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Targeting Poverty and Developing Sustainable Development Objectives for the United Nation's Countries using a Systematic Approach Combining DRSA and Multiple Linear Regressions

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Abstract

The objectives of this article is to target poverty using Dominance-based Rough Set Approach (DRSA) to help the United Nation's Countries develop objectives for sustainable development. There are 12 variables divided into 2 perspectives. The first is an economical and technological perspective composed of 6 variables. The second is a sociological and political perspective composed of 6 variables. The methodology proposed classifies all the United Nation's countries according to three different categories: [A] Developed countries; [B] Emerging economies that need support to acquire category A status; [C] Under Developed countries ranked the lowest and needing special support with regard to the criterion or criteria considered. Using this classification, DRSA provides decision rules to explain the classification and indicating precisely what are the conditions to be part of a higher category. Also, the results indicate what are the conditions to be part of the Under Developed countries category and therefore helps targeting poverty and proposing, at the same time, objectives to improve this classification. Finally, we used Multiple Linear Regressions with selected decision rules to test selected decision rules as the Gross National Income per capita as the dependent variable.

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1 Introduction

Observing and studying poverty can be quite heartbreaking. No one can stay indifferent facing the extreme poverty of an individual, community or an entire state. Often, in the developed countries, a person living in poverty may be accused that his or her poverty is caused by their own fault or that poverty is intrinsic to the individual. The first preconceived ideas are laziness, mental state, drug use, social, cultural, racial background or simple bad luck. Therefore we are searching for causes, factors and why this person is now living in poverty. These preconceived notions are spread especially when we are living in a country classified as economically developed and politically stable. When we observe extreme poverty, on our computer screen or in the media, and this poverty is distant from us in another country qualified as underdeveloped, then preconceived ideas and the causes of poverty are now caused by the environment that the individual is living in. It is no longer the fault of the individual but extrinsic causes. These extrinsic causes are now rationalised as the climate, drought, political instability, internal conflicts or war. When we

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witness extreme poverty in a foreign state and since the causes of this poverty are extrinsic to the individuals suffering, the observer might feel powerless and detached from this reality. We propose to define poverty along four different perspectives (economical, political, sociological and technological) and use a systematic approach named Dominance-based Rough Set Approach (DRSA) and Multiple Linear Regression to identify strategic objectives to improve all the countries classifications compared to similar ranking. The ranking of all the countries of the United Nations will be completed with the weighted average. DRSA will determine the decision rules and conditions for each country. We will transform these decision rules into strategic objectives for sustainable development. Finally, using the variables selected from the decision rules, we will test these combinations using Multiple Linear Regression and the Gross National Income per capita as the dependent variable. We hope that the Multiple Linear Regression will bring validity to the DRSA method. It is important to clarify that this research is to determine potential strategic objectives for sustainable development and the use of Multiple Linear Regressions to demonstrate the potential viability of the DRSA.

1.1. Literature Review

1.1.1 DRSA

Proposed by Pawlak (Pawlak 1982, 1991) and by Pawlak and Slowinski (1994), the Rough set theory is a mathematical tool with the aim of supporting decision-making processes. The use of DRSA has extended in other fields such as: medicine, banking, engineering, learning, location selection, pharmacology, finance, market analysis and economics (among other . Greco, Matarazo and Slowinski (2001) extended the methodology and renamed Rough set theory the "Dominance-based Rough Set Approach" (DRSA). Zaras extended it further for mixed data (deterministic, probabilistic and fuzzy) (2006). The DRSA systematic approach helps to resolve multi-criteria sorting problems based on dominance relation (among others Greco et al. 2001, Pawlak 2002, Renaud et al. 2007, Zaras et al. 2012, Marin et al. 2014, Prema et al. 2016, Songbian 2016, Emam et al. 2017, Boudreau et al. 2018, Marin et al. 2019). Since it is possible to classify countries in such a dominance relation using Gross National Income per capita, we believe that DRSA is suitable to deliver rules presented in a comprehensible manner. Also, it is possible to use the systematic approach with incomplete data. This is also a benefit of the DRSA approach since several countries do not provide all the statistics because of several political or structural problems.

1.1.2. Poverty

Poverty has been defined by several organisations like the United Nations, World Bank and UNESCO. The intention of this research is not to propose anything new for the definition of poverty. We are proposing to try a combination of new solutions and strategic objectives. We support the United Nation's definition that poverty is a situation where an individual does not have access to resources and services sufficient to live normally (Smelser et al. 2001) The World Bank discusses two types of poverty: relative poverty and absolute poverty. Relative poverty is qualified as a perception. An individual judges he or she has less revenue than another individual and believes that he or she is relatively poorer than this person. Absolute poverty is the situation where an individual does not have enough revenues to survive (Wagle 2002). There seems to be also biases with regard to other definitions of poverty. We are not arguing that these biases are wrong. We are stating that these biases are simplifying poverty to one indicator or factor. For example, accountants or economics will associate state poverty to strictly economic reasons. One economic indicator often used as a reference to define poverty is the GDP per capita or GNI per capita. A rich country, like the United States, has a GDP per capita of 53 812,50$ (US$) and a poor country, like Afghanistan, has a GDP per capita of 618,30$ (US$) (Wagle 2002) . The problem with this last definition of poverty is that the economical success of any country does not guarantee that poverty is inexistent within the borders of that particular state. In fact, poverty is observable in all states whether they are qualified as developed countries or under developed countries. It is the same for wealth. For example, an under developed country like Haiti has its own quantity of rich people living into capital of Port-au-Prince. In 2012, Haiti had 31.2% income share held by the highest 10% of its population. On the other hand, the United States of America, considered as the economic power, had 1.2% of its population living in abso-

