Various Trends on the National Development of Renewable Energy Source Affecting the Natural Source Depletion

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Abstract

Renewable energy sources are foreseen to rise as they become scarce and expensive fossil fuels. Considering this thought, each country implements different strategies and national policies to support the development of renewable sources. However, these emerging developments may contribute to its depletion of natural sources. In this paper, an exploratory pattern analysis was used in the 125 selected countries to determine the underlying trends on the effect of the development of renewable energy (RE) sources while utilizing the countries' natural resources. Due to different status of each country, the trends were grouped in similar associations such as negative, positive and bell-like relationships. Developed countries showed a negative relationship where the natural resources are heavily utilized in the early stages but rapidly decreased as the RE progresses. This reflects the capability of these countries with high to very-high human development index (HDI) to invest more on advanced technologies which utilize fewer natural resources. On the other hand, the underdeveloped countries with low to moderate HDI behave in a positive relationship showing their heavily dependence on its natural resources as RE progresses. Moreover, a group of developing countries between developed and underdeveloped categories and without direct relationship to HDI showed a transition between positive to negative transition as the RE progresses.

These findings support the international policymakers, developers and investors on RE market justifications and entrustments, and fair RE policies such as the integration of Carbon Footprint Policy.

Keywords: Renewable energy source, natural resources, exploratory pattern analysis, country trends

1.0 Introduction

Each country has different tracks on renewable energy (RE) deployment. The past years progress of renewable energy as well as the future development is reviewed (Bull, 2001) wherein the United States accounts about 10% of its energy consumption is coming from renewable energy already. The study of Caselli (2008) empirically suggested the role of the political elite's behavior on the RE developments. Considering also the various status of natural resources, each country strategizes correspondingly. The renewable portfolio standard (RPS) is a widely known state policy on renewable energy deployment but this implementation in the United States (Carley, 2009) has no significance on the percent of RE deployment from its generation mix. Such findings show some considerable shortcomings of RPS and

empirically on other approaches. This paper ought to generate new trends and associations on the effect of the development of the RE-source on the natural resources depletion.

A case study in Denmark by Lund (2007) presented the possibility that the current energy system be fully developed and converted into a 100% renewable energy system. In the United Kingdom, a new community-based localism was studied (Walker, Hunter, Devine-wright, Evans, & Fay, 2007) and emerged in the renewable energy policy to assess its significance in climate change governance. The diversity within the community contributes to the community RE emergence which the national policy ought to review for possible government support. In another area, Kaya (2006) investigated, the renewable energy

policies in Turkey which has substantial renewable energy reserves but with low utilization of these resources. These only show how varied each country implements policies with respect on their natural resources.

This paper uses an exploration pattern analysis from the data of 125 countries from the 2015 Human Development Report of the United Nation Development Programme. Due to the different stages and status of each country, the generated trends will be grouped according to its similar associations such as positive or negative relationships. These grouped trends will then be analyzed to provide national policy insights for the utilization of the natural resource as well as the development of renewable energy sources.
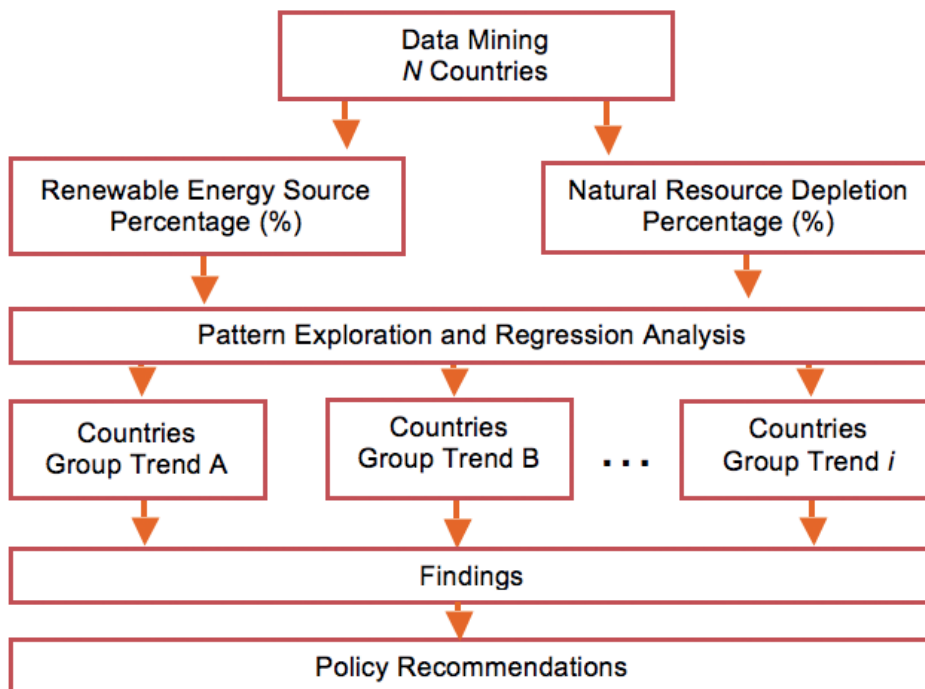

