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Achieving sustainable development goals: predicaments and strategies

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ABSTRACT

The ambitious United Nations Sustainable Development Goals (SDGs) have been criticized for being universal, broadly framed, inconsistent and difficult to quantify, implement and monitor. We contribute by quantifying and prioritising the SDGs and their impact on sustainable development. We employ structural equation models (SEM) to investigate, which of the underlying pillars of SDGs (economic, social and environment) are the most effective in achieving sustainable development. Our results reveal that the developed countries benefit most by focusing on social and environmental factors, whereas the developing countries benefit most by retaining their focus on the economic and the social factors.

1. Introduction

Milton Friedman famously said, ‘One of the great mistakes is to judge policies and programs by their intentions rather than their results’. Agenda 2030 with its 17 Sustainable Development Goals (SDGs) aims to eradicate poverty, establish socioeconomic inclusion and protect the environment (United Nations 1992). A global to-do list for sustainable development, it has been criticized for being too ambitious, universal, expansive and with potential inconsistencies, particularly between the socio-economic development and the environmental sustainability goals (Stern et al. 1996; Redclift 2005; UN SDSN 2015; ICUS and ISSC 2015; Easterly 2015; Spaiser et al. 2016). These challenges are akin to a quagmire of conceptual and quantification problems, and extrication of a measure of sustainable development and its impact is complex.

Our objective is to quantify SDGs and compare our measures to established measures of development, such as Human Development Index (HDI). Second, we investigate and quantify the impact of SDGs’ underlying pillars (economic, social and environment) on sustainable development. Third, we examine if the developing and the developed countries may pursue different strategies in achieving sustainable development in the short term.

We employ Structural Equation Models (SEM) on recent data, in the public domain, for 117 countries. Contrary to some confusion in the literature (Wilkinson 1999), SEM analysis produces quantitative causal claims, conditional on the input assumptions, along with data fitness and well-defined tests (Pearl 2013; Tarka 2018). Our results reveal that for the developed countries, all the three underlying pillars of SDGs are significant, although the magnitude of increase in sustainable development is highest from the underlying social and environmental pillars of SDGs. For the developing countries, our results suggest that these countries may continue their focus on the economic and social pillars of SDGs. Although the sustainable development gains from the SDGs environment pillar are relatively smaller in magnitude (and statistically insignificant) in the short run, it cannot be ignored due to the interlinkages, synergies and trade-offs between these three pillars of SDGs. These results are robust, even when China and India are excluded.

Monitoring and quantifying the impact of Agenda 2030 requires measuring SDGs and sustainable development, which is fraught with challenges (Bali Swain 2018). Easterly (2015) argues that the SDGs are encyclopedic where everything is top priority, implying that nothing is a priority. Moreover, there is ambiguity as to how the U.N. is going proceed in achieving the unactionable, unquantifiable targets for the SDGs, that may also be unattainable, like ‘ending poverty in all its forms and dimensions,’ ‘universal health coverage,’ ‘[end] all forms of discrimination against all women and girls everywhere,’ ‘achieve full and productive employment and decent work for all women and men,’ etc.

In spite of the inherent difficulties in measuring and monitoring SDGs, a limited body of literature has recently emerged (Nicolai et al. 2015; Green Growth Knowledge Platform 2016; Sachs et al. 2016; Spaiser et
However, to our knowledge, there are none that quantify the impact of SDGs and draw causality between the underlying SDG pillars and sustainable development. Our paper contributes at several levels. First, employing global data we measure unobservables like sustainable development and the underlying pillars of SDGs (economic, social and environment). Second, to maintain the comparability of the results, the analysis is based on global data available in the public domain. Third, we take the multiple dimensionality of the SDGs into account without computing indices or averages that impose autonomous weights. We employ the Principal Component Analysis (PCA) method to compute the scores for each of the SDGs as measured by multiple observed indicators. Moreover, to capture the connections between the SDGs and the economic, social and environmental pillars, we use Exploratory Factor Analysis (EFA), instead of imposing extraneous links between the SDGs and the SDG pillars. Fourth, by employing Structural Equation Models (SEM) we are able to establish causality between the underlying (latent) SDG pillars and another latent variable like sustainable development. Finally, our analysis enables us to examine which of these underlying pillars are most effective in achieving sustainable development for the developing and the developed countries, in the short term.

The next section briefly reviews the existing literature on quantification of sustainable development, followed by sections explaining the methodology and the data analyzed. Section 5 presents and discusses the empirical results. The final section concludes.

2. Quantifying sustainable development and goals

The Millennium Development Goals (MDGs) that preceded the SDGs were precise and measurable, which made them attractive (Easterly 2015). With eight well-defined MDGs, the demand for information was limited. Even then, the lack of reliable data rendered the unreported, invisible to the decision makers. For instance, for the MDG indicators, only three African countries have data on all indicators (United Nations 2014). As compared to the MDGs, the 17 SDGs (169 sub-targets) pose a formidable challenge. In March 2016, the UN Statistical Commission adopted a list of 230 indicators suggested by the Inter-Agency and Expert Group on SDG Indicators. 1 This is in sharp contrast to the 60 globally harmonized indicators for the MDGs. Operationalization of SDGs and their implementation involves monitoring and measuring sustainable development indicators.