lute poverty in 2016 (World Bank 2018). Poverty is observable in all countries. Some individuals living in poverty are able to get out of the state of absolute poverty and some may not. Some individuals living in wealth might one day find themselves living in absolute poverty. The causes that explain poverty vary from one person to another and one country to another. Poverty also seems to behave like a cancer or mushroom sometimes. We might find cities or regions that are unfavourable to wealth and the majority of the citizens are leaving in absolute poverty. We will also find an island of countries or even an entire subcontinent that have the majority of its citizens living in absolute poverty.

Some solutions to poverty seem to be functioning. Just like individuals, some states seem to be developing economically while others seem to be unable to get out of the under developed category.

Poverty existed throughout history. It exists in all countries of the United Nations weather they are classified as a developed country, emerging economy or undeveloped country. We are therefore proposing the following definition for a country that has a majority of its citizens living in absolute poverty: State poverty happens when a state is unable to create an environment propitious to give access to sufficient needs and services for the survival of its population. By deduction, a developed country or an emerging economy is a state able to create an environment propitious to give access to sufficient needs and services for the survival of its population. From the definition of state poverty, the intrinsic causes are political, economic, sociological or technological.

2 Observations

2.1. State Political Poverty

State Political Poverty is a situation where a state does not have adequate or necessary political structures to create an environment propitious to give access to sufficient needs and services for the survival of its population. Some recognised political indicators are: Political Stability Index (The Economist 2018), Deaths from Internal Conflict Index (CPIA Database 2018), Corruption Perception Index in the Public Sector under-developed, Global Competitiveness Index and Military Expenditures (World Bank 2018). There are several other indicators and the ones previously mentioned are just a sample of several indicators and measures available for researchers. It is therefore safe to admit that a form of state political poverty exists since the type of government, State laws or political situation of the state may create an environment in favour of wealth or poverty. Some countries suffering from political poverty create, on the majority of its population, conditions that forces absolute our relative poverty compared to citizens from another state. The distribution of wealth within a state in return of services varies from one state to another and same as tax revenues.

In order to be qualified as a developed state, the number of death caused by armed conflict index, involving at least one governmental armed group, must be equal to one. If the indicator is larger or equal to 1.26, with military spending at least 2.18% of the GDP combined with competitiveness index smaller than 4.35, the states that are in this situation are mostly qualified as under-developed (Boudreau et al. 2018).

2.2. State Economical Poverty

Economical state poverty is the most discussed type of poverty in scientific literature. An individual that possesses economic wealth may acquire needs and services to be able to survive. State economical poverty is defined as a country in a weak economic situation that is insufficient to provide sufficient needs and services for the survival of its citizens. Popular economic indicators are the Gross National Product, Gross National Income, Broad Money and Exports of Goods and Services. The Unemployment percentages are volatile and vary monthly and still represent the economic health of a specific region at a specific time. Economics will study the percentages of exports of goods and services, commercial balance, exports of merchandise percentages. State economical poverty is caused by the combination of two important indicators; GDP per capita less than 738.64$ (US$) and exports of merchandise per capita smaller

than 200.74$ (US$) (Boudreau et al. 2018). The GDP has several correlations with various economical, sociological, political and technological indicators.

2.3. State Sociological Poverty

State sociological poverty is defined as the situation where a state is unable to offer a social environment allowing its citizens to have access to sufficient needs and services for their survival. Life expectancy, analphabetism, school life expectancy, number of births per adolescents, percentages of the population living in an urban region, number of people living alone are good examples of indicators that are being studied and allow to compare one social environment from another.

Culture and religion are also important components with laws, customs and popular beliefs. Each religion seems to have various opinions about education, gender relations and views about wealth. It is therefore probable that religion impacts individual behaviours, politics, communities and businesses. Religion affects the politics, economy, sociology and even technology of any country. Many religions promote poverty as a way of living. Some religious communities have practitioners who systematically renounce any form of wealth (monetary or materially). For example, Franciscan Monks of the catholic religion will live their life in poverty and Buddhist Monks will rely on offerings from the population to survive. This is a voluntary acceptance of poverty but since they are able to survive, it is not qualified as absolute poverty nor relative poverty as their lifestyle is a choice. On the other hand, some religions seem to have less problems with acquiring wealth. Some communities from Christianity, Judaism and Hinduism are promoting acquisition of wealth. The Amish communities choose to live isolated from the modern society and renounce technology.

