Does Sustainable Competitiveness Lead to Better Life?[1]

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Abstract

The present paper studies the relationship among two variables that are often used as indicators of development - GDP per capita, Human Development Index (HDI) - with respect to the five pillars of Global Sustainable Competitiveness Index (GSCI), namely Natural Capital, Resource Intensity, Social Capital, Intellectual Capital, and Governance Performance. The objective is to gain insight how these five pillars impact the GDP per capita and the HDI through the assessment of polynomial regression models. By analyzing these relationships through linear polynomial regression models, certain inferences can be made as to which variable influenced the most these indicators of development. For this purpose, data from SolAbility Sustainable Intelligence's Global Sustainable Competitiveness Report of 2020 are analyzed for 166 countries.

Key findings include that of the five pillars four have statistically significant impact on the GDP per capita which is often used as a proxy for estimating living standards. Considering the HDI, a measure of human development, the same four pillars, namely the Resource Intensity, Social Capital, Intellectual Capital, and Governance Performance Competitiveness have an influence that is significant according to the regression analysis. Resource Intensity has an inverse relationship –a decrease in one percent results in greater GDP per capita and the HDI – while the other three pillars have a positive relationship: an increase in these scores leads to greater GDP per capita and HDI, on average, according to the sample data.

Key words

[1] The article is the result of a research project on sustainable competitiveness, carried out at the postgraduate program in Administrative Economic Sciences of the Autonomous University of Querétaro. The author is grateful for the valuable support of professor Dr. Denise Gómez-Hernández. Without funding.

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National competitiveness, sustainable competitiveness, sustainable development, economic growth, polynomial linear regression models.

Resumen

El presente artículo estudia la relación entre dos variables que a menudo se utilizan como indicadores de desarrollo - PIB per cápita, Índice de Desarrollo Humano (IDH) - con respecto a los cinco pilares del Índice de Competitividad Sostenible Global (GSCI), como el Capital Natural, la Intensidad de Recursos, el Capital Social, el Capital Intelectual y el desempeño de la Gobernanza. El objetivo es analizar cómo estos cinco pilares impactan en el PIB per cápita y el IDH a través de la evaluación de modelos de regresión polinomial. Al estudiar estas relaciones a través de modelos de regresión polinomial lineal, se pueden hacer ciertas inferencias sobre qué variable influyó más en estos indicadores de desarrollo. Para ello, se analizan los datos del Informe de Competitividad Sostenible Global de SolAbility Sustainable Intelligence de 2020 para 166 países.
Los hallazgos clave incluyen que, de los cinco pilares, cuatro tienen un impacto estadísticamente significativo en el PIB per cápita, que a menudo se usa como un indicador para estimar los niveles de vida. Considerando el IDH, una medida del desarrollo humano, los mismos cuatro pilares, la Intensidad de los recursos, el Capital social, el Capital intelectual y la Competitividad del desempeño de la gobernanza tienen una influencia significativa según el análisis de regresión. La Intensidad de Recursos tiene una relación inversa –una disminución del uno por ciento resulta en un mayor PIB per cápita y el IDH – mientras que los otros tres pilares tienen una relación positiva: un aumento en estos puntajes conduce a un mayor PIB per cápita y el IDH, en promedio, según a los datos de la muestra.

Palabras Clave

Competitividad nacional, competitividad sostenible, desarrollo sostenible, crecimiento económico, modelos de regresión lineal polinomial.

Introduction

There are several indicators of development, often used are the GDP per capita, the Human Development Index (HDI) among many others, and most recently the 17 Sustainable Development Goals (SDGs) of the UN Agenda 2030. Also, there different indexes that measure international competitiveness, such as the Global Competitiveness Index (GCI) published by the World Economic Forum, or the World Competitiveness Ranking(WCI) provided by the IMD Business School. The two perspectives, sustainable development and international competitiveness, however, are rarely viewed together or combined in one index. Although the GCI attempts to consider sustainability since 2016 (Pérez-Moreno et al., 2016), its main focus is not sustainability but rather economic competitiveness among nations.

The Korean think-tank SolAbility Sustainable Intelligence developed and has been publishing the Global Sustainable Competitiveness Index (GSCI) annually since 2013, with a specific focus on sustainability. This index includes five pillars, namely Natural Capital, Resource Intensity, Social Capital, Intellectual Capital, and Governance Performance, assuring the consideration of the three key areas of sustainability: economic, social environmental dimensions. Due to this focus, the present study will analyze this specific index and its relationship to other metrics of wellbeing.

The objective is to gain insight how these five pillars impact the GDP per capita and the HDI through the assessment of polynomial regression models. By analyzing these relationships through linear polynomial regression models, certain inferences can be made as to which variable influenced the most these indicators of development. For this purpose, data from SolAbility Sustainable Intelligence's Global Sustainable Competitiveness Report of 2020 are analyzed for 166 countries.

