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Title: Transitions Dynamics in Context: Key Factors and Alternative Paths in the Sustainable Development of Nations

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Abstract: The spatial dimension of sustainability transitions is central to understanding how systems change, yet current literature falls short when it comes to explaining transitions dynamics in context, and the central factors and alternative paths through which particular spaces move towards or away from sustainable development efforts. We conduct an exploratory factor analysis and a post-hoc cluster analysis of sustainability transition dynamics at a spatial level in 99 nations. Based on our analyses we establish a multi-dimensional measurement tool of nation sustainability that considers place, time and directionality. The analysis yielded four key dimensions - governance quality, industrial pollution, socio-environmental conditions and clean wealth creation - upon which we elaborated clusters of nations representing four distinct empirical types of transition pathways, crossroaders, compliers, athletes and laggards. In doing so we provide a holistic view of the phenomenon, which is relevant for both further theorizing and policy development.

TRANSITIONS DYNAMICS IN CONTEXT: KEY FACTORS AND ALTERNATIVE PATHS IN THE SUSTAINABLE DEVELOPMENT OF NATIONS

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Abstract

The spatial dimension of sustainability transitions is central to understanding how systems change, yet current literature falls short when it comes to explaining transitions dynamics in context, and the central factors and alternative paths through which particular spaces move towards or away from sustainable development efforts. We conduct an exploratory factor analysis and a post-hoc cluster analysis of sustainability transition dynamics at a spatial level in 99 nations. Based on our analyses we establish a multi–dimensional measurement tool of nation sustainability that considers place, time and directionality. The analysis yielded four key dimensions - governance quality, industrial pollution, socio-environmental conditions and clean wealth creation - upon which we elaborated clusters of nations representing four distinct empirical types of transition pathways, crossroaders, compliers, athletes and laggards. In doing so we provide a holistic view of the phenomenon, which is relevant for both further theorizing and policy development.

Keywords: Sustainability transitions; Nation-level sustainability measurement; Empirical typology; Sustainability pathways; Factor analysis

Highlights

- It conducts a quantitative exploration of sustainability transition dynamics at a spatial level
- It identifies sets of distinct factors and paths of sustainable development at national level
- It conducts an EFA of 22 factors at the national level
- It identifies 4 key dimensions relevant to capturing transition dynamics
- It conducts a cluster analysis of 99 countries and develops an empirical typology of paths towards SD
- It recognizes several policy implications for the four distinct groups of nations
- It provides a promising start for the identification of key variables in sustainability research

1. Introduction

In dealing with the interwoven nature of sustainability issues, transition research has developed a deep understanding of the different ways in which stabilized key industries and socio-technical systems can unlock the mechanisms that relate to sunk investments, interests, infrastructure, subsidies and regulations (Geels, 2010) and reorient their behavioral patterns towards sustainability. In this context, the spatial dimension of sustainability transitions has gained traction and attention because it allows for a deeper understanding of the complex and multidimensional changes needed to move socio-technical and economic systems forward (McCormick et al., 2013). The central argument supporting this view is that effective comparative transition analysis could benefit from a multi-scalar, spatial approach, in that such approach complements our understanding of what drives the progress of a given transition (Coenen et al., 2012).

Current conceptualizations on the role of context in transition dynamics do incorporate complexity, multi-dimensionality and territorial sensitivity as analytical artifacts. However, present models (e.g. multi-level perspective) are not geographical in nature, they rather deal with socio-cognitive dynamics at socio-technical system level (Coenen et al. 2012). Despite the fact processes entail direction and time, most studies overlook the directionality, purpose and progression of transitions, in other words, the pathway through which particular (geographical or geopolitical) places mobilize sustainability efforts in a given direction. This is a central matter, contributors argue that the most intricate questions can only be solved by looking at the when and the where of transitions (Truffer and Coenen, 2012).

In tackling this issue, we conduct a quantitative exploration of sustainability transition dynamics at a spatial level in 99 nations to establish a multi–dimensional measurement tool capable of determining whether locations, more precisely nations, are moving towards or away from sustainable development (hereafter, SD). The overall purpose of our study is to understand the dynamics and central factors that explain sustainable transformations with aggregated data at the national level. Specifically, we sought to identify which key variables allow for better explaining transition dynamics, and then identify which types of transitions exist empirically.

We draw from extant literature and broad range of data sources to select 67 relevant variables, which were reduced according to pre-defined criteria to compile a final selection of 24 variables (Appendix A). By means of factor analysis, we derived four key dimensions - governance quality, industrial pollution, socio-environmental conditions and clean wealth creation - upon which clusters of nations are yielded representing four distinct empirical types of transition pathways, i.e. Crossroaders, Compliers, Athletes and Laggards, meaning that there are four different groups of nations moving towards sustainability in distinctive ways. Based on latter, we elaborate an empirical typology of paths towards sustainability and provides a discussion of how each empirical type is composed, which allows for further theorizing in the field.

This paper contributes to literature in several ways. First, it provides a multi-dimensional, reliable measurement tool of nation sustainability that considers place, time and thus directionality. This measurement allows for further theorizing and testing whether particular nations are moving towards a sustainable future. The analysis draws on a large number of variables and uses multivariate techniques, which permits identifying interrelationships between economic, social, environmental and political dimensions, which is so far absent in terms of methodological developments in the field. As a result, it enables policy makers to think about sustainability in a holistic, yet concrete way and thus elaborate policy that considers key interrelated variables of SD. Finally, we propose an empirical typology of SD paths at national level that illustrates the benefits and possibilities of this new analytical tool. Further studies can utilize this tool to measuring sustainable development pathways in different geo-spatial levels, namely regions, cities and councils.

2. Measuring sustainable development in context

In understanding how SD unfolds, there have been many attempts to organize the main concepts associated with the phenomenon, which respond mostly to the controversial nature of the term (Gladwin et al., 1995; Hopwood et al., 2005; Kates et al., 2005; Pezzoli, 1997), as it deals with interdependent ideological, moral and political issues (Gladwin et al., 1995; Pezzoli, 1997; Shrivastava, 1995). Most nation-level studies do cover these interdependencies (Esty et al., 2012; Wackernagel and Rees, 1996), yet exhibit poor performance when it comes to capturing the full complexity of these relationships. Research efforts, as the ones mentioned above, are generally narrow in scope and affected by ideological biases (Hopwood et al. 2005), a priori assumptions regarding related relationships, simplistic modeling, and non-inclusion of a political dimension (Esty and Porter, 2005).

There is an extensive agreement on that achieving SD requires consideration of three interwoven factors (i.e. social, environmental and economic). Social development cannot be achieved without economic advancement and, in turn, economic advancement cannot be sustained over time if natural resources are used irresponsibly (Dasgupta, 1995; Daily and Ehrlich, 1996). SD, however, also entails political and ideological forces (Gupta, 2002; Hopwood et al., 2005; Pezzoli, 1997; Shrivastava, 1995). A nation's ability to develop and enforce appropriate policy is crucial for SD, without which is unlikely that individual and collective actors will modify or adjust their behavior (Bansal, 2001; Barnhizer, 2006).