2.4. State Technological Poverty

State technological poverty is defined as a country that is technologically undeveloped, lacks innovation affecting the development of its population. It is important to mention that absolute technological poverty does not exist but rather a relative technological poverty. Technological development and innovation allows a country or state to ease the method in which needs and services are delivered. Also, technology allows a country to innovate with all the economical benefits it creates and sociological benefits such as education and health issues. Technology plays an important role in the economical, sociological development of any state. Some countries still do not have access to internet or telephones. This explains why we prefer discussing a relative technological poverty rather than absolute form of poverty.

2.5. State Environmental Poverty

Africa is the poorest continent of the World. Populations are face with insufficient resources, food, worked and medical care. Added to this, several countries are not stable politically or are faced with internal conflicts and high crime rates. The poverty in Africa is multifactorial. When all countries are classified in different categories with regard to political, sociological, economical and technological indicators, most of the countries listed at the bottom of the list are almost all sub-Saharan and more precisely in the region named Sahel. Those countries, part of the Sahel Region suffer from analphabetism, corruption and high adolescent fertility rates (Boudreau et al. 2018). Since most of these countries touch one another and are in the same region, we could argue that the environment is responsible for the continuous poverty. Access to water, polluted air could be important factors responsible for this type poverty. Therefore, state environmental poverty is define as a state that offers insufficient water supplies, dangerous environmental conditions for the health of its people.

3 Research Questions and Hypothesis

From the previous definitions and observations, we propose to research the various causes of state absolute poverty. Several research questions are raised:

a. What are economical, technological, political and sociological decision rules for state economical poverty using DRSA?
b. What is the viability of the DRSA decision rules using Multiple Linear Regressions?

From these research questions, we propose the following hypothesis:
Null Hypothesis 0: There is no cause and relationship between the GNI per capita and sociological, political and environmental indicators.
Alternative Hypothesis 1: There is a cause and relationship between the GNI per capita and sociological, political and environmental indicators.

4 Methodology

4.1 Variables

The data will be taken from the World Bank data base, the United Nations and the International Institute for Strategic Studies (World Bank 2018, CPIA Database 2018, United Nations, 2018) and we collected data of all the United Nation's countries for the year 2016. Table 1 describes the variables. All variables are on a continuous scale. The main reason why we are proposing to use the year 2016 is because some data are still not available from 2017 and we found that 2016 have more results. These variables were separated into two categories. The first category is composed of economical and technological indicators. The second is composed of sociological, environmental and political indicators.
This research suggests the use a systematic approach using a combination of research methods. We will try to determine decision rules for all the United Nation's countries based on a classification of data using Dominance-based Rough Set Approach combined with Multiple Linear Regression to verify the validity of the rules obtained by DRSA.

Table 1: Variables

Variables	Definitions	Indicators	↑= High is better ↓=Low is better
Economical and Technological Indicators			
1.Households Final Consumption expenditure per capita (Constant 2010 US$)	Household final consumption expenditure is the market value of all goods and services, including durable products (cars, home computers) purchased by households. (World Bank 2016)	Amount US$	↑
2.Gross Domestic Product per capita (Current US$)	Gross Domestic Product per capita is the sum of gross value added by all residents producers in the economy. (World Bank 2016)	Amount US$	↑
3.Urban Population (% of total)	Urban population refers to people living in urban areas. (World Bank 2016)	% of population	↑

4.Renewable internal freshwater resources per capita (Cubic Meters)	Internal renewable resources in the country. (World Bank 2016)	Number	↑
5. Internet Users (%)	Individuals who have used the Internet in the last 3 months. (World Bank 2016)	% of population	↑
6. Scientific Technical Journals per capita	Number of scientific and technical journal articles published per 1 000 000 people.	Number	↑
Sociological, Environmental and Political Indicators			
7. Mortality rate under 5 (per 1000 live births)	Probability per 1000 that a newborn baby will die before reaching age 5. (World Bank 2016)	Number out of 1000 newborns	↓
8. Adolescent fertility	Number of births per 1000 women ages 15-19 (World Bank 2016).	Number out of 1000 female adolescents	↓
9. Mortality rate attributed to air pollution	Mortality rate attributed to household and ambient air pollution per 100 000 population. (World Bank 2016)	Number per 100 000 population	↓
10. Probability of dying at age 5-14 years old (per 1000 children)	Probability of dying between age 5-14 years of age per 1000 children aged 5. (World Bank 2016)	Number per 1000 children aged 5)	↓
11. School enrolment, tertiary (% Gross)	Ratio of total enrolment, regardless of age, to the population of the age group that corresponds to the level of education. Normally requires completion of secondary level education. (World Bank 2016)	%	↑
12. Corruption Perception Index	The corruption perception index ranks 180 countries and their perceived levels of public sector corruption according to experts and business people. The scale is 0-100. 0 is highly corrupt and 100 is very clean. (2017 Transparency International)	0-100	↑

4.2 The Dominance-based Rough Set Approach (DRSA) Applied to Determine the Strategic Developmental Objectives of the United Nations countries.