In this section, we describe some of the significant publications in the emerging literature on SDG measurement, while in the next section we go into the details of the methodology that we develop to evaluate SDGs. Three major studies in the developing literature are: the GKP Report on Measuring Inclusive Green Growth at the Country Level (Green Growth Knowledge Platform 2016); the SDG Index and Dashboards Global Report prepared by the UNSDSN and the Bertelsmann Stiftung (Sachs et al. 2016); and the Overseas Development Institute Report (Nicolai et al. 2015). The GKP Report on Measuring Inclusive Green Growth 2 (IGG) at the Country Level is not limited to the SDGs and focuses on the Inclusive Green Growth and their interaction in a dynamic perspective (Fay 2012).

The Overseas Development Institutes report (Nicolai et al. 2015) develops a grading system for each of the SDGs. The report classifies them into three categories: reform, revolution, and reversal. Reform level SDGs are more than halfway to achievement by 2030, while goals that require progress by multiples of current rates are graded as revolution. The most extensively used SDG Index is the one presented in the SDG Dashboards report (Sachs et al. 2016). It identifies multiple indicators from the most recent published, to measure each SDG goal. Employing geometric and arithmetic averages, it computes scores for the data across all indicators that apply to each of the SDG. The method enables them to calculate a country scores for each of the 17 goals. These scores are averaged to find the overall SDG Index for each country. This study finds that three Scandinavian countries (Sweden, Denmark and Norway) have the highest SDG index, implying that they are the closest to achieving the SDG targets for 2030.

In our earlier paper (Spaiser et al. 2016) we construct two separate measures of SDGs. These measures assume a true latent variable for sustainable development with the three components of child mortality, education and CO2 emissions (representing the economic, social and environment pillar). We find that these two different constructs of sustainable development perform better than the common indices, namely, HDI and GDP per capita. Spaiser et al. (2016) also quantify the incompatibility and inconsistency in the SDGs.

While these studies present indices and hence the possibility to monitor sustainable development and SDGs, they are restricted by major data limitations. Furthermore, they do not inform the policy makers on which of the underlying economic, social or environment pillars are significant in impacting sustainable development. This is critical, given the inconsistencies and trade-offs between the various components of SDGs (Spaiser et al. 2016).

We also need to measure sustainable development. Efforts to quantify sustainable development are not neoteric. As far back as in the 1970s, Agenda 21 formulated the need for sustainable development indicators. 3 On sustainable development indicators, Agenda 21 (paragraph 40.4) states that: ‘Indicators of sustainable development need to be developed to provide solid bases for decision-making
at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems.’ Sustainable development was initially interpreted to be a dynamic optimization problem of intergenerational equity. It was about ensuring optimal consumption that could be maintained in the long run without depleting the generated (Pierantoni 2004).

Since the early 1990s, multiple measures of sustainability have been developed and used by policy makers. These range from conventional measures of economic performance, such as gross domestic product (GDP), to measures that aim to capture the sustainable development. Output measures like GDP, net domestic product and real consumption per capita are widely used but only capture the economic aspect of development (Parris and Kates 2003) and may be misleading as they disregard the overexploitation of the natural resources (Goodland and Ledec 1987). This has led to a spate of measures that account for the depletion of environmental or natural capita, such as, Green Net National Product (Hartwick 1990; Weitzman 1997), Genuine Savings Index (Hamilton 1994; Neumayer 2001), Ecological footprint (Rees 1992; Lin et al. 2016), Environmental Sustainability Index (Parris and Kates 2003) etc.

An alternate set of sustainable development indices attempt to measure the well-being. These include the Well-being index (Parris and Kates 2003), Genuine Progress indicator Gross National Happiness index (Ura et al. 2012), etc. However, these indices suffer from errors and biases, which are significant for the environmental data in general. Also, measures for the social aspect of sustainability suffer from subjectivity in the selection of input variables (Custance and Hillier 1998). Ambiguity, errors and biases in data collection and analysis of sustainable development measures have thus implied that there are no indicators that are universally accepted by policy makers (Parris and Kates 2003). An added problem is the lack of a measure that is easily comparable and interpreted across countries and sectors (Boehringer and Jochem 2007). Thus, UNDP’s Human Development Index (HDI) remains one of the most accepted indicators of social development with its three major components: longevity, knowledge, and income (United Nations Development Programme 2010).