Figure 1. Conceptual Framework

The study is initiated by gathering information of *N* number of countries. The first set of data is on the percentage of the renewable energy source development that served as the predictor. The second set of data is on the percentage of the natural resource depletion as presented in the responses of this study. A pattern exploration will be performed through establishing scatter plots. Accordingly, these have produced a number of patterns. Both the primary and secondary data were subjected to normality test to determine whether they are normally distributed and statistically correlated. Then, the generated patterns will be subjected to a regression analysis determining the different functions between the two variables. Finally, the said functions will be grouped accordingly with the relationships between the two variables and a number of policy recommendations will be suggested.

3.0 Methodology
Data Mining

The data was sourced from the 2015 Human Development Report (United Nation Development Programme, 2015). The gathered data on the percentage of the renewable energy source and the percentage of the natural resource depletion were of the same period on the years 2012 and 2010-2012 respectively. These data were both taken as the percentage of the gross national income (GNI).

Statistical Modeling

The two normal data were displayed in a scatter plot. Through visual inference, various patterns were explored. Then, these patterns underwent normality test to determine whether it is normally distributed. Otherwise, inconsistencies could occur when performing statistical modeling. Secondly,

these were subjected to regression analyses to determine their relationships. The regression analyses have used the Minitab 13 software for the simulations of the models. Furthermore, the chart tools layout of MS Excel has provided ease on finding trend lines on layouts of the given patterns.

The significance level was maintained at 0.01. The derived r-squared values indicated how close the data on the fitted regression line. The r-squared values, greater than 0.90, have showed the well-fitted models of the relationship. Similar relationships with similar fitted regression line were grouped into a single group trend. The produced group trends were finally interpreted based on the relationship behaviors between the predictor and the response variables.

4.0 Results and Discussions

The gathered data stored in Appendix A are the percentage of the gross-national income (%GNI) of *N*=125 countries. The growth in renewable energy source on every country, in general, does not directly affect the natural resource depletion as shown in the Figure 2. It can be observed from the median line of the graph that in 2012, most of the countries have not yet exploited more than 25% of their natural resources. Moreover, these countries have renewable energy source technologies that are still underdeveloped as shown from the encircled red line in the Figure 2. Turkey is one of those with substantial renewable energy reserves with low utilization of its natural resources (Kaya, 2006).
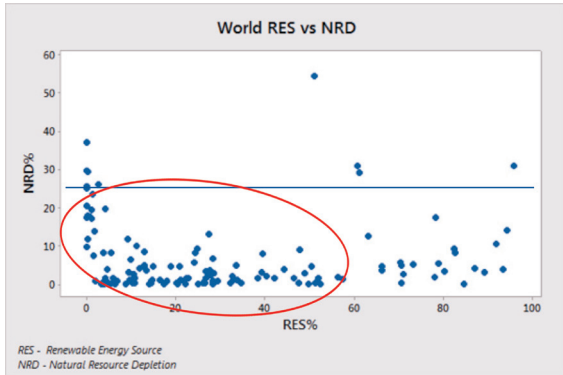
Figure 2. *Scatter Plot of Percent Natural Resource Depletion (NRD%)
Versus the Percent of Renewable Energy Source (RES%)*