This is a central issues in transition research, as geography (i.e. cities, regions and nations) is increasingly recognized as a central factor to understanding the interrelations between spaces and sustainability (Hodson and Marvin, 2010) and ―the complex and multi-dimensional shifts considered necessary to adapt societies and economies to sustainable modes of production and consumption‖ (Coenen et al. 2012, p.968). Recent research indeed argues that there are strong and reciprocal linkages between climate change, urban form and geo-spatial planning processes (Wamsler et al., 2013). These shifts require transformations in areas such as ―governance and planning, innovation and competitiveness, lifestyle and consumption, resource management and climate mitigation and adaptation, transport and accessibility, buildings, and the spatial environment and public space‖ (McCormick et al., 2013, p.1), which mostly depend on appropriate policy intervention.

Transitions-related policy development requires appropriate measurement. Despite current efforts towards developing and implementing adequate SD indicators, e.g. Environmental Kuznets Curve (EKC), the resulting tools tend to suffer from conceptual vagueness, nonstandard terminology and, often times, lack of focus (Dasgupta et al., 2002 Ebert and Welsch, 2004). They usually focus on relatively few variables to attain a comprehensive understanding of the environment-economy relationship (Harbaugh et al., 2002; Stern, 2004), assume a priori structures as to the nature of SD conditioning results, and their empirical underpinnings are mostly derive from developed nations (Lopez and Mitra, 2000), excluding other types of countries.

In facing geopolitical complexity, inherent to sustainability, scholars have moved from mono-dimensional approaches to social-environmental-economic relationships (Briassoulis, 2002) towards observing national-level sustainable development from a wider perspective, i.e. composite indicators that provide summarized descriptions of multidimensional states (Hezri and Dovers, 2006; Moran et al., 2008; Wilson et al., 2007).

Despite the contribution of current tools for measuring sustainability at the national level, several scholars have raised concerns with regards to the plausible relationship between a nation's governance system and SD (Siche et al., 2008; Wilson et al., 2007). It has been argued that current approaches, for example the Environmental Sustainability Index or the Environmental Performance Index, implicitly assume a priori structures of latent variables confusing cause and effect relationships (Jha and Bhanu-Murthy, 2003), use static measures of sustainability (Siche et al., 2008), and disregard economic, social and political issues leading to no comprehensive SD indicators. In addition, the creation of such indices is arbitrary so that their methodological rigor has been called into question (Jha and Bhanu-Murthy, 2003).

In spite of the ups and downs of current attempts to measure nations' SD dynamics and direction, these multidimensional endeavors have increased the awareness of the necessity of country benchmarking and post hoc assessment of public policy implementation adequacy and success.

3. Research method, data collection and analysis

We conducted a quantitative exploratory analysis of 113 nations. By using exploratory factor analysis (EFA), we selected a set of indicators to measure how the nations under examination are moving in relation to sustainable development, i.e. to or way from SD. Once these dimensions were defined, we used cluster analysis to subsequently create four groups of nations conforming an empirical typology of alternative paths towards sustainability. In selecting the method for this study, we draw on prior research that emphasize Principal Component Analysis (PCA) and cluster analysis as relevant and novel approaches to deal with certain neglected areas of the environmental aspect of SD (Petcharat, et al. 2012; Xia, et al. 2011).

The sample of countries for this study was drawn from the World Bank Data Catalog and the European Commission Joint Research Center. The sample period spans a minimum of 15 years for each indicator, starting in 1990 since data becomes more readily available for the sample. After data analysis, we excluded nations with over 10% missing data. The final sample contains 99 countries. Multivariate analysis techniques usually require in depth treatment of outliers since these can substantially alter the results (Hair et al., 2009). Given the nature and purpose of this study we retain the outliers. A priori elimination of outliers implies nonrecognition of the true underlying variable structure and groupings, concealing the real behavior of observations. Based on our review of literature, we chose 67 conceptually similar variables. This data set was reduced to one that best represented the intersecting dimensions of SD based on a deep analysis of each variable. Further variables were eliminated if they presented 15 or more observations with no data for the study period. This ultimately reduced the variable set to 24 (see

Appendix A for variable explanation). This reduction was necessary to obtain a variable to observation ratio close 1:5 (Hair et al., 2009).

Since one of the purposes of our study is to understand key factors and alternatives paths towards sustainability at the national level, data need to be transformed. For all non-political variables, two possible methods were considered. The first one involved using initial and final variable value to calculating percentage of change. This method reflects overall variable change, ignoring tendency changes that occur within the observed period. The second one involved calculating percentage of change of variable value, period to period, and then computing an overall average to be used in the analysis. This method takes into account tendency changes that occur period to period. The second method of data transformation was finally chosen since it allows for capturing changes in tendency for each variable more closely than the first method, which is what we seek to capture from a transition dynamics perspective. In addition, as a relative measure, this operationalization enables us to understanding the progression and direction of sustainability-related efforts in countries, regardless of the size of the country[1]. The latter is relevant for the subsequent cluster analysis.

For political variables, an average of the scores of each variable was used instead because the rate of change concept was deemed unsuitable. Economic, social and environmental changes can occur in relatively short periods of time (5 years or less), however political structures and governance systems tend to be more static over time (even in the presence of globalization) and changes occur in longer periods of time (more than a generation: 25-30 years). This is because

1 In this case we are referring to economic size (and not territorial size) and the effects of this condition to achieve sustainable development (for instance, effects on emissions, energy use, and all the variables used in this study)

political structures and governance systems tend to be bureaucratic in nature and, therefore, less prone to changes.

3.1 Exploratory Factor Analysis

In analyzing the data's underlying structure, we use three EFA techniques: Principal Components Analysis (PCA), Maximum Likelihood and Principal Axis Factoring. All procedures yielded similar solutions with equally high communalities in this study. Since our goal was data reduction for post hoc cluster analysis, we finally selected PCA.

For factor extraction, the parsimony criterion was used alongside the scree-plot criterion. In order to determine the variables to be included in the solution it is necessary to establish basic criteria that allow the definition of a starting point for the acceptance of variables and only then begin interpretation and verification of factors. To this extent we defined conflictive variables as those with significant loadings in two or more factors (cross loadings above 0.5). Two variables were defined as conflictive and eliminated for the remainder of the study. A final solution was established with 22 variables. Based on the main statistics from the PCA (See Tables B1, B3 and B4 in Appendix B for factors' explained variance, factor loadings, and factors correlation matrix) we analyzed different factor model solutions (5, 4, and 3 factors). Finally, a 4-factor solution was chosen based on screen-plot criteria and for interpretation purposes. Regression score method was then used to compute factor scores for the cluster analysis.

3.2 Cluster analysis

Given that we make no a priori assumptions regarding group structures, a post hoc segmentation of the country data was conducted. It can be argued that using average rates, resulting factors computed by regression scores, may affect the results because it changes cluster outcomes across different periods of data. Although this might be problematic in other type of studies, capturing change was precisely what we aimed at exploring. In consequence, we started our inquiry with an EFA (PCA) study to establish factors of movement and then clustering nations based on these dynamics patterns. We applied five clustering techniques to the factor scores: four hierarchical techniques (nearest neighbor, furthest neighbor, Ward's method and centroid clustering), and a non-hierarchical method using different fixed cluster numbers as a solution derived from the hierarchical methods.