Sen’s theory of development as freedom and capabilities approach provides a wider interpretation of development to include social capital and human capital (Sen 1985, 2001, 2010). A recent body of literature defines Sustainable Development in terms of Inclusive Wealth or intergenerational well-being (Arrow et al. 2012). Inclusive Wealth is the society’s stock of all its capital assets (reproducible/productive capital, human capital and natural capital) and their changes over time, accounting for population growth and technological change. Unlike GDP per capita and Human Development Index (HDI), empirical evidence shows that the Inclusive Wealth Index can better capture sustainable development through changes in intergenerational well-being (Dasgupta 2013). This measure is, however, severely limited by cross-country, time-series data availability (Arrow et al. 2012; Dasgupta 2013).

3. Methodology

We employ Factor Analysis exploratory factor analysis and Structural Equation Models (SEM) in our analyses. The path diagram of the model of interest is explained in Figure 1. The ellipses in the middle of the path diagram (with the arrows) represent the structural model, which reveals the causal relationship between the latent factors (SDGs underlying pillars and sustainable development). The three underlying pillars of sustainable development are represented by the latent variables: economic, social and environment (left-hand side ellipses). The causal impact of these three latent variables on the latent sustainable development variable (right-hand side ellipse) is estimated in the structural model. SEM models have been widely used in economics (for a review refer to Tarka (2018)). A large body of literature present SEM as the prime language of causal analysis for both linear and non-linear analyses (Pearl 2012; Bollen and Pearl 2013).

3.1. The measurement model

The measurement models are captured by the rectangles and arrows connect the observed and the latent variables on the left and right-hand side of Figure 1. The measurement of the three pillars of SDGs (left-hand side) is estimated in two steps.

In step 1, the Principal Component Scores (PCA) are calculated for each of the SDGs using the set of observed indicators for that specific goal. PCA is a common dimension-reduction or data compression tool often used to reduce high-dimensional data structures while retaining most of the information. It is a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. We apply this technique to compute the scores for each of the SDG goals. The calculation of the principal component scores is briefly summarized in the Appendix.

In Step 2, instead of extraneously imposing the connections between the SDG scores (in rectangles) and the latent factors, namely, Economy, Social, Environment (in ellipses), we employ Exploratory Factor Analysis (EFA) to identify the underlying theoretical structure of the latent phenomena. EFA is used to identify the structure of the relationship between the observed variables and the latent factors, i.e. SD, Economy, etc. It tests whether the correlation structure of the observed indicators allows to extract one or several factors. It thus examines if the observed variables can be predicted by one or several latent factors.
The other measurement model (on the right-hand side) of Figure 1, determines the latent sustainable development (in ellipses) using indicators (measures in rectangles). The arrow pointing to the sustainable development (SD) ellipse signifies the error term in the structural model with the latent variables.

### 3.2. The structural equation models

The structural model that corresponds to Figure 1 and measures the causal relationship between the underlying pillars of SDGs and sustainable development can be expressed in the matrix form as follows:

\[
x = \Lambda x \xi + \delta, \tag{1}
\]

\[
y = \Lambda y \eta + \epsilon, \tag{2}
\]

\[
\eta = \Gamma \xi + \varsigma, \tag{3}
\]

where \( x \) and \( y \) are the indicator vectors of latent factors, namely, \( x \) includes the SDGs on the left-hand side of the path diagram and \( y \) represents the matrix of measures of sustainable development on the right-hand side. \( \eta \) is latent sustainable development and \( \xi \) includes latent factors (pillars) economic, social and environment. \( \Lambda x \) and \( \Lambda y \) are factor loadings which connect the latent factors and the observed indicators. The \( \Gamma \) coefficients indicate the causal relations between the latent factors, whereas \( \delta, \epsilon \) and \( \varsigma \) are the error terms associated with the measurements.

The model is estimated by the Maximum Likelihood estimation method. The Maximum Likelihood (ML) approach estimates the unknown parameters in the model by minimizing the fit function

\[
F(\Theta) = \log \left( \sum \right) + \text{tr}(S^{-1}) - \log(\|S\|) - k + (z - \mu)^{\top} S^{-1} (z - \mu), \tag{4}
\]

where \( k \) is the number of indicators, \( S \) and \( \Sigma \) are the sample and model implied variance and covariance matrix, respectively. This fit function assumes that the observed indicators have a multi-normal distribution.

### 4. Data

Quantifying SDGs require data and data in the developing countries is often remarkably poor and often missing. In fact, there is not a single five-year period since 1990 where countries have enough data to report on more than 70% of MDG progress (United Nations 2014). Child mortality is widely assumed to have the best reported data, yet of the 161 developing countries, only 136 have data on it (Rodríguez-Pose and Samuels 2015). Even where comprehensive data exists, certain groups are missing, such as ethnic minorities or indigenous populations and slum-dwellers. The SDG Dashboards report (Sachs et al. 2016) identifies 77 indicators for 149 countries to measure SDGs based on five quality criteria for data selection, namely, global relevance and applicability to a broad range of country settings; statistically
Table 1 presents the analytical and social indicators, developed by the World Health Organization (WHO 2016), the Human Development Report (United Nations Development Programme 2015), and OECD Statistics (OECD 2016), etc. They include indicators for which 80% of the data is available for countries with population greater than 1 million. We begin with this dataset as the base for our analyses.