By a thorough exploratory analysis, there are three similar trends (i=3) found in the graph, namely, A, B and C. In the IEO 2016 Reference case by the U.S. Energy Information Administration (EIA), the renewable energy share in the world electricity generation grows from 22% in 2012 and is expected to increase by 29% by 2040. The countries' renewable energy technologies are expected to utilize more natural resources. The following generated trends best serve as a guide and reference for every country's respective national renewable energy policy and other agenda.
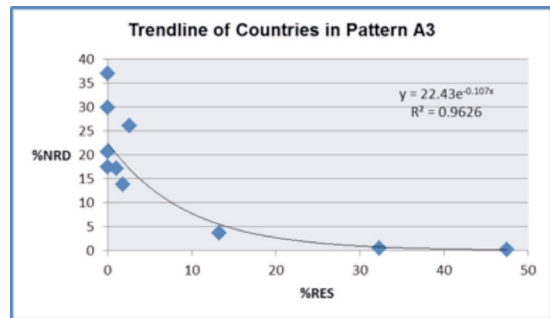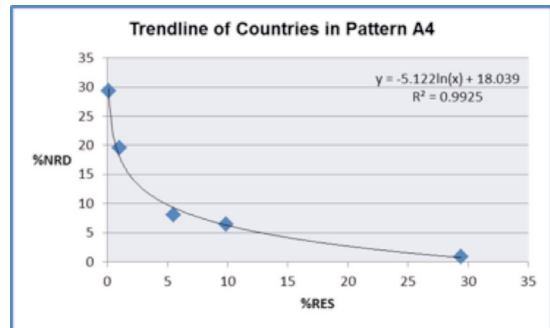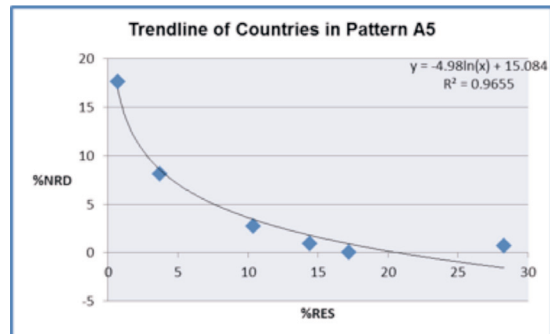
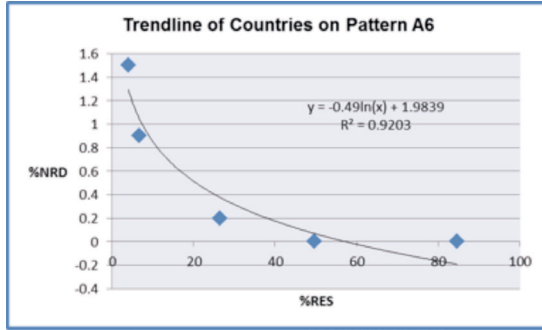**Group Trend A**
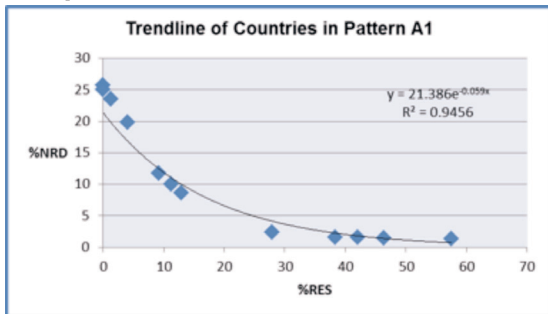
(a)
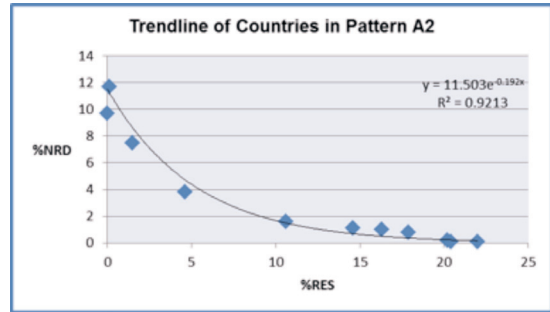
(b)

(c)

(d)

(e)

(f)