To help determine the strategic objectives of the United Nations countries, the methodology used is the Dominance-based Rough Set Approach (DRSA). The methodology has three steps:

1. The first step, we separated the indicators into three categories. The first category is the overall (O) results where all the indicators classify the 193 U.N. countries. The second category is the economical and technological (ET) perspective where all the economical and technological indicators classify the 193 U.N. countries. The third category is the Sociological, Political and Environmental (SPE) perspective where all the respective indicators classify all the 193 U.N. countries;
2. Secondly this methodology continues with the classification of all the United Nations countries for each perspectives (O, ET and SPE), in category A, B or C : Category [A] Developed countries; [B] Emerging economies that need support to acquire category A status; [C] Under Developed countries ranked the lowest and needing special support with regard to the criterion or criteria considered. These classifications are presented in Annex A, where all the 193 U.N. countries are categorised using the overall (O) classification;
3. Thirdly, we extract decision rules for each classification. Fourth, we use the decision rules to identify potential strategic objectives for sustainable development and compared to each country's respective actual performance. Finally, we will use the indicators found in the decision rules and compare with Multiple Linear Regressions using GNI per capita as the dependent variable. Table 2 describes the entire methodology.

Table 2: Methodology

STEPS	**ACTIVITIES**	**RESULTS**
1	Separate all indicators into 3 categories	Overall indicators Economical and Technological indicators (ET) Sociological, Political and Environmental indicators (SPE)
2	Classification	Category A: Developed countries Category B: Emerging economies Category C: Under developed countries
3	Extraction of decision rules for each classification (O, ET, SPE)	Three set of decision rules
4	Defining strategic objectives for each country for sustainable development.	Strategic objectives for each country
5	Multiple Linear Regressions	Test validity of decision rules results and make predictions.

4.3 Formulation of the multi-criteria problems

Our first task was to get the overall ranking of the 193 countries on the basis of the 12 criteria measured by 12 indicators. Secondly, we did the same but for each perspective according to its respective criteria. That approach can be described with the use of the AXE model, where:

A is a finite set of countries a_i for i = 1, 2… 193;

X is a finite set of criteria X_k for k = 1, 2 ,…, 12 or X_{kj} for kj =1,2,…, nj for each perspective j.

E is the set of evaluations measured by indicators $e_{i,k}$ with respect to criterion X_k or indicators $e_{i,kj}$ with respect to criterion X_{kj} for each perspective j.

The weighted average rank method was used to obtain the ranking of countries. Thus, countries were ranked from the most to the least preferable in regards of each indicator in relation to each criterion. Since weights of indicators are considered equal, we calculated the weighted average rank for each country. This enable us to obtain the ranking of the countries with respect to a given perspective as well for the overall classification.

For each perspective j, the weighted average of country i *is*

$$r_{i_j} = \sum_{k_j} w_{k_j} r_{k_j i} \quad (1)$$

The overall weighted average of country i is

$$r_i = \sum_k w_k r_{ki} \quad (2)$$

where w_k is the weight of criterion k and w_{kj} is that for perspective j;

r_{ki} is the rank of country i with respect to criterion k and is that for perspective j.

With the classifications of 193 countries, overall and for each perspective, the following step is to group them into three categories A, B and C. Annex A presents these classifications of the 193 United Nation's countries according to the two perspectives (ET, SPE) as well for the overall (O).

4.4 Decision Rules

In order to identify the decision rules, we used the 4eMka2 software, which was developed by the intelligent decision support systems laboratory (IDSS) at the computing science institute of the Poznan University of Technology. This system extracts classification rules from the proposed list of variables (Greco et al. 1999). Rules for the two perspectives and the overall combination are presented below in Table 3, 4 and 5. Since we wanted to get the most significant combination, we only kept rules with a minimal relative strength of 25% and those that were limited to 4 conditional criteria.

Table 3: Decision Rules for the Overall perspective

#	Decision Rules	Condition 1	Condition 2	Condition 3
1	Decision at least A	Mortality 5 years ≤ 5.4 deaths per 1000		
2	Decision at least A	Urban population ≥ 81.86%	Mortality 5 years ≤ 16.3 deaths per 1000	
3	Decision at least B	Internet Users ≥ 47.5%		

#	Decision Rules	Condition 1	Condition 2	Condition 3
4	Decision at least B	Adolescent Fertility ≤ 10.42 per 1000		
5	Decision at least B	Scientific articles ≥ 354.69 per million people	Mortality 5 years ≤ 22.9 deaths per 1000	
6	Decision at most C	Mortality 5 years ≥ 65.2 deaths per 1000	Internet Users ≤ 46.79%	
7	Decision at most C	GDP per capita ≤ 2143.93$	Urban population ≤ 33.18%	
8	Decision at most C	GDP per capita ≤ 2143.93$	Adolescent Fertility ≥ 67.64 per 1000	