Sachs et al. (2016) have full information on 77 indicators for only 34 countries to calculate the augmented SDG Index. However, the 149 countries are ranked based on the overall arithmetic and geometric score while ignoring the missing values. Starting with the same data as Sachs et al. (2016), we delete the missing values. Our analyses is based on the remaining 51 SDG indicators for 117 countries. The observed indicators that were used to estimate the SDG scores are described in Table 1 with their definition, data source and year. Data on SDG 14 and 17 were missing and had to be dropped. For instance, for several land-locked countries, there is limited information on indicators for SDG 14, Life in water. This implied that SDG 14 had to be deleted from our analysis.

The variables have also been scaled in the same direction. For instance, if the amount of untreated sewage decreases, it is a positive development, whereas if the number of school-going children decline, it has a negative impact on development. The variables are scaled, such that increase in it implies a positive impact on SDG and a decline implies a corresponding negative impact on SDGs.

The sustainable development (right-hand side latent variable in Figure 1) is measured by three indicators, namely, GDP per capita in 2014 (economic), greenhouse gas emissions equivalent in 2012 (environment) and subjective well-being in 2014 (social). Subjective well-being consists of three components: cognitive evaluations of one’s life, positive emotions (joy, pride), and negative ones (pain, anger, worry) (OECD 2013; Helliwell 2016). It thus broadly captures the state of well-being that includes experiencing pleasant emotions, low levels of negative moods, and high life satisfaction.

For robustness check, we repeat the analysis by employing Healthy life expectancy at birth (HALE) as the social indicator, developed by the World Health Organization (WHO 2003). HALE is defined as the estimate of the number of healthy years that an individual is expected to live at birth by subtracting the years of ill health weighted according to the severity from the overall life expectancy.

5. Results

5.1. Quantifying and comparing sustainable development measure

Employing Principal Component Scores (PCA) we compute the latent SDG measure, whereas the Exploratory Factor Analysis (EFA) suggests their relationship to the three underlying pillars of SDGs (Figure 1). We begin by examining the results from the left-hand side measurement model in the path diagram. It specifies how the pillars of SDGs (economic, social and environment) are measured from the SDGs and describes their reliability and validity. The SDG scores are calculated from their respective observed indicators. Tables 2, 3 and 4 present the estimated parameters of the measurement models for all countries, developed countries and developing countries, respectively. The coefficients indicate the linear causal relationship between the observed indicators of SDGs (xi) and the latent (SDG pillar) factors (li). The statistical significance of the coefficients indicate that the SDG scores are a valid measure of the three underlying pillars of sustainable development (latent factors). As stated earlier, the scales are all in the same direction but to interpret the coefficients, one has to rely on the description of indicators in Table 1. Table 2 presents the analytical result of the measurement.

Model for all countries and shows the connection between the latent factors and observed indicators that measure them. For instance, a negative sign on the SDG 1 (No Poverty) coefficient shows that as the Poverty headcount ratio at $1.90 a day (2011 PPP) (percent of population) decreases, the economic factor (pillar) of sustainable development improves.

Based on the EFA, the economic SDG factor includes SDGs related to the socio-economic well-being (SDGs 1–6); affordable and clean energy (SDG 7); decent work and economic growth (SDG 8); industry, innovation and infrastructure (SDG 9); Sustainable cities and communities (SDG 11); responsible consumption and production (SDG 12) and Climate Action (SDG 13). Clearly, SDGs are strongly inter-linked; thus, economic factor has a strong well-being, social and environmental component. Thus, actions that remove poverty also overlap with changes in education, health and climate change. The interlinkages also emerge in other pillars of SDGs. The social SDG factor includes indicators focused towards the well-being of the poor and lower income groups. It includes No Poverty (SDG 1), Zero Hunger (SDG 2); and good health and well-being (SDG 3). Additional components include responsible consumption and production (SDG 12); Climate Action (SDG 13); and Life on Land (SDG 14). Finally,
the environmental component includes Zero Hunger (SDG 2); good health and well-being (SDG 3); Affordable and Clean Energy (SDG 7); Reduced inequalities (SDG 10); Sustainable cities and communities (SDG 11) and Peace, Justice and strong institutions (SDG 16).