Key findings include that of the five pillars four have statistically significant impact on the GDP per capita which is often used as a proxy for estimating living standards. Considering the HDI, a measure of human development, the same four pillars, namely the Resource Intensity, Social Capital, Intellectual Capital, and Governance Performance Competitiveness have an influence that is significant according to the regression analysis. Resource Intensity has an inverse relationship –a decrease in one percent results in greater GDP per capita and the HDI – while the other three pillars have a positive relationship: an increase in these scores leads to greater GDP per capita and HDI, on average, according to the sample data.

Theoretical Background

Different measures of national competitiveness have been developed since the 1990s, with diverse approaches and levels of analysis. Some of the most well-known approaches refer to competitiveness as a measure of national productivity (Porter, 1990), or adding cost efficiency to provide goods and services (Aiginger & Vogel, 2015; Chikán, 2008), with the expectation to increase the prosperity of a country, which is often measured in GDP. Further refinement of the national competitiveness includes the distinction between human resource-driven and natural resource-driven prosperity (Aiginger & Firgo, 2015). In spite of the different definitions of competitiveness, most authors consider that its main purpose is to improve the capacity to provide better living conditions for the population. How the better living conditions are measured, however, is yet another complex subject, as some of the measures focus on assessing the change in material well-being (e.g., GDP growth, GDP per capita), or social wellbeing such as Human Development Index (HDI) and the OECD´s Better Life Index (OECD, 2020), and other metrics including the environmental aspects of development, for example, the Happy Planet Index (HPI) (New Economics Foundation, 2021), including the UN´s evaluation of the progress measured by Sustainable Development Goals (SDGs) of the Agenda 2030 (United Nations, 2020). Of these different measures, this paper uses the GDP per capita and the HDI as measures for desirable outcomes as a result improved competitiveness, given their scope and widespread use in the literature (Aiginger & Vogel, 2015; Berger, 2008; Collazzo & Taieb, 2015; Delgado et al., 2015; Falciola et al., 2020; Korez-Vide & Tominc, 2016; Kozyr et al., 2018).

With respect to the diverse measures of competitiveness, several international organizations took on the challenge to define an adequate measure for competitiveness on a global level. Among them some of the best-known indexes include the Global Competitiveness Index (GCI) form the World Economic Forum, the World Competitiveness Ranking (WCR) from IMD World Competitiveness Centre (IMD), the Doing Business Index (DBI) from the World Bank, and Global Sustainable Competitiveness Index (GSCI) from SolAbility Sustainable Intelligence (SSI). From these measures, the present report evaluates the latter index, GSCI which incorporates the concepts of sustainability differently from the GCI. SolAbility provides the following definition for the GSCI:

> "Sustainable competitiveness means that current wealth levels are not in danger of being reduced or diminished through over-exploitation of resources (i.e. natural and human resources), the lack of innovation investments required to compete in the globalized markets (i.e. education), or the discrimination, marginalization or exploitation of segments of a society". (SolAbility Sustainable Intelligence, 2020, p. 13).

In addition to its broad view on sustainable competitiveness, another reason for selecting the GSCI is that there very few studies in the academic literature that assess the impact of this index on the abovementioned prosperity and wellbeing indexes, in spite of the fact that it has been published since 2014. One recent study on the GSCI (Janković-Milić & Jovanović, 2019) assesses the statistical method of this composite index but does not focus on its impact on GDP per capita or HDI. For this reason, this paper adds to the discussion and research on the impact of sustainable competitiveness to improved living standards and quality of human lives measured GDP per capita and HDI respectively.

Methodology

Data available

Data comes from three sources: the GDP per capita data for 166 countries were retrieved from the Word Bank Open Data site (2020a), the Global Sustainable Competitiveness Index and its five subindexes according to the five pillars were retrieved from the 2020 Sustainable Competitiveness Report (SolAbility Sustainable Intelligence, 2020) and the Human Development Index from the United Nations Development Programme´s 2020 Report (UNDP, 2020). The sample uses 166 countries for which there was no missing data in these reports. All data were collected in 2019 and published in 2020 by the three organizations described before. Table 1 below displays the variables considered for analysis.

Table 1. Description of Variables

Abbreviation	Description
$GDPPC$	**Annual GDP per capita**, at purchasing power parity (in constant 2017 international USD), World Bank, 2020.