Since cluster analysis always finds relationships between proposed subjects (Hair et al., 2009), we applied several control methods to ascertain that intragroup similarities in fact exist in our final solution. The best solution obtained through the hierarchical cluster technique was retained (Ward's method in this case). Results indicate the presence of 4 to 7-clusters solutions. For depuration purposes, we calculated cluster centroids, which were used as seeds for the non-hierarchical method, k-means. We analyzed the results for all the cluster range (4 to 7). It should be noted that Ward's Method and the k-means solution are nearly identical for the 5-cluster solution, which is also nearly identical to the 4-cluster solution since there is a cluster group with only two countries. Moving from the 5-cluster solution to the 4-cluster solution entailed a rearrangement of only four countries. This, in addition to the non-hierarchical method and its corresponding random seeds conclusion, leads us to select the 4-cluster solution obtained through the k-means procedure with predetermined seed points. Table B5 (Appendix B) shows, through ANOVA analysis, that the distances for the 4-clusters solution are statistically significant.

4. Key Sustainable Development Nation-level Factors

The final solution of four factors allows for an adequate factor interpretation explaining 68.7% of the total variance, thus suggesting a strong relationship between the variables. The Kaiser-Meyer-Olkin test for the proposed solution is 0.847, and the Bartlett Test of Spherecity is also significant (see Table B2 in Appendix B for goodness of fit). Overall, these tests support the use of PCA. Based on an in-depth analysis of the loading variables of each factor (see Table B3 in Appendix B), and of the particular characteristics of these variables (see Appendix A to variable explanation), we label the four final factors: Governance Quality, Industrial Pollution, Socio-Environmental Conditions and Clean Wealth Creation.

4.1 Governance Quality

This factor represents a country's level of institutional quality regarding SD. It accounts for 37.5% of total variance (Table B1 in Appendix B). It is composed almost purely of governance related variables. This factor encompasses public debate, the political decision-making process as well as policy formation and implementation. Governance Quality represents the ability of a government to design and implement public policy that addresses SD. It is a static factor since all but two of the eight variables not transformed to gauge rate of change.

The highest loading variable (Table B3 in Appendix B) in this category is Regulatory Quality (0.905). Government Effectiveness, Rule of Law, Voice and Accountability and Control of Corruption show loadings above 0.85. Age Dependency Ratio (% of working age population) and Fertility Rate present loadings of 0.807 and 0.831 respectively. Finally Political Stability and No Violence present loading of 0.741. Age Dependency Ratio (% of working age population) and Fertility Rate are closely linked to past public policy decisions. Governments can shape fertility rates through public policies that stimulate (e.g. monetary incentives) or stifle child birth rates (e.g. China's one son policy and/or sexual education). Age Dependency Ratio (% of working age population) is an indirect result of Fertility Rate since the births in a certain year determine the future working population. Variance in this category relates to strong or weak political frames for the creation and implementation of sustainable development policies.

4.2 Industrial Pollution

The variables comprising Industrial Pollution were transformed to measure rates of change. It accounts for 14.9% of total variance (Table B1 Appendix B), partly supporting the predominantly environmental approaches most SD studies have adopted. Variables that load in this factor show clear relationships with industrial activity (see Table B3 in Appendix B): CH_4, NO_x, NH_3, SO_2 and Electric Power Consumption (KwH per capita). The first four loading variables represent anthropogenic gasses emitted from industrial practices (loadings ≥0.7). Electric Power Consumption (KwH per capita) reflects energy intensiveness (loading of 0.544). Most of the world's power grid is fossil fuel based, accounting for approximately 82 percent of the world's primary energy use (EIA, 2012). Relatedly, we have witnessed an increment in

Electric Power Consumption, from 2245 KWh per capita in 1980 to 4180 KWh per capita in 2011, which results in an increment of anthropogenic gas emissions (IEA, 2014), reinforcing an economic-environmental factor interpretation.

Higher factor scores on this dimension represent adoption of dirty paths on economic-environmental issues (Esty and Porter, 2005) since negative aspects of increased economic activity deteriorate the environment. Conversely, a negative scores represent clean paths towards development. Clean paths may result from clean technology adoption, industrial process innovations or end-of-pipe pollution abatement practices (Hart, 1995), and also from pollution displacement from developed to developing nations (Boyce, 2004; He, 2006; Taylor, 2005).

4.3 Socio-Environmental Conditions

The three variables composing this factor present loadings between 0.75 and 0.8 (Table B3 in Appendix B), accounting for 8.3% of the variance (Table B1 in Appendix B). All variables relate to the environmental impact of social development and represent rates of change. These are: Improved water source access (% of population with access), CO_2 intensity (kg per kg of oil equivalent energy use), and Improved Sanitation Facilities access (% of population with access).

Improved water source (% of population with access) and Improved Sanitation Facilities (% of population with access) have a direct relationship with health objectives set by the Millennium Development Goals (2011). These variables represent standards of living that are indirectly connected to poverty levels (see Appendix A). Although Improved Water Source (% of population with access) and Improved Sanitation Facilities (% of population with access) represent positive aspects of progress, nations showing high scores will eventually experience diminishing rates of change, since, over time, the population's basic hygienic are satisfied. A high factor score thus implies social development deficiencies and persistently worse socio-environmental problems. On the other hand, negative scores suggest the opposite because changes in water and sanitation access tend to eventually reach 0% while, at the same time; there are substantial and persistent improvements in CO_2 levels, partially because these nations strive to be eco-efficient.

4.4 Clean Wealth Creation

This factor comprises value creation, energy efficiency rate of change, and particulate emissions rate of change, and accounts for 7.8% of the variance (Table B1 in Appendix B). The factor represents rates at which nations adopt better energetic practices regarding wealth creation within a country. The highest loading variable for the factor is GNI per capita, Atlas Method (current US$) with a loading of -0.818. The other two variables, Energy Use (kg of oil equivalent) per $1.000 GDP (constant 2005 PPP) and PM10, Country level (micrograms per cubic meter), suggest that countries must deal with energy efficiency and environmental results. Both these variables have loadings of 0.767 and 0.647 respectively (Table B3 in Appendix B). Since the GNI per capita, Atlas Method (current US$) is inversely related with Energy Use and PM10 in factor loadings, we assume that some link must exist between wealth creation and sound environmental practices.

In crafting our labeling and items, we acknowledge the fact that the idea and measurement of clean wealth creation is still under debate. Some contributors suggest that energy use cannot be considered as static and that the flows of products from one country to another need to be accounted for into any energy analysis. They argue that not doing so may lead to distortions in the perception of so-called clean wealth creation countries because they rely on production from energy intensive countries (Chen and Chen, 2011; Chen and Chen, 2013). Despite the relevance of this argument, we emphasize that capturing in-country values do enables researchers to make valid inferences regarding the ways in which countries create wealth.