The left-hand side measurement model in the path diagram computes the measure of sustainable development from the underlying pillars of SDGs, which are presented in the world map (Figure 3). This SDG measure traces the countries’ level of success in achieving its SDGs. The countries with the lower SDG scores are depicted in red color and countries with the higher level of SDGs are represented in blue. Scandinavian countries are the top SDG performers. Most of Western Europe, North America, New Zealand and Australia is performing well in meeting the socio-economic and environmental targets, though there is substantial scope for improvements. Parts of Eastern Europe and Central Asia are lagging behind. The situation is acute in several African countries. Although South Asia and South-east Asia does not perform well on their SDGs, China does relatively better. South American countries, with the exception of a few, also

Table 1. Indicators included in the SDG index and dashboards and our study.

| SDG | Indicator | Year(s)* | Source |
|-----|-----------|----------|--------|
| Sustainable Development | Gross Domestic Product per capita | 2014 | World Bank (2016) |
| Subjective wellbeing (average ladder score, 0-10) | 2014 | Helliwell et al. (2015) |
| Greenhouse gas emissions equivalent | 2012 | World Bank (2016) |
| Sustainable Development Goals indicators | SDG1 Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population) | 2009-2013 | World Bank (2016) |
| SDG2 Cereal yield (t/ha) | 2013 | FAO (2015) |
| SDG3 Mortality rate, under-5 (per 1,000 live births) | 2013 | World bank (2016) |
| Maternal mortality rate (per 100,000 live births) | 2015 | WHO et al (2015) |
| Neonatal mortality rate (per 1000 live births) | 2015 | WHO et al (2015) |
| Physician density (per 1000 people) | 2004-2013 | WHO (2016a) |
| Incidence of tuberculosis (per 100,000 people) | 2014 | WHO (2016a) |
| Traffic deaths rate (per 100,000 people) | 2013 | WHO (2016a) |
| Adolescent fertility rate (births per 1,000 women ages 15-19) | 2005-2015 | WHO (2016a) |
| Healthy life expectancy at birth (years) | 2015 | WHO (2016a) |
| Percentage of surviving infants who received 2 WHO-recommended vaccines (%) | 2014 | WHO & UNICEF (2016) |
| SDG4 Expected years of schooling (years) | 2013 | UNESCO (2016) |
| Net primary school enrolment rate (%) | 1997-2014 | UNESCO (2016) |
| SDG5 Proportion of seats held by women in national parliaments (%) | 2012-2014 | IPU (2015) |
| Female years of schooling of population aged 25 and above (% male-female) | 2014 | UNDP (2015) |
| Estimated demand for contraception that is unmet (% of women married or in union, ages 15-49) | 2015 | WHO (2016c) |
| SDG6 Access to improved water source (% of population) | 2011-2015 | WHO & UNICEF (2016) |
| Access to improved sanitation facilities (% of population) | 2011-2015 | WHO & UNICEF (2016) |
| Freshwater withdrawal (% of total renewable water resources) | 1999-2012 | FAO (2016) |
| SDG7 Access to electricity (% of population) | 2012 | World Bank (2016) |
| Access to non-solid fuels (% of population) | 2010 | SE4All (2016) |
| SDG8 Unemployment rate (% of total labour force) | 2015 | ILO (2016) |
| Automated teller machines (ATMs per 100,000 adults) | 2009-2014 | IMF Financial Access |
| Proportion of the population using the internet (%) | 2012 | OECD (2016) |
| SDG9 Research and development expenditure (% of GDP) | 2005-2012 | UNESCO (2016) |
| Logistics Performance Index: Quality of trade and | 2014 | World Bank (2016) |
| Quality of overall infrastructure (1-7) | 2014/2015 | WEF GCR 2015-2016 |
| Mobile broadband subscriptions (per 100 inhabitants) | 2012-2015 | ITU (2015) |
| Proportion of the population using the internet (%) | 2014 | ITU (2015) |
| SDG10 Gini index (0-100) | 2003-2012 | World Bank (2016) |
| SDG11 Annual mean concentration of particulate matter of less than 2.5 microns of diameter (PM2.5) (µg/m3) in urban areas | 2015 | WHO & UNICEF (2016) |
| Improved water source, piped (% of urban population) | 2015 | WHO & UNICEF (2016) |
| Percentage of anthropogenic wastewater that receives wastewater withdrawal (% of total renewable water resources) | 2012 | OECD (2016a) |
| SDG12 Percentage of the population that is undernourished (%) | 2012 | FAO (2016) |
| SDG13 Energy-related CO2 emissions per capita (tCO2/capita) | 2011 | World Bank (2016) |
| Climate Change Vulnerability Monitor (0-1) | 2014 | HCSS (2014) |
| SDG14 Red List Index of species survival (0-1) | 2016 | IUCN and BirdLife International (2016) |
| Annual change in forest area (%) | 2012 | YCELP & CIESIN (2014) |
| Terrestrial sites of biodiversity importance that are completely protected (%) | 2013 | BirdLife International, IUCN & UNEP-WCMC (2016) |
| SDG15 Fish catch per capita (kilogram per year) | 2014 | UNEP-WCMC (2016) |
| SDG16 Homicides (per 100,000 people) | 2006-2015 | Gallup (2015) |
| Prison population (per 100,000 people) | 2002-2013 | ICPR (2014) |
| Proportion of the population who feel safe walking alone at night in the city or area where they live (%) | 2014 | Transparency International |

Source: Adapted from Sachs et al. (2016), please refer to it for further data details.