Table 4: Decision Rules for the ET perspective

#	Decision Rules	Condition 1	Condition 2	Condition 3
9	Decision at least A	Urban population ≥ 79.84%	House Consumption ≥ 3076.54$	
10	Decision at least A	Internet Users ≥ 75.9%	Scientific articles ≥ 1324.69 per million people	Urban population ≥ 66.88%
11	Decision at least B	Urban population ≥ 77.54%	GDP per capita ≥ 2913.97$	
12	Decision at least B	Renewable Water ≥ 10291.49 Cubic Meters	Urban population ≥ 39.43%	GDP per capita ≥ 1762.81$
13	Decision at least B	Scientific articles ≥ 119.69 per million people	Renewable Water ≥ 287.63 Cubic Meters	Urban population ≥ 68.35%
14	Decision at most C	GDP per capita ≤ 1493.51$	Urban population ≤ 59.92%	
15	Decision at most C	GDP per capita ≤ 2175.66$	Renewable Water ≤ 19.61 Cubic Meters	

Table 5: Decision Rules for the SPE perspective

#	Decision Rules	Condition 1	Condition 2	Condition 3
16	Decision at least A	Mortality 5 years ≤ 5.4 deaths per 1000	School Tertiary Enrolment ≥ 47.8%	
17	Decision at least B	Probability of death 5-14 ≤ 3.5 per 1000	School Tertiary Enrolment ≥ 36.85%	
18	Decision at least B	Mortality 5 years ≤ 25 deaths per 1000	Adolescent Fertility ≤ 74.74 per 1000	
19	Decision at least B	Adolescent Fertility ≤ 36.92 per 1000	Probability of death 5-14 ≤ 4.4 per 1000	School Tertiary Enrolment ≥ 28.84%

In the «at most C classification» for the SPE perspective, we found two combinations of 4 decision rules that are worth publishing to identify poverty in under developed countries. Table 6 shows these findings.

Table 6: At most C classification decision rules with four conditions

Decision Rules	Condition 1	Condition 2	Condition 3	Condition 4
At most C	Probability of death 5-14 ≥ 9.8 per 1000	School Tertiary Enrolment ≤ 17.21%	Corruption ≤ 40 out of 100	Mortality due to pollution ≥ 78.1 per 100 000 people
At most C	Corruption ≤ 27 out of 100	Mortality 5 years ≥ 28.6 deaths per 1000	Adolescent Fertility ≥ 24.83 per 1000	School Tertiary Enrolment ≤ 21.28%

A study demonstrated that to be qualified as an under developed country, the decision rules are an adolescent fertility rate higher than 42.75 per 1000 adolescents combined with an urban population less than 35.04% and school life expectancy less than 10 years. On the other hand, the combination of urban population higher than 89.55%, school life expectancy more than 11 years and life expectancy for men higher than 73.68 years demonstrates that you will be most likely qualified as a developed country. Finally, to be qualified as developed country, the percentage of internet users must be over 80.48% combined with academic papers higher than 18.05 per million people (Marin et al. 2019). We have therefore selected the variables shown in table 1 to verify how they impact the GNI per capita of a selected country and verify if we can make predictions about how a country might improve it's GNI per capita if the variables change over time.

The first step is to produce the correlation matrix for the 12 variables. We will expose linear relations between the selected variables. Only the correlations having a p-value (Sig.) $\alpha = 0.05$ are presented in the correlation matrix.

The second step is to conduct simple linear regressions for all the independent variables that correlate significantly with the dependent variable GNI per capita. We wish to be able to predict the GNI per capita from the independent variables. For the linear regressions, the null hypothesis are that they do not have a relationship between the dependent variable and the independent variables and does not predict the de-

pendent variable. The alternative hypotheses is that it is possible to predict the GNI per capita from the independent variables. The relations studied has the following form:

$Y \leftarrow X$
Y is the variable GNI per capita
X is an independent variable
Simple linear regression should give us formulas to help us study the link between each independent variable and the variable GNI per capita. The Formulas obtained are the following:

$$\hat{y} = a + b_1 x_1 \quad (3)$$

For each simple linear regression, we will present a model summary explaining the linear correlation coefficient R and the R^2 which is the percentage of the total variation Y that is explained by the regression line. The R^2 adjusted are estimates of how robust is the model if a different sample came from the same population or subject.

Also, we will provide the ANOVA table that allows to analyse the following hypothesis test:
H_0 = The regression is not significant in the population
H_1 = The regression is significant in the population
The last table displayed for simple linear regressions will be the Coefficients tables. These tables will allow to determine which independent variables contribute to the model and are significant p-value (Sig.) $\alpha = 0.05$.

Finally, we will use the multiple linear regressions in order to explain, or predict, the variance of the GNI per capita with the help of a combination of independent variables. The null hypothesis is that there is no linear relation between the combination of independent variables (x_1, x_2, x_3, x_n) and the dependent variable Y. The formulas obtained are the following:

$$\hat{y} = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 \quad (4)$$

Where

a is the value of $\hat{Y}$ when all the values of the independent variables are null.

b_j is the size of the variation of $\hat{Y}$ when the particular variable X_j increases by 1 unit and the value of all the other independent variable is constant.

