Q = \frac{\sigma^2 \sum VIF_i}{p\sigma^2} = \frac{\sum VIF_i}{p} \tag{3}$$

can also be used as a measure of multicollinearity – a large value of Q indicating the presence of multicollinearity. Table 3 shows the variance inflation factors for the OLS regression coefficients.

TABLE II. VARIANCE INFLATION FACTORS

X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
4.025	1.783	14.788	1.929	1.220	10.918	1.110	4.666	2.206

As can be seen from table 2, the VIFs for the coefficients of X_3 and X_6 are both greater than 10 (14.788 and 10.918 respectively) indicating that the multicollinearity may be present. Also,

$Q = \frac{42.645}{3} = 14.215$ implies that the distance of the OLS estimators from their true values as measured by Q is over 14 times greater than what would be if the explanatory variables were orthogonal. All the above values also point to the presence of multicollinearity.

Application of Ridge Regression

When multicollinearity is present, a technique called Ridge regression is used to estimate the parameters. It is an estimation technique [16, 17] which produces estimates in the face of multicollinearity that are closer, on the average, to the true population parameter than are the OLS estimates [13]. The OLS estimator is given by $\hat{\beta} = (X'X)^{-1} X'Y$ while the ridge estimator for a given value of k is obtained as $\hat{\beta}$ (k)= $(X'X + kI)^{-1} X'Y$ where k is the bias parameter which takes values in the interval from 0 to 1 [17]. This is because the problem stems from the inflated values in the diagonal of the inverse matrix, and the addition of kI to $X'X$ counters this tendency [20].

The ridge estimates obtained for small values of k may be viewed as resulting from a set of data that have been slightly changed. If multicollinearity is a problem, the ridge estimates will show large fluctuations for small values of k, demonstrating instability. In other words, multicollinearity is detected by observing the instability in the estimated coefficients resulting from slight changes in the estimation data. We are concerned with those values of k for which stability is achieved. Since the size of k is directly related to the amount of bias introduced, it is desirable to select the smallest value of k for which stability occurs. Obviously for k = 0, the ridge estimates are also the OLS estimates.

In our analysis a significant instability is not warranted among the ridge estimates, that is, the estimated coefficients did not show large fluctuations for small values of k. This is also evident from the fact that the VIFs are in excess of 10 for the coefficients of X_3 and X_6 only by 4.788 and 0.918 respectively (table 3). These small excess values, although indicate the presence of multicollinearity, show that the multicollinearity is not large enough to plague the results severely. Hence, the OLS estimates may well be used to describe the relation between Y and the explanatory variables. The model is, therefore,

$$Y = -18.090 - 0.001X_1 - 0.001X_2 - 2.933X_3 - 0.303X_4 + 0.010X_5 + 2.060X_6 + 0.422X_7 - 0.185X_8 - 0.555X_9$$

Or, POVERTY = -18.090 – 0.001 GNI – 0.001 ENG – 2.933 TFR – 0.303 URB + 0.010 DEN + 2.060 DEP + 0.422 EAF – 0.185 SSF – 0.555 CPI (4)

The coefficients show that a one unit increase in total fertility rate, corruption index, percentage of urban population, gross national income per capita, energy use per capita, and percentage of females in secondary education decrease the poverty level, i.e., the percentage of people living below $2 a day, by 2.933, 0.555, 0.303, 0.001, 0.001 and 0.185 respectively, while a one percent increase in the dependent population, a one percent increase in the economically active females, and a one unit increase in density increase the poverty level by 2.060, 0.422, and 0.010 respectively.

In order to evaluate the relative importance of the explanatory variables in determining the level of poverty the standardized coefficients are also examined (table 1). The table shows that the percentage of dependent population has the largest positive impact on the poverty level - the higher the percentage of dependent population, as measured in standard deviation units, the higher the poverty level (0.443), followed by the percentage of economically active female, (0.240), and population density (0.130). The largest contribution for lowering the poverty level is the gross national income per capita (-0.226), followed by the percentage of urban population (-0.198), percentage of females in secondary school (-0.188), and total fertility rate (-0.145) in that order.