Figure 3.(a)-(c). Similar Exponential Relationships of
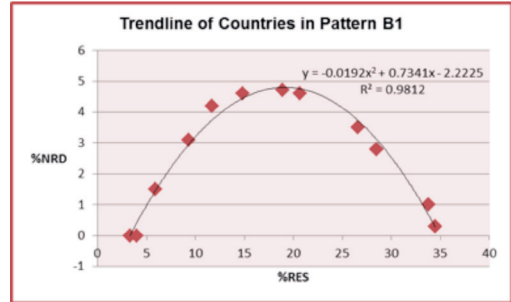34/125 Countries
(d)-(f). Similar Logarithmic Relationships of
16/125 Countries

The first group trend has two exponential and logarithmic relationships as shown in Figure 3. The 34 and 16 countries in (a)-(c) and (d)-(f) are tabulated in Table A of Appendix B. The figures show that all the r-squared values are greater than 0.90 (90%) which shows that the data best fit the indicated relationships.

These countries tend to decrease their utilization of the natural resources exponentially and logarithmically even if their renewable energy source development grows. These countries already seem to be ahead in terms of utilizing their natural resources with less comparable development on the renewable energy sources.

Group Trend B

The group trend B has bell-curve characteristics as shown in Figure 4. The countries included on this group are stored in Table B of Appendix B. The models are well-fitted the relationships based in all of their r-squared values greater than 0.90. These countries tend to increase the depletion of their natural resources when increasing their RE source capabilities.

(a)
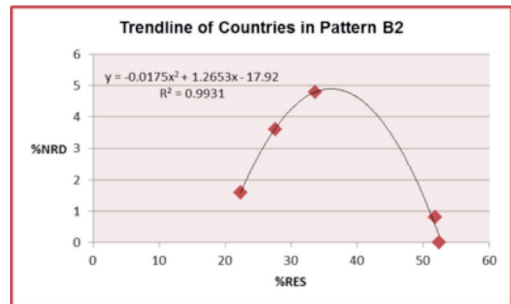
(b)
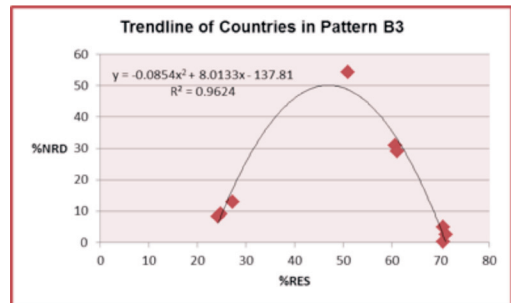
(c)
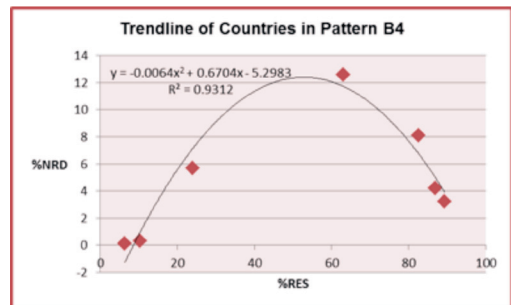
(d)

Figure 4. (a)-(d). Similar 2nd Degree Polynomial Relationships of 33/125 Countries

However, upon reaching a maximum point when further increasing the RE sources, such countries tend to recover depleted natural resources. This maximum point ranges from 20-55% of the RE developments.