The multiple regression process is used to verify the validity of the DRSA method in economics. There are several other econometrics methods that could verify, in better detail, the cause and effect relationships overtime. The purpose of this research is to compare the DRSA decision rules collected and multiple linear regression as a supplement to add validity to the approach.

5 Data

5.1. Correlations

Table 7 is the correlation matrix for the 12 variables. Only the significant correlation at 0.01and 0.05 are displayed.

Table 7: Correlations Matrix

Variables	HC	GDP	UP	RF	IU	SJ	M5	AF	MP	PD	SET	CPI
Households C.	**1**											
GDP per capita	**.891**	**1**										
Urban Pop.	**.525**	**.421**	**1**									
Renewable F.				**1**								
Internet Users	**.728**	**.647**	**.673**		**1**							
Scient. Journ.	**.826**	**.835**	**.532**		**.708**	**1**						
Mortality 5 yrs	**-.518**	**-.457**	**-.530**		**-.795**	**-.512**	**1**					
Adolescent F.	**-.517**	**-.498**	**-.420**		**-.689**	**-.551**	**.778**	**1**				
Mortality Pol.	**-.601**	**-.582**	**-.605**		**-.812**	**-.583**	**.870**	**.650**	**1**			
Prob. of Death	**-.462**	**-.407**	**-.498**		**-.724**	**-.450**	**.907**	**.798**	**.823**	**1**		
School Enr. T.	**.635**	**.421**	**.667**		**.755**	**.694**	**-.724**	**-.625**	**-.710**	**-.644**	**1**	
Corruption PI	**.807**	**.790**	**.512**		**.755**	**.786**	**-.585**	**-.546**	**-.613**	**-.501**	**.596**	**1**

5.2 Multiple Linear Regression Decision Rule #9, #10 and #18

Table 8 displays the results for the multiple linear regression based on the results of the decision rule 9, 10 and 18. For all three models, GNI per capita is the dependent variable. Model 1 independent variables are household consumption per capita and urban population percentages. Model 2 independent variables are Internet Users, Scientific Journals and Urban population. Model 3 independent variables are Mortality rates under 5 years old per 1000 and School enrolment tertiary percentages.

Table 8 : Models Summaries

Model 1	**Correlation R**	**R^2**	**R^2** adjusted	Standard error of estimate
1. GNI is the dependent variable. Household consumption per capita and urban population % are independent variables.	0.912	0.832	0.830	7328.98058
Model 2	**Correlation R**	**R^2**	**R^2** adjusted	Standard error of estimate

2. GNI is the dependent variable. Internet Users, Scientific Journals and Urban Population are Independent variables	0.874	0.764	0.760	8530.17406
Model 3	**Correlation R**	**R** ^{2}	**R** ^{2} adjusted	Standard error of estimate
3. GNI is the dependent variable. Mortality Rate under 5 years and School Tertiary % are the independent variables.	.571	.326	.316	15308.30635

5.2.1 General Test: ANOVA Decision Rule #9, #10 and #18

We verify if the predictive variables explain the dependent variable GNI per capita. We verified if all the regression coefficients are equal to 0. Table 9 shows the Anova Tests conducted with SPSS.

The null hypothesis for both test is:

$$H_0 : B_1 = B_2 = B_3 = B_{34}$$

The alternative hypothesis for both test is:

$$H_1 : \text{at least one of the } B_j \neq 0$$

Table 9: Anova Test for the multiple regressions for Decision Rule #9, #10 and #18

Model 1	Sum of Squares	df	Mean Square	F	Sig.
Regression	42565874832.819	2	21282937416.410	396.227	0.000
Residual	8594233010.126	160	53713956.313		
Total	51160107842.945	162			
Model 2	Sum of Squares	df	Mean Square	F	Sig.
Regression	40072448648.576	3	13357482882.859	183.573	.000
Residual	12369857827.286	170	72763869.572		
Total	52442306475.862	173			
Model 3	Sum of Squares	df	Mean Square	F	Sig.
Regression	15514057814,.577	2	7757028907.289	33.101	.000
Residual	32105161324.708	137	234344243.246		
Total	47619219139.286	139			

5.2.2. Coefficients Decision Rule #9, #10 and #18

As displayed in table 10, the beta weight and statistical significance will be analysed. All of the variables show significance.