*Data for the most recent available year was used for the period specified.
### Table 2. All countries: estimated parameters of the measurement model for sustainable development and underlying SDG pillar factors.

| Factors | Sustainable Development | Economic | Social | Environment |
|---------|------------------------|----------|--------|-------------|
| Gross domestic product per capita | 1.0 | - | - | - |
| Subjective Well Being | 0.8 (0.06)** | - | - | - |
| Greenhouse gas emissions | 0.12 (0.09) | - | - | - |
| SDG 1 No Poverty | -0.82 (0.9)** | 0.25 (0.05)** | - | - |
| SDG 2 Zero Hunger | 0.95 (0.09)** | -0.22 (0.06)** | -0.20 (0.07)** | - |
| SDG 3 Good Health and well-being | 0.75 (0.09)** | -0.29 (0.07)** | -0.23 (0.07)** | - |
| SDG 4 Quality Education | 0.91 (0.07)** | - | - | - |
| SDG 5 Gender Equality | -0.66 (0.08)** | - | - | - |
| SDG 6 Clean Water & Sanitation | 0.86 (0.07)** | - | - | - |
| SDG 7 Affordable & Clean Energy | 0.99 (0.08)** | - | - | - |
| SDG 8 Decent Work & Economic Growth | -0.77 (0.08)** | - | - | - |
| SDG 9 Industry, Innovation & Infrastructure | -0.74 (0.12)** | 0.52 (0.06)** | - | - |
| Reduced Inequalities | - | - | 0.73 (0.09) | - |
| SDG 11 Sustainable cities & communities | -0.78 (0.09)** | - | -0.27 (0.07)** | - |
| Responsible consumption & prod. | 0.81 (0.11)** | 0.49 (0.06)** | - | - |
| SDG 13 Climate Action | -0.45 (0.09)** | 0.26 (0.06)** | - | - |
| SDG 15 Life on Land | -0.45 (0.09)** | - | - | - |
| SDG 16 Peace, Justice & strong Institutions | - | - | -0.93 (0.08)** | - |

***Significant at the 1% level. Standard error in parentheses. Analysis based on 117 countries.

### Table 3. Developed countries: estimated parameters of the measurement model for sustainable development and underlying SDG pillar factors.

| Factors | Sustainable Development | Economic | Social | Environment |
|---------|------------------------|----------|--------|-------------|
| Gross domestic product per capita | 3.33 (0.43)** | - | - | - |
| Subjective Well Being | 2.71 (0.39)** | - | - | - |
| Greenhouse gas emissions | 1.0 | - | - | - |
| SDG 1 No Poverty | -0.86 (0.25)** | 0.55 (0.28)* | - | - |
| SDG 2 Zero Hunger | 1.23 (0.27)** | 3.9 (1.42)** | 4.67 (1.31)** | - |
| SDG 3 Good Health and well-being | 0.21 (0.19) | -3.11 (0.58)** | -3.44 (0.60)** | - |
| SDG 4 Quality Education | 0.83 (0.12)** | - | - | - |
| SDG 5 Gender Equality | -0.68 (0.15)** | - | - | - |
| SDG 6 Clean Water & Sanitation | 0.60 (0.15)** | - | - | - |
| SDG 7 Affordable & Clean Energy | 1.18 (0.30)** | - | - | 0.68 (0.37)* |
| SDG 8 Decent Work & Economic Growth | 0.44 (0.16)** | - | - | - |
| SDG 9 Industry, Innovation & Infrastructure | 0.76 (0.14)** | 0.12 (0.13) | - | - |
| SDG 10 Reduced Inequalities | -0.38 (0.21)* | - | 0.31 (0.17)* | SDG 11 |
| Sustainable cities & communities | -0.36 (0.11)** | - | -0.48 (0.11)** | SDG 12 |
| Responsible consumption & prod. | 0.97 (0.17)** | -0.13 (0.17) | - | - |
| SDG 13 Climate Action | 0.77 (0.17)** | -0.26 (0.18) | - | - |
| SDG 15 Life on Land | - | 0.22 (0.15) | - | - |
| SDG 16 Peace, Justice & strong Institutions | - | - | -0.85 (0.15)** | - |

*Significant at the 5% level. ***Significant at the 1% level. Standard error in parentheses. Analysis based on 51 countries.