It is to be noted that five of the nine explanatory variables have demonstrated the hypothesized directions of the relationships with poverty. It is difficult to interpret the negative relationships of the variables - corruption index and total fertility rate, and the positive relationships of the variables - density and the percentage of economically active female with poverty. The directions of such relationships are counter to our expectations, and whether these directions will persist after inclusion of other variables and more data from other countries into the analysis remains to be seen.

4. SUMMARY AND CONCLUSIONS

Although the per capita income of the developing countries has increased annually by an average of 3 percent since 1990, the number of people living in extreme poverty has also increased considerably in some regions. Given that the aim of all governments is to reduce poverty to its minimum possible level, it is important to analyze the correlates of poverty to identify their relative weights necessary for ascertaining priorities while formulating social and economic policies.

This paper analyzed the cross-national variations in poverty level measured as the percentage of population living below US $2 per day with national level data for 68 countries for which data on all the relevant variables are available. The analysis shows that the gross national income per capita contributes most in lowering poverty level, followed by the percentage of urban population, percentage of females enrolled in secondary school, and total fertility rate, in that order.

The study has a number of policy implications. The gross national income appears to be the most important contributor to the reduction of poverty. It is rational to think that the poverty level will decrease with the increase in the income growth since such an increase generally generates employments as well as raises wages [18]. This is supportive of the contention that the economic growth is strongly negatively related to poverty [15, 18]. The second most important variable that contributes negatively to the poverty level is urbanization - the higher the percentage of the urban population the lower the poverty. The next important factor that contributes in the reduction of poverty is the female education at the secondary level.

The study has a number of limitations as well. Due to a lack of availability of data a number of important variables could not be included. For example, family structure is known to influence poverty [18, 21]. Also, the level of unemployment may be construed to be associated with poverty. Unfortunately, none of these variables could be included in the analysis. Moreover, data from only 68 countries have been used in this paper. It is difficult to interpret as to how the total fertility rate and corruption index negatively impact poverty, and percentage of economically active female, and population density impact poverty positively

Efforts made by many governments to reduce poverty level, particularly in the developing countries, are usually guided by the equation: more resources = less poverty. Although this basic formula is consistent with conventional wisdom, there is a growing literature [4, 10, 11] to suggest that empirically it does not work, unless the distribution of resources is even. The poor may not be able to escape the vicious circle of poverty without targeted assistance. The rich are reaping more benefits while the others are paying a greater cost.

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APPENDIX

Country	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Algeria	15	6770	773	2.4	49	36	36	7	74	2.8
Egypt	44	4440	985	3.1	43	195	40	20	85	3.4
Morocco	14	4360	3433	2.5	55	184	35	27	36	3.2
Tunisia	7	7900	483	2	65	160	34	24	81	4.9
Benin	74	1110	340	5.6	40	200	47	69	16	2.9
Cote d'I	49	1490	397	5.1	47	158	44	44	16	1.9
Ghana	79	2370	411	4.4	44	245	43	73	34	3.5
Senegal	63	1770	319	5.3	45	157	47	61	15	3.2
Kenya	58	1170	489	4.9	36	155	45	74	30	2.1
Mozambiq	78	1170	436	5.4	32	64	46	83	10	2.8
Tanzania	90	730	408	5.7	32	104	48	87	5	2.9
Zambia	94	950	639	5.7	35	41	48	66	21	2.6
Zimbabwe	83	1940	751	3.6	34	87	44	65	38	2.6
Cameroon	51	2150	417	4.9	53	94	46	29	48	2.2
Namibia	56	7910	599	3.9	33	6	46	54	65	4.3
South Af	34	12120	2502	2.8	53	100	37	48	90	4.5
Costa Ri	8	9680	904	1.9	59	217	34	42	68	4.2
El Salva	41	5120	670	3	59	862	41	46	56	4.2