Group Trend C
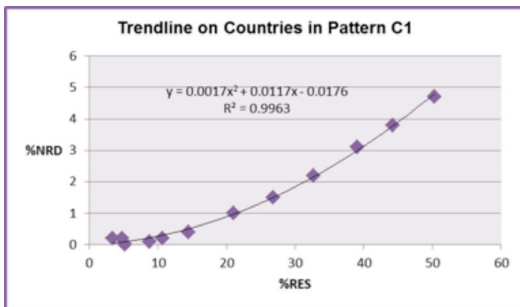
(a)
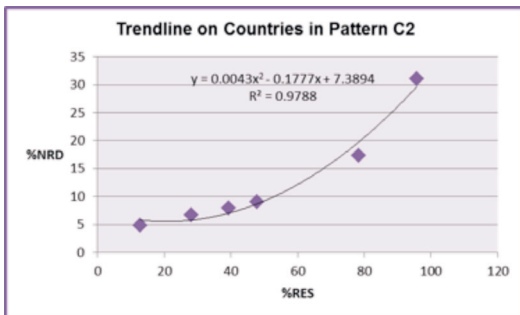
(b)
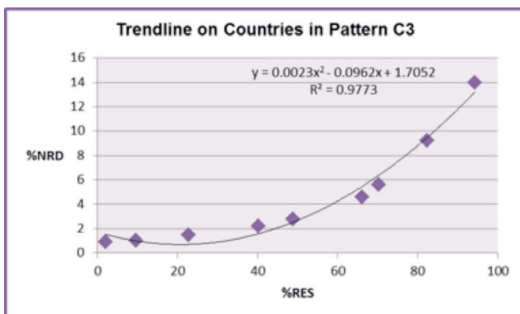
(c)
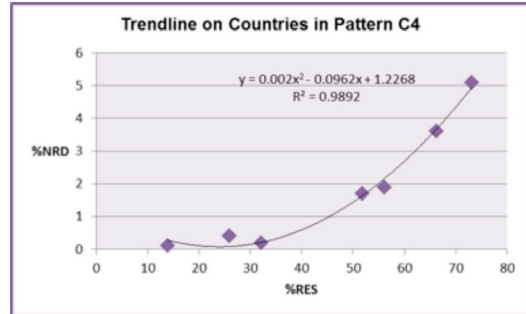
(d)
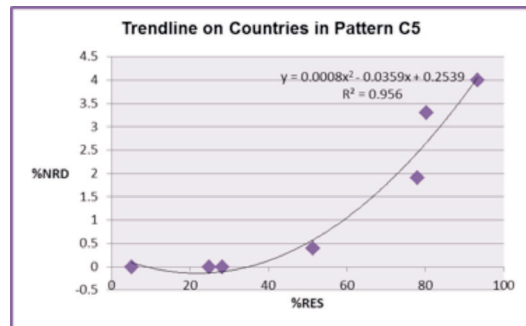
(e)

Figure 5. *(a)-(e). Similar 2nd Degree Polynomial Relationships of 42/125 Countries*

The associations of Group C as shown in Figure 5 (a)-(d) tend to increase rapidly the depletion rate of the natural resources of the country while increasing the deployments of the renewable energy sources. The associations were nonlinear due to the fact that the study is limited between the two variables only.

Human Development Index (HDI) Findingson Group Trends A, B and C

Table 1. *HDI of Grouped Countries*

HDI	COUNTRIES			
	A	**B**	**C**	**TOTAL**
VERY HIGH	22	8	13	43
HIGH	20	11	6	37
MID	6	9	13	28
LOW	2	5	10	17
TOTAL	50	33	42	125

The high human development index (HDI) of the grouped countries based on the report of the United Nation Development Programme (UNDP) are shown in Table 1. Accordingly, HDI summarizes the average achievement in key dimensions of human development on physical health, mental health and lifestyle. Though, this does not reflect and capture poverty, human security and empowerment index of every country, it directly influenced by the standard of living dimensions measured by gross national income per capita (GNI index). This indeed follows the fact that the predictor and response variables are in terms of percent GNI.

Table 2. *Contingency Table with Row Proportions for HDI and Countries*

HDI	COUNTRIES			
	A	**B**	**C**	**TOTAL**
VERY HIGH	**0.5116**	0.1860	0.3023	1.0000
HIGH	**0.5405**	0.2973	0.1622	1.0000
MID	0.2143	0.3214	**0.4643**	1.0000
LOW	0.1176	0.2941	**0.5882**	1.0000
TOTAL	0.4000	0.2640	0.3360	1.0000

Majority of the countries with high to very high HDI follow the characteristics of Group Trend A while most countries with low to medium HDI follow the Group Trend C as presented in Table 2. According to the UNDP, countries with very high HDI are categorized as developed countries while high HDI as developing countries. Countries with low HDI countries are also categorized as underdeveloped. The developed countries tend to decrease rapidly its utilization of natural resources as the development of RE progresses. In fact, these countries have high developed economy and advanced technological infrastructures that can

invest more on advancing RE technologies without heavily exploiting its natural resources such as coal and oil. On the other, the less developed countries tend to increase rapidly its depletion of natural resources as the development of RE progresses. This is due to their low economic structure allowing more exploitation on its natural resources as the RE technology advances.