This suggests that if a country is to develop efficient energy practices, energy usage and particulate emissions should be accounted for when measuring economic growth. Thus, a positive Clean Wealth Creation score suggests that value is being created more efficiently, supporting the notion that high-income nations achieve development without jeopardizing the environment.

5. Alternative Paths to Sustainable Development

In uncovering how countries move differently towards sustainable development outcomes, we conduct a deeper revision of the clusters analysis, upon which we propose an empirical typology of paths towards sustainability.

Summary Table 1 portraits four distinct groups of countries: Crossroaders, Compliers, Athletes and Laggards. Table 2 presents the resulting clusters of countries, as well as cluster membership and distance to cluster center. These four groups constitute alternative ways though which nations confront sustainability issues.

---Insert Tables 1 and 2 about here---

Figure 1 provides factor score means for each cluster. Because all non-political variables in this study have been transformed to represent rates of change, the mean scores for factor 2, 3 and 4 in Figure 1 represent the direction that each cluster, as a whole, is taking for each dimension. Factor 1 does not represent rate of change due to the nature of the variables that compose it.

-- Insert Figure 1 about here –

5.1 Sustainability Crossroaders

The first cluster includes nations that are in a predominantly developing state and are at a SD crossroads. This cluster comprises diverse countries from all continents but Europe. On average, this group presents the lowest level of Governance Quality (Figure 1). In general these countries follow dirty paths, scoring high on Industrial Pollution whilst consistently alleviating issues related to Socio-Environmental Conditions. These nations show positive Clean Wealth Creation changes, most likely as a result of swift economic development as a solution to poverty. The latter suggests that, on average, they have taken less energy to increase wealth. However, pollution and emissions have not been effectively controlled within this group. Most countries in this cluster either rely on natural resource extraction and industry (e.g. Argentina, Brazil, Kuwait, Saudi Arabia, Iran or Venezuela) or are transitioning from primarily agrarian to more industrialized economies (e.g. Mongolia, Philippines or Bolivia).

EKC theory (Grossman and Krueger, 1995; Kaika and Zervas, 2013) suggests that economic activity increments are responsible for the severe environmental stresses experienced by most of these countries. However, this could also be due to the shift of dirty industrial processes from developed nations through increases in foreign direct investment (Boyce, 2004). Since this cluster exhibits lower levels of Governance Quality, it seems plausible that dirty practices that are not competitive in developed nations are relocated to this cluster because they are cheaper and more competitive.

With regards to the Socio-Environmental Conditions dimension, our findings suggest that modest progress within the group has been made. The economic development of these nations has pushed social concerns towards a better outcome, and most nations in the group have achieved adequate access to water and sanitation, and limited CO_2 emissions. However, because this is by far the most heterogeneous cluster, we do not wish to imply that all nations have effectively addressed these issues.

The dynamics of this group suggest that cluster members are not close to achieving SD paths. On average, members have addressed social issues regarding SD, and the group's rate of change is reflected in the Socio-Environmental Conditions dimension. Unfortunately, this group has not reduced its Industrial Pollution. Furthermore, the cluster is consistently adopting dirty practices and straying from environmental sustainability. Finally, the group has taken steps to increase its Clean Wealth Creation. The countries in this group face the challenge of not drifting back into the sustainability laggards' cluster. Nations that better represent the specific characteristics of this first cluster include Egypt, Nicaragua, Tunisia and Brazil (see distances in Table 1). Furthermore, the group shows four clear outliers: Guatemala, Bolivia, Kuwait and Korea, which exhibit strong Industrial Pollution.

However, within these four countries, Guatemala presents the dirtiest path of development in spite of not having below average Governance Quality levels. Korea, on the other hand, qualifies as a member because of its position with regards to both economic and environmental issues. Results indicate that Korea follows a dirty path with regards to Industrial Pollution while still achieving a negative Clean Wealth Creation and high Governance Quality score. In other words, Korea is becoming a dirtier nation at the time wealth increases, which has an effect on energy consumption.

5.2 Sustainability Compliers

This cluster comprises 15 nations. Notably, all of them are ex-eastern bloc nations, (Uzbekistan is the only exception). On average, countries included in this cluster exhibit high Governance Quality levels, and the lowest levels of Clean Wealth Creation.

The group presents the biggest departure from Industrial Pollution practices. Although Compliers have experienced lower overall levels of SD, they tend to follow clean paths, which refutes general assumptions in environmental studies (e.g. EKC). However, although their economies have strengthened our results indicate that this group of countries has not dealt with energy efficiency in an effective manner. In fact, over time, these countries have steered away from Clean Wealth Creation. These countries are, however, actively addressing the impacts of their Socio-Environmental Conditions. These findings provide support to arguments that state that energy consumption patterns in this cluster are inefficient and getting worse over time. It is likely that high levels of energy inefficiency result from post Soviet Union Nations' cultural issues regarding energy consumption and functioning of market. This resonates with prior work (e.g. Lotspeich, 1995; Martinot, 1998; Midttun and Chander, 1998).

Based on their level of Governance Quality (+/- positive), we identify two distinct groups within this cluster. Nations displaying positive results are those closest to Western Europe (e.g. Bulgaria, Poland). On the other hand, ex-eastern bloc nations outside of Europe or near Asia present negative levels of Governance Quality. These results suggest that SD not only comprises environmental aspects, but also economic, political and social aspects, establishing a complex construct. This resonates with Midttun and Chander (1998) in that, in minimizing negative environmental externalities, institutional normative processes generally accompany the industrial pollution dimension. For example, those Eastern European nations in process of becoming EU nations need to fulfill higher standards of sustainable development.

Notably, an examination of group dynamics reveals that, on average, these nations have taken decisive steps to improve their economic-environmental standards by addressing various Socio-Environmental issues (Figure 1). While this cluster is advancing towards sustainable development, the latter emerges as a major drawback. Compliers present adequate access to water and sanitation facilities, yet severe high rates of change in CO_2 emissions. Considering the distances to center in Table 1, Lithuania, Slovak Republic and Poland stand out as exemplar cases. These three nations, Poland in particular, have undertaken serious political and economic reforms in order to comply with European Union standards.

5.3 Sustainability Athletes

The Sustainability Athletes cluster comprises 26 nations (Table 1); most of them are well-developed economies and members of the Organization for Economic Co-Operation and Development (OECD). Athletes exhibit the highest level of Governance Quality, positive Clean

Wealth Creation and negative levels of Industrial Pollution. Strong regulatory frameworks (high level of Governance) and pollution prevention actions, such as environmental management practices, adoption of clean technologies, and/or pollution displacement practices, account for the low levels of industrial pollution and high environmental and social performance. Socio-Environmental Conditions outcomes are mainly related to CO_2 emissions levels (all these countries have access to improved water and sanitation), and Sustainability Athletes have made major improvements towards reducing their emissions.