Table 10: Coefficients for Decision Rule #9, #10 and #18

Model 1	Unstandardised Coefficients		Standardised coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	-6893.327	1684.682		-4.092	.000
Urban Population	159.761	30.219	-.194	5.088	.000
Household Consumption	1.480	0.071	.795	20.887	.000
Model 2	Unstandardised Coefficients		Standardised coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	-6049.837	1860.293		-3.252	.001
Internet Users	132.136	40.230	.214	3.284	.001
Scientific Journals	9.751	.810	.635	12.038	.000
Urban Population	84.833	41.403	.111	2.049	.042
Model 3	Unstandardised Coefficients		Standardised coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	8302.103	44223201		1.877	0.063
Mortality Rate Under 5 per 1000	-158.707	66.836	-.242	-2.375	0.019
School Enrolment Tertiary	234.211	64.496	.370	3.631	.000

6 Data Analysis

6.1 Correlations

The correlation matrix dictates that the GNI per capita is strongly correlated to all economical and technological indicators selected as well as the selected sociological, political, environmental indicators. The only indicator that shows low correlation is the renewable fresh water indicator. We believe that the states GNI with low fresh water supplies might not be correlated because of several countries with low water supplies but large amount of oil exportation revenues per capita. This, of course, should be research fur-

ther to explain this lack of statistical link between the GNI and fresh renewable water supplies at the Continent levels and Regional Levels.

6.2 Multiple Linear Regressions

6.2.1. First Multiple Linear Regression Model

For the first model studied the GNI per capita as the dependent variable and households final consumption per capita and urban population percentages as the independent variables. A total of 162 states were included in the analysis. When combined, 83.2% of the variability of the GNI per capita is explained.
The Anova test rejects H_0 and the multiple regression is significant, therefore:
H_1 *: at least one of the* $B_j \neq 0$
All coefficients show a p-value $p < 0.05$. All the coefficients are significant and demonstrate a relationship with the dependent variable GNI per capita.
The regression equation for the first multiple regression is:
$\hat{y} = -6893.327 + 153.761x_1 + 1.480x_2$

6.2.2. Second Multiple Linear Regression Model

The second model studied the GNI per capita as the dependent variable and the percentage of Internet Users, the number of scientific articles published per 1 000 000 people and the urban population percentages. A total of 173 states were included in the analysis. When combined, 76.4% of the variability of the GNI per capita is explained by those independent variables.
The Anova test rejects H_0 and the multiple regression is significant, therefore:
H_1 *: at least one of the* $B_j \neq 0$
All coefficients show a p-value $p < 0.05$. All the coefficients are significant and demonstrate a relationship with the dependent variable GNI per capita.

The regression equation for the first multiple regression is:
$\hat{y} = -6049.837 + 132.136x_1 + 9.751x_2 + 84.833x_3$

6.2.3. Third Multiple Linear Regression Model

The third model studied the GNI per capita as the dependent variable and the independent variables are the percentages of school enrolment at the tertiary level and the mortality rate at age under 5 per 1000. A total of 139 states were included in the analysis. When combined, 32.6% of the variability of the GNI per capita is explained by those independent variables.
The Anova test rejects H_0 and the multiple regression is significant, therefore:
H_1 *: at least one of the* $B_j \neq 0$
All coefficients show a p-value $p < 0.05$. All the coefficients are significant and demonstrate a relationship with the dependent variable GNI per capita.
The regression equation for the first multiple regression is:
$\hat{y} = 8302.103 – 158.707x_1 + 234.211x_2$

7 Conclusions

We reject the Null Hypothesis and accept the Alternative Hypothesis that there is a cause and effect relationship between sociological, political and environmental indicators and the Gross National Income per capita of a country.
The DRSA method is viable and demonstrates what combination of indicators are defining poverty and the values that under developed countries must reach to improve sociologically, environmentally, economically, politically and technologically. Policymakers of underdeveloped countries could develop specific strategic objectives to improve their classification based on the proposed decision rules.

Multiple linear regressions of the decision rules bring validity to the DRSA method but does not prove that all the decision rules contribute to explain the variability of the GNI per capita (see Third Multiple Linear Regression Model). We believe that DRSA should be considered as a potential tool for identifying the value of indicators to improve countries classifications.

7.1. Limits of the Research

It is important to state that several multiple regressions based on the DRSA method are not usable to demonstrate all the decision rules. In many cases, collinearity could explain why many regressions are not published in this research.

7.2 Future Research

We propose that fresh water supplies and other climate indicators be used in other researches to identify if these factors may cause poverty. We also propose to segment continents or economic regions to verify if there are decision rules to support this statement. The impact of the corruption perception index, adolescent fertility and school enrolment at the tertiary level on the economy of a country should be the subject of future research.

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Appendix

Country Name	ET	SPE	O
Afghanistan	C	C	C
Albania	B	B	B
Algeria	B	B	B
Andorra	A	A	A
Angola	C	C	C
Antigua and Barbuda	B	A	B
Argentina	A	A	A
Armenia	B	B	B
Australia	A	A	A
Austria	A	A	A
Azerbaijan	B	B	B
Bahamas. The	A	A	A
Bahrain	A	A	A
Bangladesh	C	C	C
Barbados	B	A	A
Belarus	B	A	A
Belgium	A	A	A
Belize	B	B	B
Benin	C	C	C
Bhutan	B	B	B
Bolivia	B	C	B
Bosnia and Herzegovina	B	A	B
Botswana	B	B	B
Brazil	A	B	A
Brunei Darussalam	A	A	A
Bulgaria	B	A	A