Country	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Guatemal	32	4410	616	4.4	39	310	47	23	38	2.5
Mexico	20	10030	1560	2.4	75	143	37	38	78	3.5
Nicaragu	80	3650	544	3.3	59	112	43	36	61	2.6
Panama	17	7310	1028	2.7	62	113	36	46	72	3.5
Dom.Repu	11	7150	948	2.8	64	479	38	38	75	3
Jamaica	13	4110	1493	2.3	52	628	38	53	85	3.6
Argentin	23	13920	1543	2.4	89	36	37	46	103	2.8
Bolivia	42	2740	499	3.8	63	21	43	60	83	2.5
Brazil	21	8230	1093	2.3	81	57	34	54	113	3.7
Chile	10	11470	1585	2	87	56	33	36	90	7.3
Colombia	18	7420	625	2.4	75	106	36	58	69	4
Ecuador	37	4070	706	3.2	61	121	39	54	59	2.5
Paraguay	33	4970	709	2.9	57	40	36	35	64	2.1
Peru	32	5830	450	2.4	73	57	37	56	86	3.5
Uruguay	6	9810	747	2.2	93	48	37	49	108	5.9
Venezual	28	6440	2141	2.7	88	77	36	55	74	2.3
Armenia	31	5060	7943	1.7	64	262	33	60	92	2.9
Azerbaij	1	4890	1435	2	52	254	31	43	79	2.2
Jordan	7	5280	1036	3.7	82	164	41	22	87	5.7
Yemen	45	920	221	6.2	26	106	50	29	27	2.7
Banglade	83	2090	155	3	23	2637	38	56	49	1.7
India	80	3460	513	2.9	29	884	40	41	42	2.9
Iran	7	8050	2044	2	67	112	34	11	75	2.9
Kazaksta	16	7730	3123	2.2	57	15	35	65	88	2.6
Nepal	69	1530	353	3.7	14	457	45	57	37	2.5
Pakistan	74	2350	454	4.6	34	539	45	16	19	2.1
Sri Lank	42	4520	430	2	20	784	33	36	89	3.2
Tajikist	43	1260	518	3.8	26	127	35	55	74	2.1
Indonesi	52	3720	737	2.4	42	307	34	52	58	2.2
Malaysia	9	10320	2129	2.6	62	211	37	44	73	5.1
phlillip	48	5300	525	3.4	48	745	39	53	86	2.5
Thailand	25	8440	1353	1.7	33	329	30	65	81	3.8
China	47	6600	960	1.6	37	355	28	74	62	3.2
South Ko	1	21850	4272	1.1	82	1265	29	49	90	5
Estonia	8	15420	3324	1.5	69	77	32	52	97	6.4
Latvia	5	13480	1825	1.3	68	92	32	50	95	4.2
Lithuani	8	14220	2476	1.3	67	135	32	53	100	4.8
Belarus	1	7890	2496	1.2	72	121	30	53	88	2.6
Bulgaria	6	8630	2417	1.3	70	180	31	44	93	4
Hungary	1	16940	2505	1.3	65	280	32	47	104	5
Moldova	64	2150	703	1.3	45	306	30	54	73	2.9
Poland	1	13490	2333	1.3	62	306	30	48	100	3.4
Romania	13	8940	1696	1.3	55	234	30	48	85	3
Russia	12	10640	4288	1.3	73	22	29	53	92	2.4
Slovakia	3	15760	3448	1.3	56	285	29	53	90	4.3
Ukraine	5	6720	2684	1.2	68	201	30	58	97	2.6
Albania	12	5420	617	1.9	45	284	35	49	80	2.4
Croati1a	1	12750	1852	1.4	56	204	32	45	89	3.4
Portugal	1	19730	2546	1.4	53	299	33	55	117	6.5
Slovenia	1	22160	3486	1.2	49	256	29	50	108	6.1