An examination of group dynamics suggests that these nations are constantly improving their environmental, economic and social outcomes, as evidenced in Figure 1, showing the strongest outcome in comparison to the other clusters. United States, France and Australia emerge as exemplar cases, yet the group exhibits high homogeneity. Croatia, Chile, Iceland, Uruguay and Ireland stand out within the group of Athletes, because of their counterintuitive nature. Despite its distance from the center, Iceland, for example, exhibits one of the cleanest paths by limiting both Industrial Pollution and Socio-Environmental Conditions while, at the same time, encouraging Clean Wealth Creation. Iceland is indeed the fourth highest ranked country of the entire data set for Socio-Environmental Conditions and Clean Wealth Creation, suggesting a departing from the center to an even higher state of SD.

5.4 Sustainability Laggards

This cluster includes 17 poor nations (income per capita). As a group, these nations show Governance for SD levels that are nearly as low as the Sustainability Crossroaders cluster and relatively high levels of Industrial Pollution. These nations scored a modest positive level of

Clean Wealth Creation (Figure 1). Similar to Sustainability Crossroaders, the most likely reason for these results is the constant need for economic development.

Unlike Sustainability Crossroaders, this group presents one distinct attribute, namely Socio-Environmental Conditions. With no exception, nations within this cluster have not been able to effectively manage their Socio-Environmental Conditions, hence showing the worst performance of all nations included in the study. They constitute a group of poor nations lacking enough resources to address sustainability issues. We observe that CO_2 rate of change tends to zero percent, implying little to no economic advancement at all. However, the group exhibits a high positive rate of change on the improved water and sanitation access dimensions. We find to possible explanations. First, governments tend to focus on hunger and poverty alleviation and, second, the economic resources they possess are not sufficient to satisfy the combined needs of a growing population.

These nations face serious challenges regarding their future sustainable development. Despite the efforts towards improving circumstances, an examination of group dynamics suggests that Laggards are moving in the opposite direction, i.e. becoming less sustainable with the years, as Figure 1 shows. Environmental and social problems have increased over the study period, and economic advancement, in per capita terms, has been modest. It seems that these nations are facing serious sustainable ―meta-problems‖, meaning that to effectively address problems on one dimension it is necessary to address problems on the remaining dimensions simultaneously (Roome, 2001). Findings in the cluster suggest that economic factors alone are unable to explain the problems these nations are facing.

Uganda is the most representative nation within the group of Sustainability Laggards, and China and Ethiopia emerge as outliers, yet for completely different reasons. While China and Ethiopia both exhibit low levels of Governance Quality, the Chinese have the lowest level of Clean Wealth Creation. This is consistent with China's energy consumption-production patterns (Economy, 2007). Ethiopia, on the other hand, shows the second highest intragroup score on Clean Wealth Creation, but it also shows the highest score (of the entire data set) of SocioEnvironmental Conditions.

Following dirty paths to sustainable development entails that there are serious challenge ahead. Negative environmental and social outcomes are becoming more acute and these countries have experienced very few changes with regards to their Clean Wealth Creation path, suggesting that current production practices regarding energy efficiency have not changed significantly from their original static levels.

6. Discussion

Transition research has made a major contribution to our understanding of how changes unfold within socio-technical systems. However, transition analyses have so far neglected where transitions occur (Coenen et al., 2012), and the dynamics and key factors that explain transformations with aggregated data at the national level.

This work provides a promising start for the identification of key variables that need to be addressed and studied if SD is to become more than a utopian concept. Our work offers a reliable basis for theorizing and effective public policy creation, because, unlike prior studies, it is based on countries' current path to SD and not on inferred trends, which allows for better resource allocation.

Relatedly, this paper contributes to the literature by addressing methodological voids. Our empirical typology of alternative paths to SD is based on recent developments in the literature, using EFA (PCA method) and cluster analysis (Xia et al, 2001), which is conceptually different from those structures used in extant works (Cf. Esty et al., 2012; Wackernagel and Rees, 1996), enabling the identification and understanding of key variables that each group faces. Cluster analysis has proven helpful in leading to more efficient policy development by means of a finer-grained approach for managing energy problems, for example, by setting differentiated energy reduction goals for different types of entities (Petcharat et al., 2012; Xia et al., 2011).

The effect of identifying these country-level clusters permits a finer-grained approach in aiding countries through public policies to achieve a more sustainable level. Policy development is particularly relevant in the case of transitioning clusters such Crossroaders and Compliers. For example, Crossroaders constitute a group of very disparate nation types characterized by having low levels of Governance Quality, within which we identify two subgroups: one that addresses Industrial Pollution issues in a clean manner, regardless of their low levels of Governance Quality, and one that deals with Industrial Pollution in a dirty fashion. Thus, in addressing sustainability issues, two different sets of policies are required. Nations with clean results in Industrial Pollution need to set strong economic incentives (such as tax exemptions) to maintain or enhance their clean path, whilst simultaneously improving their political framework as a warranty that they will not deviate from this path, and also, that their clean results do not rely on importation of goods that have high energy inputs from other countries (Chen and Chen, 2013).

Those nations following dirty paths along the Industrial Pollution dimension need to implement and enforce legal coercive measures (such as high fines) to move industries towards adopting sustainable environmental practices whilst simultaneously improving their political framework. Extended energy accounting provides a useful assessment of the development of a socio-economic system (Dai et al. 2014). Countries are socio-economic systems, therefore, by assessing their state of development a course can be chartered to make it more sustainable and to move from one cluster to another.

Furthermore, the inclusion of a large number of variables coupled with multivariate techniques permits identifying interrelationships between economic, social, environmental and political dimensions, which is so far absent in terms of methodological developments in the field. In doing so, we contribute to literature by uncovering a number of key factors that explain SD at national level. While most transition research studies draw on insights from institutional and neo-evolutionary economics theories to elaborate conceptual models and alternative pathways to sustainability (e.g. Geels 2005; Geels and Schot 2007), our work takes a substantive approach to theory building based on observation and analysis of interrelationship of a multitude of variables. Even recent place-based transition studies (e.g. Nevens et al., 2013) assume a narrow view of the phenomenon by looking at efforts towards SD from an overarching, yet restrictive institutional perspective. Indeed, contributors observe SD pathways as mere social learning processes located in institutional sites.

In addition, our results suggest that a relationship exists between increased SD policy stringency and improved environmental and social performance. As shown in Table B4 (Appendix B), as a nation's Governance Quality increases there is a tendency to undertake cleaner paths along the Industrial Pollution dimension (-.279), scarcely affecting Clean Wealth Creation (-.035). Our selection of statistical techniques certainly restricts the possibility of making causal inferences, however from a theoretical point of view (e.g. Esty and Porter, 2005) we can argue that our results support the notion that the development and implementation of more stringent policies leads to economic advancements while alleviating environmental stresses. Similarly, from a social point we also observe a negative relationship where the higher the Governance Quality, the lower the Socio-Environmental Conditions (-.280).

A nation's government can build competitive advantage through public policy as it can effectively develop capabilities for SD (Hamann and April, 2013) and modify the nation's pathway. Looking at this issue is central to prompting SD; especially when the ―transformative potentials of routinely performed strategic activities of urban governments tend to be overlooked‖ (Quitzau et al., 2013:140).