Moreover, there are countries under Group Trend B with no direct relation on HDI level. As suggested by the findings of Group Trend B, these countries however have 20-55% peak range of RE development, whereby, any progress in RE below this range will result to a positive relationship and becomes negative once exceeded. This relationship shows that these countries are in transition between the underdeveloped and the developed category.

5.0 Conclusion

Majority of the countries are still on their early stages in the development of the renewable energy (RE) technologies as well as in the utilization of their natural resources. Developed countries utilize its natural resources heavily in the early stages of RE developments. As the developed countries invest more in RE technologies, the natural resources become less utilized instead of depleting them. This reflects the capability of these countries with high to very high human development index to invest more in advanced RE technologies which utilize fewer natural resources. On the other hand, the underdeveloped countries tend to deplete their natural resources rapidly as the RE development progresses. This shows the incapability of these countries with low to moderate human development index to secure investments on RE developments, thus, heavily

dependent on its natural resources. In return for further RE advancements, their natural resources become depleted rapidly. Other developing countries which do not belong to the developed and underdeveloped categories exhibit a bell-like relationship between RE development and natural resources depletion, wherein, there is a point of transition from positive to negative relationship as the RE progresses. Hence, these findings support the international bodies' observance of the country's economic structure for RE market justification and for fair policy-making such as the enforcement of Carbon Footprint Policy. In addition, these will help developers and researchers design better market entrustment for renewable energy sources.

6.0 References

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Appendix A

Data of RES and NRD

Countries	Renewable sources (%)	Natural resource depletion (% of GNI)	Countries	Renewable sources (%)	Natural resource depletion (% of GNI)
Switzerland	49.7	0	Tanzania (United Republic of)	89.3	3.2
Iceland	84.7	0	Kenya	80.3	3.3
Korea (Republic of)	17.2	0	Albania	26.6	3.5
Luxembourg	4	0	Cuba	13.3	3.6
Japan	5.2	0	Guatemala	66.2	3.6
Belgium	28.3	0	India	27.6	3.6
France	52.4	0	Australia	4.6	3.8
Spain	24.9	0	Brazil	44.2	3.8
Cyprus	5.1	0	Mozambique	93.3	4
Lebanon	3.3	0	China	11.7	4.2
Germany	20.4	0.1	Nepal	86.9	4.2
Ireland	6.4	0.1	Ukraine	20.7	4.6
Italy	13.9	0.1	Tunisia	14.8	4.6
Greece	8.8	0.1	Paraguay	66.2	4.6
Portugal	22	0.1	Thailand	18.9	4.7
Israel	4.8	0.2	Nicaragua	50.3	4.7
Austria	32.2	0.2	Indonesia	33.6	4.8
Finland	47.5	0.2	South Africa	12.9	4.8
Czech Republic	26.5	0.2	Sudan	70.5	4.8
Panama	20.2	0.2	Cameroon	73.2	5.1
Dominican Republic	10.7	0.2	Côte d'Ivoire	79	5.4
Moldova (Republic of)	3.4	0.2	Zimbabwe	70.3	5.6
Sweden	70.5	0.3	Peru	24	5.7
Slovenia	34.5	0.3	Mexico	9.9	6.4
Turkey	10.3	0.3	Viet Nam	28.2	6.7
Lithuania	14.5	0.4	Yemen	1.5	7.5
Hungary	26	0.4	Kyrgyzstan	39.4	7.9
Sri Lanka	51.3	0.4	Malaysia	5.5	8.1
Slovakia	32.3	0.5	Egypt	3.7	8.1
Georgia	28.3	0.7	Nigeria	82.6	8.1
Costa Rica	51.8	0.8	Chile	24.2	8.3
Jamaica	17.9	0.8	Ecuador	12.9	8.6
Netherlands	6.7	0.9	Norway	47.8	9
United Kingdom	14.4	0.9	Colombia	24.8	9.2
Bulgaria	29.4	0.9	Togo	82.4	9.2
Jordan	2	0.9	Bahrain	0	9.7