### Table 4. Underdeveloped countries: estimated parameters of the measurement model for sustainable development and underlying SDG pillar factors.

| Factors | Sustainable Development | Economic | Social | Environment |
|---------|------------------------|----------|--------|-------------|
| Gross domestic product per capita | 1.0 | - | - | - |
| Subjective Well Being | 0.66 (0.09)** | - | - | - |
| Greenhouse gas emissions | 0.16 (0.12) | - | - | - |
| SDG 1 No Poverty | -0.66 (0.18)** | 0.21 (0.17) | - | - |
| SDG 2 Zero Hunger | 0.71 (0.22)** | 0.03 (0.21) | 0.31 (0.11)** | - |
| SDG 3 Good Health and well-being | 0.11 (0.40) | -0.79 (0.38)** | 0.02 (0.14) | - |
| SDG 4 Quality Education | 0.81 (0.10)** | - | - | - |
| SDG 5 Gender Equality | -0.54 (0.11)** | - | - | - |
| SDG 6 Clean Water & Sanitation | 0.78 (0.10)** | - | - | - |
| SDG 7 Affordable & Clean Energy | 0.87 (0.09)** | - | 0.17 (0.07)** | SDG 8 |
| Decent Work & Economic Growth | 0.79 (0.10)** | - | - | - |
| SDG 9 Industry, Innovation & Infrastructure | 0.79 (0.35)** | 0.61 (0.33)* | - | - |
| SDG 10 Reduced Inequalities | -0.36 (0.11)** | - | 0.84 (0.11)** | SDG 11 |
| Sustainable cities & communities | -0.36 (0.11)** | - | -0.48 (0.11)** | SDG 12 |
| Responsible consumption & prod. | 0.74 (0.24)** | 0.21 (0.24) | - | - |
| SDG 13 Climate Action | 1.31 (0.33)** | 0.66 (0.29)** | - | - |
| SDG 15 Life on Land | - | 0.56 (0.12)** | - | - |
| SDG 16 Peace, Justice & strong Institutions | - | - | -0.66 (0.12)** | - |

*Significant at 10% level. **Significant at the 5% level. ***Significant at the 1% level. Standard error in parentheses. Analysis based on 66 countries.
have a long path to transverse before the SDG targets can be met. Comparing our SDGs measure with other widely used indices, for example, the UN SDG dashboard report index (Sachs et al. 2016) and Human Development Index (HDI) show a strong correlation. Figure 2 shows a strong positive relationship with the widely used measure of development, the HDI.

5.2. Factors impacting sustainable development

The SEM model of sustainable development captures the causal relationship between the underlying pillars of SDGs (economic, social and environment) and sustainable development. The results help determine the most effective factor in impacting and creating sustainable development.

Table 5 presents the parameter estimates and some of the fit indices for the structural model for sustainable development. These coefficients are standardized and may thus be interpreted on both significance and magnitude. The fit of the structural equation model can be assessed by examining the Satorra–Bentler scaled chi-square goodness of fit index, the Comparative Fit Index (CFI) and Root Mean Square residual (RMR). The estimated Satorra–Bentler scaled chi-square in Table 5 indicates that the model shows a good fit for all countries (column 1), developed countries (column 2) and developing countries (column 3).
For a good approximate fit the RMR should be less than 0.8 and the CFI should be close to 0.9. The model fits well for all countries and developing countries; however, for the developed countries, the model fit is on the margin and should be interpreted carefully.

The results in Table 5 reveal causality between the underlying pillars of SDGs and sustainable development. For the developed countries we find that while all the three latent factors have a positive and significant impact on their sustainable development; the environmental and the social pillars of SDGs have the strongest impact, both in terms of statistical significance and magnitude. The environmental SDG factor has an impact that is 3.5 times greater than that of the economic SDG factor on sustainable development. The impact of the social SDG factor is equally strong. As compared to the economic SDG factor, the social SDG factor has a 3.3 times greater effect on the sustainable development of developed countries. Thus, for developed countries, emphasis on the environmental and social SDGs factors would lead to greater sustainable development. Most developed countries have effectively provided basic amenities and standard. However, for greater impact on sustainable development, they need to continue their focus on No Poverty (SDG 1), Zero Hunger (SDG 2), good health and well-being (SDG 3), reduced inequalities (SDG 10) and responsible consumption and production (SDG 12). In addition, focus on Climate Action (SDG 13), Life on Land (SDG 14), Afforable and Clean Energy (SDG 7), Sustainable cities and communities (SDG 11) and institutional factors like Peace, Justice and strong institutions (SDG 16) are of critical importance to developed countries’ strategy for sustainable development.

The results for the developing countries are presented in Table 5 (column 3). Our results confirm that for the developing countries, the economic factor is the most significant in its impact on sustainable development. In many of these countries achieving a basic standard of living is a challenge. A large proportion of the developing countries’ population is struggling in poverty and are malnourished with limited opportunities to decent livelihood. The strongest impact on sustainable development comes through the underlying economic SDG pillar, which has a 44 times greater impact on sustainable development as compared to the environmental SDG pillar. The economic SDG factor is also 2.4 times stronger than the social SDG factors. Developing countries should focus on SDGs related to the socio-economic well-being (SDGs 1–6), affordable and clean energy (SDG 7), decent work and economic growth (SDG 8); industry, innovation and infrastructure (SDG 9); Sustainable cities and communities (SDG 11); responsible consumption and production (SDG 12) and Climate Action (SDG 13).