Contributors argue that this argument holds also when it comes to SD policy (Barnhizer 2006; Meadowcroft 2007; Porter and van der Linde 1995). Our results contribute to better understanding this statement, and also the notion that governments play a central role in achieving sustainable development outcomes (Meadowcroft, 2007; Steurer, 2007), and that Governance Quality mediates the remaining rate of change factors. This is the case of Sustainability Athletes Chile and Uruguay. Our results would not support the claims against environment regulation (e.g. Palmer et al., 1995). All of the above leads us to conclude that stringent regulatory frameworks do not necessarily affect the trend of wealth creation in a sustainable way.

Interestingly, our analysis shows that although economic activity has increased in recent years, roughly 54% of our observations experienced persistently lower Industrial Pollution outcomes. Since we measure pollution using variables that are typically included in environmental studies (e.g. EKC), we suggest that these nations do not support extant results and traditional policy recommendations, partly supporting the criticisms made by Stern et al. (1996), Harbaugh et al. (2002), Perman and Stern, (2003) and Stern (2004). These studies are too limited in scope to be truly representative of the SD phenomenon at an international level and therefore their conclusions (and subsequent SD policies) should be followed with caution.

6.1 Limitations

There are, inevitably, limitations to our study. One concern relates to data. First, we were unable to incorporate certain variables (e.g. gender, income equality, literacy rates, among others) to assess a broader and more accurate scope of SD dimensions.

Our second limitation pertains sample composition. Given data access, we did not include Russia and Israel in the study, which may have affected our propositions with regards to Sustainability Compliers, or make inferences regarding development patterns of Middle East countries.

Third, given the comprehensiveness of the SD construct, observing, analyzing and understanding all possible relations and interconnections becomes a methodological and empirical impossibility, especially considering the controversial nature of the concept and its traditional embeddedness in environmental aspects (Esty and Porter 2005; Esty et al., 2012; Sharma and Ruud 2003; Stern 2004; Wackernagel and Rees 1996).

Finally, the statistical techniques selected for this study present limitations when it comes to assess causality, which may affect both factor and cluster interpretations. Limitations result from tradeoffs in the research design and open up avenues for future research. Given that we demonstrate that a coherent structure for nation level SD can indeed be ascertained, new multidimensional studies are necessary to begin unraveling, and piecing together, the SD puzzle. Also, future studies can use this new structure (factors) to better define hypothesis the effects of this component variables in the dynamic that some countries follow in the pursuit of sustainability. In general, SD research should seek to operationalize the construct to establish a more accurate explanation of each nation's particular reality and start research into public policies tailored for each country's (or at least group of countries) specific reality.

7. Concluding remarks

By identifying key variables and alternative paths we respond to the overall purpose of the study, providing an empirical account of sustainable transformations at the national level. The holistic understanding offered by our empirical typology opens a new approach, calling for further research and theorizing. We hope that this work will also encourage more adequate policy development in the field of SD. In conclusion, we strongly believe that this work establishes a starting point for focalized research of sustainable development dynamics in context, upon which policy-makers can design relevant instrument to address each nation's specific reality. Accurate measurement operates as the basis for effective policy, which in turn can eventually pave the road for all nations to become Sustainability Athletes.

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Tables and figures

Table 1: Cluster Membership and Distance to Cluster Center

Cluster Membership

Cluster 1	
Country	Distance to center
Algeria	1.422848
Argentina	0.94219
Bangladesh	0.760971
Bolivia	2.1367
Botswana	1.205422
Brazil	0.48678
Colombia	1.229961
Costa Rica	1.118718
Dominican Republic	1.352359
Ecuador	0.89537
Egypt, Arab Rep.	0.401061
El Salvador	0.522101
Gabon	1.479448
Guatemala	5.116113
Iran, Islamic Rep.	1.943644
Jamaica	1.217934
Jordan	1.142444
Korea, Rep.	2.00396
Kuwait	3.320731
Lebanon	0.856824
Malaysia	0.692479
Mexico	0.763582
Mongolia	1.632901
Morocco	0.780602
Nicaragua	0.447499
Pakistan	0.946453
Panama	1.034662
Peru	1.141102
Philippines	0.942376
Saudi Arabia	1.156555
Senegal	1.290017
South Africa	1.141528
Sudan	1.527614
Syrian Arab Republic	0.984893
Thailand	0.918279
Togo	1.777852
Tunisia	0.47711
Turkey	0.72709
Uzbekistan	1.603348
Venezuela, RB	0.81149
Zimbabwe	1.366908

Cluster 2	
Country	Distance to center
Albania	1.018114
Armenia	2.41036
Azerbaijan	3.330671
Bulgaria	1.221566
Czech Republic	0.853484
Estonia	1.30675
Hungary	1.127
Kazakhstan	0.859787
Kyrgyz Republic	1.889189
Latvia	0.960427
Lithuania	0.775734
Moldova	1.763832
Poland	0.82476
Slovak Republic	0.823701
Ukraine	1.387602

Cluster 3	
Country	Distance to center
Australia	0.348309
Austria	0.482042
Belgium	0.504767
Canada	0.428726
Chile	1.170658
Croatia	1.077069
Denmark	0.752195
Finland	0.596146
France	0.324426
Germany	0.82045
Greece	0.72511
Iceland	1.251866
Ireland	1.683968
Italy	0.757299
Japan	0.937716
Netherlands	0.564309
New Zealand	0.660647
Norway	0.709711
Portugal	0.736575
Slovenia	0.574045
Spain	0.383077
Sweden	0.435088
Switzerland	0.58569
United Kingdom	0.856514
United States	0.288043
Uruguay	1.254398

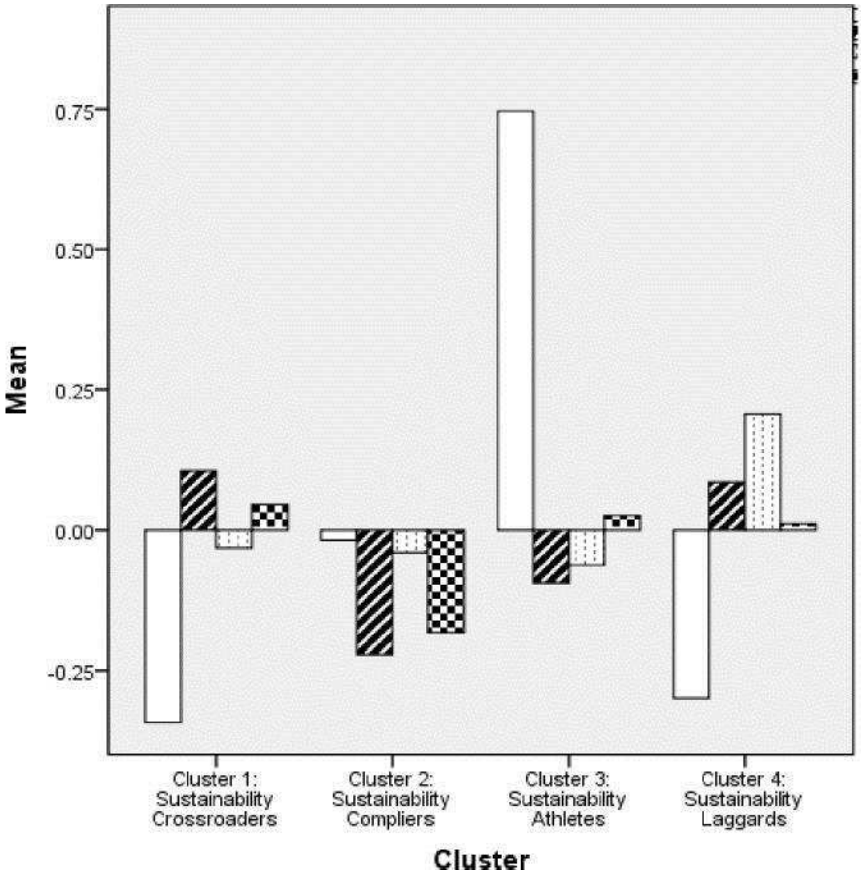
Cluster 4	
Country	Distance to center
Benin	1.518217
Cameroon	1.138789
China	2.097748
Ethiopia	2.936715
Ghana	0.783754
Honduras	1.240183
India	0.820987
Indonesia	1.699064
Kenya	1.080885
Mozambique	1.426664
Nepal	1.161485
Nigeria	1.74248
Paraguay	1.073474
Rwanda	1.345461
Sri Lanka	0.701693
Uganda	0.454544
Vietnam	1.525235