Burkina Faso	C	C	C
Burundi	C	C	C
Cabo Verde	B	B	B
Cambodia	C	C	C
Cameroon	C	C	C
Canada	A	A	A
Central African Republic	C	C	C
Chad	C	C	C
Chile	A	A	A
China	B	B	B
Colombia	A	B	B
Comoros	C	C	C
Congo. Rep.	B	C	C
Costa Rica	A	A	A
Cote d'Ivoire	C	C	C
Croatia	A	A	A
Cuba	B	B	B
Cyprus	A	A	A
Czech Republic	A	A	A
Democratic Peop. Rep. of Korea	C	B	B
Democratic Rep. of Congo	C	C	C
Denmark	A	A	A
Djibouti	C	B	C
Dominica	B	B	B
Dominican Republic	B	B	B
Ecuador	B	B	B
Egypt. Arab Rep.	C	B	B
El Salvador	B	B	B
Equatorial Guinea	B	C	C
Eritrea	C	C	C

Estonia	A	A	A
Eswatini	C	C	C
Ethiopia	C	C	C
Fiji	B	B	B
Finland	A	A	A
France	A	A	A
Gabon	A	C	B
Gambia. The	C	C	C
Georgia	B	B	B
Germany	A	A	A
Ghana	C	C	C
Greece	A	A	A
Grenada	B	A	B
Guatemala	B	C	B
Guinea	C	C	C
Guinea-Bissau	C	C	C
Guyana	B	C	B
Haiti	C	C	C
Honduras	B	B	B
Hungary	A	A	A
Iceland	A	A	A
India	C	B	C
Indonesia	B	B	B
Iran. Islamic Rep.	B	B	B
Iraq	B	C	C
Ireland	A	A	A
Israel	A	A	A
Italy	A	A	A
Jamaica	B	B	B
Japan	A	A	A

Jordan	B	B	B
Kazakhstan	B	B	B
Kenya	C	C	C
Kiribati	C	C	C
Kuwait	A	A	A
Kyrgyz Republic	C	B	C
Lao PDR	C	C	C
Latvia	A	A	A
Lebanon	A	B	A
Lesotho	C	C	C
Liberia	C	C	C
Libya	B	B	B
Liechtenstein	A	B	A
Lithuania	A	A	A
Luxembourg	A	A	A
Madagascar	C	C	C
Malawi	C	C	C
Malaysia	A	A	A
Maldives	B	B	B
Mali	C	C	C
Malta	A	A	A
Marshall Islands	B	C	B
Mauritania	C	C	C
Mauritius	B	A	B
Mexico	B	B	B
Micronesia. Fed. Sts.	C	B	C
Monaco	A	A	A
Mongolia	B	B	B
Montenegro	B	A	A
Morocco	B	B	B

Mozambique	C	C	C
Myanmar	C	C	C
Namibia	B	C	B
Nauru	A	C	B
Nepal	C	C	C
Netherlands	A	A	A
New Zealand	A	A	A
Nicaragua	B	C	C
Niger	C	C	C
Nigeria	C	C	C
North Macedonia	B	B	B
Norway	A	A	A
Oman	A	A	A
Pakistan	C	C	C
Palau	A	B	A
Panama	A	B	B
Papua New Guinea	C	C	C
Paraguay	B	B	B
Peru	B	B	B
Philippines	B	C	B
Poland	A	A	A
Portugal	A	A	A
Qatar	A	A	A
Republic of Korea	A	A	A
Republic of Moldova	B	B	B
Romania	B	B	A
Russian Federation	A	A	A
Rwanda	C	B	C
Saint Kitts and Nevis	B	B	B
Saint Lucia	B	B	B

Saint Vincent and the Grenadines	B	B	B
Samoa	C	B	B
San Marino	A	A	A
Sao Tome and Principe	B	C	C
Saudi Arabia	A	A	A
Senegal	C	C	C
Serbia	B	A	B
Seychelles	B	B	B
Sierra Leone	C	C	C
Singapore	A	A	A
Slovakia	A	A	A
Slovenia	A	A	A
Solomon Islands	C	B	C
Somalia	C	C	C
South Africa	B	B	B
South Sudan	C	C	C
Spain	A	A	A
Sri Lanka	B	B	B
Sudan	C	C	C
Suriname	B	B	B
Sweden	A	A	A
Switzerland	A	A	A
Syrian Arab Republic	C	B	C
Tajikistan	C	B	C
Thailand	B	B	B
Timor-Leste	C	C	C
Togo	C	C	C
Tonga	C	B	B
Trinidad and Tobago	B	B	B
Tunisia	B	B	B

Turkey	A	A	A
Turkmenistan	C	C	C
Tuvalu	B	C	B
Uganda	C	C	C
Ukraine	B	B	B
United Arab Emirates	A	A	A
United Kingdom	A	A	A
United Republic of Tanzania	C	C	C
United States	A	A	A
Uruguay	A	A	A
Uzbekistan	C	B	C
Vanuatu	B	B	B
Venezuela. RB	A	B	B
Vietnam	C	B	B
Yemen. Rep.	C	C	C
Zambia	C	C	C
Zimbabwe	C	C	C