Rapidly developing economies of China, India, Brazil, Indonesia, Mexico, Turkey, etc. have become large emitters along with the developed large economies such as the United States, the United Kingdom, Canada, Japan, Germany, Italy, etc., accounting for the majority of the future global emissions till 2020 (Ranganathan et al. 2014; World Bank 2016). The Asian economies account for two-thirds of the global increase in carbon emissions, with China and India as the two main contributors to carbon emissions (IEA 2018). China and India (along with United States, Russian Federation and Japan) are amongst the top five emitters contributing to more than 50% of total global emissions of greenhouse gases. China overtook the United States as the highest emitter in 2005, and India bypassed Russia as the third largest emitter in 1998. We, therefore, re-estimate the structural model for the developing countries by excluding India and China. The results are robust and slightly stronger for the remaining set of developing countries.

6. Conclusions

The path to quantifying and monitoring SDGs is a quagmire. It requires a profound understanding of sustainable development, commitment and ability to operationalize and implement the multi-dimensional SDGs, access to all forms of data and the expertise to analyze and interpret the results. Furthermore, there is an inherent conflict between the socio-economic development and ecological sustainability, which makes it challenging to determine the most effective strategy to create sustainable development (Redclift
Undertaking these challenges, we employ published open access data for 117 countries to investigate which one of the three underlying pillars of SDGs are the most effective in creating sustainable development.

The theoretical foundation of SDGs is weak (ICSU and ISSC 2015; Szirmai 2015) and a comprehensive sustainable development theory does not exist. Instead, there are different contested theoretical approaches and definitions (Hopwood and O’Brien 2005; Holden et al. 2014). The SDGs provide a list of targets, with no clear priorities and no theory on how these goals can be attained (Bali Swain 2018). We therefore rely on confirmatory and exploratory factor analysis approaches. Employing SEM models we estimate a structural model that enables us to find causality between sustainable development and the three underlying pillars of SDGs, namely, economic, social and environmental. Our results suggest that while all three factors are critical to sustainable development, the developing countries should focus their resources and policies in the short run on economic growth and social development. Resources are limited and SDGs are fraught with trade-offs and inconsistencies. Therefore, strategic policy focus on socio-economic development in the developing countries may be a successful short-run policy to achieve sustainable development. Developed countries’ results, however, suggest a greater propensity to achieve sustainable development by focus on the environmental and social factors.

The recent (IPCC 2018) report calls for the impact of global warming to be limited to 1.5°C, which requires a strengthened global response to the threat of climate change, sustainable development and efforts to eradicate poverty. Given the urgency of responding effectively to these challenges, our results may be interpreted to suggest that the developing countries should continue pursuing the MDG agenda of focusing on socio-economic development in the short-run to create a greater impact on their sustainable development, given their scarce resources and structural constraints. These results are in line with the literature that visualizes SDGs as an interlinked set of policies with trade-offs and synergies (Spaiser et al. 2016; Bali Swain and Ranganathan 2018). Maintaining the momentum on the MDG agenda in the shortrun should not imply ignoring the environment. On the contrary, the synergies, trade-offs and inter-linkages between the SDGs may be better leveraged in achieving sustainable development, by focusing on the economic and social factors in the developing countries.

Notes
1. Some of these proposed indicators lack data and statistical definitions. The list may be accessed from https://unstats.un.org/unsd/statcom/47th-session/documents/2016-2-IAEG-SDGs.E.pdf.

2. The GGKP report identifies five broad characteristics of IGG: Natural Assets; Resource Efficiency and Decoupling; Resilience and Risks; Economic Opportunities and Efforts; and Inclusiveness.

3. It was adopted by 183 governments at the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (United Nations, 1992) and was reaffirmed at the World Summit on Sustainable Development held in Johannesburg, South Africa in 2002, and the 2012 Rio de Janeiro conference.

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Appendix

Let $X$ be a data matrix of order $N \times p$ where $N$ is the number of cases and $p$ is the number of variables. $C = AX$ is the normal linear combination where $A$ satisfies $AA' = I$. The sample covariance matrix $S$ can be written as $S = (1/N)XX' = AA'$ where $A$ is defined as $A$ and $\Gamma$ is a diagonal matrix. For simplicity, we assume that all eigenvalues of $y_1, y_2, \ldots, y_p$ of $S$ are positive.

Then, the principal component scores $C$ is given as a $N \times p$ matrix

$$\hat{C} = XA$$

Post multiply $A'$ to equation $C$ gives $X = CA'$ We can show that the covariance matrix of the principal component scores is $\Gamma$,

$$(1/N)\hat{C}'\hat{C} = (1/N)\hat{A}'XXA = \hat{A}'S\hat{A} = \hat{\Gamma}$$