* Scores closer to 0 indicate proximity to cluster center

Table 2: Cluster Summary

Cluster \ Factor	Governance Quality	Industrial Pollution	Socio-Environmental Conditions	Clean Wealth Creation
Sustainability crossroaders	Low levels impedes effective public policy creation and enforcement.	Pursuit of economic development has resulted in continued environmental stresses.	Corrective steps to alleviate poverty are being moderately taken. The group shows relatively low levels of CO_2 emissions.	Swift need for economic development has made energy resources usage persistently more effective.
Sustainability compliers	Medium levels and isomorphic pressures help enforcement of public policies.	Adoption of improved industrial environmental practices has persistently alleviated environmental stresses.	Corrective steps to alleviate poverty are being moderately taken. The group shows low levels of CO_2 emissions.	Post USSR cultural issues have meant that energy use for wealth creation has become persistently less efficient.
Sustainability Athletes	High levels allow strict enforcement of public policies.	Pollution displacement and/or improved environmental management have persistently alleviated environmental stresses.	The group has persistently become more eco-efficient, persistently reducing levels of CO_2 emissions.	Consciousness of the need for energy efficiency has meant that it has been persistent energy efficiency improvements.
Sustainability Laggards	Low levels impedes effective public policy creation and enforcement.	Pursuit of economic development has resulted in continued environmental stresses.	No corrective steps to alleviate poverty are being taken. Problems in this sphere have persistently become more acute and basic hygiene conditions are not present.	Swift need for economic development has made energy resources usage slightly more effective.

Figure 1. Factor Score Means for Each Cluster



White bar – Governance Quality | Small dots bar – Socio-Environmental Conditions
Striped bar – Industrial Pollution | Large dots bar – Clean Wealth Creation

Table

Appendix A. Variables definition

SD occurs at the intersection of three basic dimensions (economic, social and environmental). However, this means that there are actually four relevant inter-dimensions to analyze: socio-economic, environmental-economic, socio-environmental and socio-environmental-economic development. Also to be able to incorporate political framework and public policy concerns a political dimension was included in the analysis. Based on this and the variables used in the multidimensional studies of our literature review 67 initial variables were chosen. As a first step, variables were reduced to those that best represented the intersecting dimensions of SD, leaving a total of 43. As a second step, variables were eliminated if they presented 15 or more observations that had no data at all for the proposed study period. This ultimately reduced the variable set to 24

Variable	Measure	Description	Source	Dimension
Age dependency ratio	Percentage of working-age population	Age dependency ratio is the ratio of dependents--people younger than 15 or older than 64--to the working-age population--those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population	World Bank staff estimates from various sources including census reports, the United Nations Population Division's World Population Prospects, national statistical offices, household surveys conducted by national agencies, and Macro International	Socio-Economic Sustainability
Agriculture, value added	Percentage of GDP	Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. For VAB countries, gross value added at factor cost is used as the denominator.	World Bank national accounts data, and OECD National Accounts data files	Economic-Environmental Sustainability
CO2 intensity	Kg per kg of oil equivalen	Carbon dioxide emissions from solid fuel consumption refer mainly to emissions from use of coal as an energy source	Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, United States	Socio-Environmental Sustainability
Electric power consumption	kWh per capita	Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants	International Energy Agency (IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp), Energy Statistics and Balances of Non-OECD Countries and Energy Statistics of OECD Countries	Economic-Environmental Sustainability

Energy use	Kg of oil equivalent per $1,000 GDP	Energy use per PPP GDP is the kilogram of oil equivalent of energy use per constant PPP GDP. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. PPP GDP is gross domestic product converted to 2005 constant international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as a U.S. dollar has in the United States	International Energy Agency (IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp), and World Bank PPP data	Economic Environmental Sustainability
Fertility rate, total	Births per woman	Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates	(1) United Nations Population Division. 2009. World Population Prospects: The 2008 Revision. New York, United Nations, Department of Economic and Social Affairs (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) Secretariat of the Pacific Community: Statistics and Demography Programme, (5) U.S. Census Bureau: International Database, and (6) household surveys conducted by national agencies, Macro International, and the U.S. Centers for Disease Control and Prevention.	Socio-Economic Sustainability
Food production index	1999-2001 = 100	Food production index covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value.	Food and Agriculture Organization (FAO), electronic files and web site data.	Economic-Environmental Sustainability
GNI per capita, Atlas method	Current US$	GNI per capita (formerly GNP per capita) is the gross national income, converted to U.S. dollars using the World Bank Atlas method, divided by the midyear population. GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. GNI, calculated in national currency, is usually converted to U.S. dollars at official exchange rates for comparisons across economies, although an	World Bank national accounts data, and OECD National Accounts data files.	Socio-Economic Sustainability

		fluctuations in prices and exchange rates, a special Atlas method of conversion is used by the World Bank. This applies a conversion factor that averages the exchange rate for a given year and the two preceding years, adjusted for differences in rates of inflation between the country, and through 2000, the G-5 countries (France, Germany, Japan, the United Kingdom, and the United States). From 2001, these countries include the Euro area, Japan, the United Kingdom, and the United States.		
Improved sanitation facilities	Percentage of population with access	Access to improved sanitation facilities refers to the percentage of the population with at least adequate access to excreta disposal facilities that can effectively prevent human, animal, and insect contact with excreta. Improved facilities range from simple but protected pit latrines to flush toilets with a sewerage connection. To be effective, facilities must be correctly constructed and properly maintained.	World Health Organization and United Nations Children's Fund, Joint Measurement Programme	Socio-Environmental Sustainability
Improved water source	(% of population with access	Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 liters a person a day from a source within one kilometer of the dwelling.	World Health Organization and United Nations Children's Fund, Joint Measurement Programme	Socio-Environmental Sustainability
Industry, value added	% of GDP	Industry corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is	World Bank national accounts data, and OECD National Accounts data files	Economic-Environmental Sustainability