Countries	Renewable sources (%)	Natural resource depletion (% of GNI)	Countries	Renewable sources (%)	Natural resource depletion (% of GNI)
United States	16.3	1	Venezuela (Bolivarian Republic of)	11.2	10
Poland	9.6	1	Zambia	91.8	10.5
Latvia	33.8	1	United Arab Emirates	0.1	11.7
Namibia	21	1	Russian Federation	9.2	11.8
Estonia	14.6	1.1	Ghana	63.1	12.6
Tajikistan	57.5	1.3	Bolivia (Plurinational State of)	27.3	13
Denmark	26.8	1.5	Uzbekistan	1.8	13.8
Belarus	5.9	1.5	Ethiopia	94.3	14
Romania	22.8	1.5	Kazakhstan	1	17.2
Morocco	4.1	1.5	Eritrea	78.3	17.3
Senegal	46.4	1.5	Qatar	0	17.4
New Zealand	38.4	1.6	Iran (Islamic Republic of)	0.7	17.6
Croatia	10.6	1.6	Algeria	0.1	18
Uruguay	42.1	1.6	Iraq	1	19.5
Botswana	22.3	1.6	Mongolia	4.1	19.8
El Salvador	51.9	1.7	Saudi Arabia	0	20.6
Haiti	78	1.9	Libya	1.3	23.5
Benin	56.2	1.9	Kuwait	0	25.1
Armenia	32.7	2.2	Oman	0	25.7
Philippines	40.3	2.2	Azerbaijan	2.6	26
Canada	27.9	2.4	Gabon	61.1	29.1
Cambodia	71.1	2.5	Trinidad and Tobago	0.1	29.3
The former Yugoslav Republic of Macedonia	10.4	2.7	Brunei Darussalam	0	29.8
Honduras	48.8	2.8	Angola	60.7	31
Bangladesh	28.5	2.8	Congo (Democratic Republic of the)	95.8	31
Argentina	9.3	3.1	Turkmenistan	0	37
Pakistan	39.1	3.1	Congo	51	54.4

Appendix B

Table A. Countries in Group Trend A

A1	A2	A3	A4	A5	A6
Oman	United Arab Emirates	Saudi Arabia	Trinidad and Tobago	Korea (Republic of)	Switzerland
Kuwait	Bahrain	Kazakhstan	Iraq	United Kingdom	Iceland
Libya	Yemen	Uzbekistan	Malaysia	The former Yugoslav Republic of Macedonia	
Mongolia	Australia	Cuba	Mexico	Egypt	Netherlands
Russian Federation	Croatia	Slovakia	Bulgaria	Iran (Islamic Republic of)	Morocco
Venezuela (Bolivarian Republic of)	Estonia	Finland		Georgia	Czech Republic
Ecuador	United States	Qatar			
Canada	Jamaica	Brunei Darussalam			
New Zealand	Panama	Turkmenistan			
Uruguay	Germany	Azerbaijan			
Senegal	Portugal				
Tajikistan	Algeria				

Table B. Countries in Group Trend B

B1	B2	B3	B4
Lebanon	Botswana	Congo	Ireland
Luxembourg	India	Angola	Turkey
Belarus	Indonesia	Gabon	Peru
Argentina	Costa Rica	Sweden	Ghana
China	France	Sudan	Nigeria
Tunisia		Cambodia	Nepal
Thailand		Bolivia (Plurinational State of)	Tanzania (United Republic of)
Ukraine		Colombia	
Albania		Chile	
Bangladesh			
Latvia			
Slovenia			

Table C. Countries in Group Trend C

C1	C2	C3	C4	C5
Nicaragua	Congo (Democratic Republic of the)	Jordan	Zambia	Mozambique
Brazil	Eritrea	Poland	Cameroon	Haiti
Pakistan	Norway	Romania	Guatemala	Cyprus
Armenia	Kyrgyzstan	Philippines	Benin	Kenya
Denmark	Viet Nam	Honduras	El Salvador	Sri Lanka
Namibia	South Africa	Paraguay	Italy	Spain
Lithuania		Zimbabwe	Austria	Belgium
Dominican Republic		Togo	Hungary	
Greece		Ethiopia		
Japan				
Moldova (Republic of)				
Israel				