rate actually applied in international transactions. To smooth

Life expectancy at birth, total	Years	Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same	Derived from male and female life expectancy at birth. Male and female life expectancy source: (1) United Nations Population Division. 2009. World Population Prospects: The 2008 Revision. New York, United Nations, Department of Economic and Social Affairs (advanced Excel tables), (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) Secretariat of the Pacific Community: Statistics and Demography Programme, and (5) U.S. Census Bureau: International Database	Socio-Economic Sustainability
PM10, country level	Micrograms per cubic meter	Particulate matter concentrations refer to fine suspended particulates less than 10 microns in diameter (PM10) that are capable of penetrating deep into the respiratory tract and causing significant health damage. Data for countries and aggregates for regions and income groups are urban-population weighted PM10 levels in residential areas of cities with more than 100,000 residents. The estimates represent the average annual exposure level of the average urban resident to outdoor particulate matter. The state of a country's technology and pollution controls is an important determinant of particulate matter concentrations	Kiren Dev Pandey, David Wheeler, Bart Ostro, Uwe Deichmann, Kirk Hamilton, and Katherine Bolt. "Ambient Particulate Matter Concentrations in Residential and Pollution Hotspot Areas of World Cities: New Estimates Based on the Global Model of Ambient Particulates (GMAPS)," World Bank, Development Research Group and Environment Department (2006).	Socio-Environmental Sustainability
Population density	People per sq. km of land area		Food and Agriculture Organization and World Bank population estimates	Socio-Environmental Sustainability
		Industrial Classification (ISIC), revision 3 Population density is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes		
SO2	SO2	Emission levels of SO2, an anthropogenic acidifying gas	European Commission, Joint Research Centre	Economic-

			(JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), release version 4 . 1 . http://edgar .jrc .ec.europe.eu , 2010	Environmental Sustainability
NOx	NOx	Emission levels of NOx, an anthropogenic ozone precursor and acidifying gas	European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), release version 4 . 1 . http://edgar .jrc .ec.europe.eu , 2010	Economic-Environmental Sustainability
NH3	NH3	Emission levels of NOx, an anthropogenic acidifying gas	European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission	Economic-Environmental Sustainability
CH4	CH4	Emission levels of CH4, an anthropogenic greenhouse and ozone precursor gas	European Commission, Joint Research Centre (JRC)/Netherlands Environmental Assessment Agency (PBL). Emission Database for Global Atmospheric Research (EDGAR), release version 4. 1 . http://edgar .jrc .ec.europa.eu/archived_datasets.php	Economic-Environmental Sustainability
Voice and Accountability		Extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media	The Worldwide Governance Indicators, www.govindicators.org	Political
Political Stability and No Violence		Likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism	The Worldwide Governance Indicators, www.govindicators.org	Political
Government Effectiveness		Quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies	The Worldwide Governance Indicators, www.govindicators.org	Political
Regulatory Quality		Ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development	The Worldwide Governance Indicators, www.govindicators.org	Political
Rule of Law		Extent to which agents have confidence in and abide by the	The Worldwide Governance Indicators,	Political

	rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence	www.govindicators.org	
Control of Corruption	Extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as " capture" of the state by elites and private interests	The Worldwide Governance Indicators, www.govindicators.org	Political

Appendix B.

Table B1: Total Variance Explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.250	37.502	37.502	8.250	37.502	37.502	7.411
2	3.294	14.971	52.473	3.294	14.971	52.473	4.588
3	1.829	8.316	60.789	1.829	8.316	60.789	3.351
4	1.736	7.892	68.681	1.736	7.892	68.681	2.401
5	1.128	5.126	73.807				
6	.962	4.374	78.181				
7	.855	3.888	82.069				
8	.672	3.055	85.123				
9	.543	2.470	87.594				
10	.475	2.161	89.754				
11	.443	2.014	91.768				
12	.346	1.574	93.342				
13	.320	1.455	94.797				
14	.284	1.291	96.087				
15	.239	1.088	97.176				
16	.181	.821	97.996				
17	.159	.721	98.717				
18	.096	.438	99.156				
19	.093	.423	99.579				
20	.052	.236	99.814				
21	.024	.110	99.924				
22	.017	.076	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Table B2: PCA Goodness of Fit Statistics

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.847
Bartlett's Test of Sphericity	Approx. Chi-Square	1986.556
	df	231
	Sig.	.000

Table B3: Factor Loadings

Pattern Matrix[a]

	Component			
	1	2	3	4
RegulatoryQuality	.905	.041	-.156	-.059
GovernmentEffectivness	.899	.009	-.179	.037
VoiceandAccountability	.892	-.046	-.079	.045
ControlofCorruption	.868	.005	-.197	.127
RuleofLaw	.849	-.034	-.214	.077
Fertiliy Rate	.831	-.036	.183	-.084
Age dependency ratio (% of working-age population)	.807	-.049	.365	.004
PoliticalStabilityandNo Violence	.741	-.096	-.204	.019
CH4	-.069	.853	-.076	-.104
Nox	.005	.850	.097	.056
NH3	.081	.799	-.052	-.024
SO2	-.085	.707	.145	.237
Electric power consumption (kWh per capita)	.027	.544	.239	-.038
Food production index (1999-2001 = 100)	-.374	.449	.080	.147
Industry, value added (% of GDP)	-.325	.435	-.042	-.038
Improved water source (% of population with access)	-.053	.099	.778	.073
CO2 intensity (kg per kg of oil equivalent energy use)	-.075	.068	.756	-.180
Improved sanitation facilities (% of population with access)	-.069	.088	.747	.143
GNI per capita, Atlas method (current US$)	-.096	.182	-.168	-.818
Energy use (kg of oil equivalent) per $1,000 GDP (constant 2005 PPP)	-.020	.191	-.181	.767
PM10, country level (micrograms per cubic meter)	.249	.380	-.196	.647
Agriculture, value added (% of GDP)	-.405	-.111	.146	.549

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 8 iterations.

Table B4: Component Correlation Matrix

Component Correlation Matrix

Component	1	2	3	4
1	1.000	-.279	-.280	-.035
2	-.279	1.000	.130	.178
3	-.280	.130	1.000	.014
4	-.035	.178	.014	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

1. Governance Quality, 2. Industrial Pollution, 3. Socio-Environmental Conditions, 4. Clean Wealth Creation.

Table B5: Cluster ANOVA

ANOVA

	Cluster		Error			
	Mean Square	df	Mean Square	df	F	Sig.
REGR factor score 1 for analysis 2	23.912	3	.276	95	86.491	.000
REGR factor score 2 for analysis 2	10.902	3	.687	95	15.862	.000
REGR factor score 3 for analysis 2	20.424	3	.387	95	52.830	.000
REGR factor score 4 for analysis 2	15.319	3	.548	95	27.963	.000

The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.