$NATCAP$	**Natural Capital Competitiveness Scores**: This score refers to the availability of natural resources and how they change due to depletion over time. It is calculated from quantitative measures with respect to the given natural environment, including the availability of resources, and the level of the depletion of those resource; SolAbility Sustainable Intelligence, 2020.
$RESINT$	**Resource Intensity Competitiveness Scores**: This score refers to the efficiency of using available scarce resources for economic activities. It includes indicators such as cover water usage and intensity, energy usage, intensity and energy sources, climate change emissions; from SolAbility Sustainable Intelligence, 2020.
$SOCCAP$	**Social Capital Competitiveness Scores:** This score includes indicators such as life expectancy, GINI coefficient, homicide rate, human rights index, obesity rate, etc., from SolAbility Sustainable Intelligence, 2020.
$INTCAP$	**Intellectual Capital Competitiveness Scores**: This score refers to the capability to generate jobs and wealth via innovations in globalized markets. It includes measures such as education levels, R&D performance indicators, infrastructure investment levels, employment indexes, among others; from SolAbility Sustainable Intelligence, 2020.
GOV	**Governance Efficiency Competitiveness Scores**: This score refers to the results of core areas of state investments, such as infrastructure, market, and employment, with the provision of a sustainable future. This score indicator consists of both physical indicators (infrastructure) as well as non-physical attributes (business legislation, level of corruption, government investments, exposure to business and volatility risks, exposure to financial risks, etc.); from SolAbility Sustainable Intelligence, 2020.
HDI	**Human Development Index (HDI),** for 166 countries, published by UNDP, 2020
HDI_100	HDI transformed to a 0-100 scale (HDI_100= HDI *100)

Note: Complete dataset can be found in Annex A while Annex I contains the list of all indicators included in variables $ATCAP, RESINT, SOCCAP, INTCAP, GOV$.

Data Analysis – Linear Regression Models

To analyze the relationship between the GDP per capita of countries and the five pillars of GSCI that may have an impact on it, regression analysis is conducted, using the multivariable linear regression model that are assessed with the method of ordinary least squares (OLS) presented by Guajarati (2003).The multivariable linear regression model is defined as follows [1], using logarithmic scale of the variables described in Table 1:

$$LnY_i = \beta_1 + \beta_2 Ln\, X_{2i} + \beta_3 Ln\, X_{3i} + \ldots + \beta_6 Ln\, X_{6i} + u_i \qquad [1]$$

Where: Y_i = dependent variable from country i: Y_i refers to GDP per capita (in two models), or HDI_100 (in two other models);

$X_{1,2\ldots6}$ = explanatory variables from 1 to 6, referring to the five pillars of GSCI;

β_1 = parameter of intercept;

$\beta_{2,3\ldots6}$ = parameters from 2 to 6 of slope coefficients;

u_i = stochastic perturbance or residual for country i;

i = country 1 to 166 in the sample.

The use of logarithmic scale helps to compare data that are in different units and scale, and it has been commonly used in regression models (Benoit, 2011). For similar studies that applied linear regression analysis on the impact of competitiveness on GDP per capita the authors Delgado et al. (2015) also used logarithmic scale. Considering the assessment of the five independent variables on the HDI, no logarithmic scale is applied as all independent variables have the same scale as well as the dependent variable HDI once it is multiplied by 100 (HDI_100), it acquires the same scale from 0-100 as the regressors.

First the four regression models are presented; second, the assumptions of the OLS test are assessed if the models meet the criteria; third, the estimating values for the partial regression coefficients in each equation that indicate the change in the mean value of $GDPPC$ (GDP per capita) in response to the per unit change in any of the variable separately while holding the values of the other(s) constant. The statistical significance of each model and estimator are evaluated along with confidence intervals. Finally, the conclusions are presented to assess which model and variable(s) can explain the GDP per capita outcome and HDI based on 166 countries´ data in 2019.

Based on equation [1], Table 2 below shows four multivariable linear regression models that are constructed and considered for evaluation how the five pillars of GSCI influence the outcome as GDP per capita or HDI:

Table 2. Four polynomial regression equations

$LnGDPPC = \gamma_1 + \gamma_2 LnNATCAP_i + \gamma_3 LnRESINT_i + \gamma_4 LnSOCCAP_i + \gamma_5 LnINTCAP_i + \gamma_6 LnGOV_i + u_i$	[2]
$LnGDPPC = \beta_1 + \beta_2 LnRESINT_i + \beta_3 LnSOCCAP_i + \beta_4 LnINTCAP_i + \beta_5 LnGOV + u_i$	[3]
$HDI\_100 = \lambda_1 + \lambda_2 NATCAP_i + \lambda_3 RESINT_i + \lambda_4 SOCCAP_i + \lambda_5\, INTCAP_i + \lambda_6\, GOV_i + u_i$	[4]
$HDI\_100 = \theta_1 + \theta_2 RESINT_i + \theta_3 SOCCAP_i + \theta_4\, INTCAP_i + \theta_5 GOV_i + u_i$	[5]

Equations [2] and [3] consider GDP per capita ($GDPPC$) as a result on a logarithmic scale using the independent variables also on the same scale, as the values of these are different. Equations [4] and [5] model the impact of the sustainable competitiveness index´s pillars on the transformed HDI (HDI_100). Models in equations [2] to [4] use all five pillars of the GSCI as independent variables, while those in equations [3] to [5] only include those independent variables that were statistically significant in the previous models shown in equations [2] to [4].

Results

Descriptive Statistics

The dataset is complete for the variables as described in Table 1; there is no missing data this was the criteria for selecting 166 countries out of 181 that was included in the 2020 GSCI Report.

Table 3. Descriptive Statistics

Variable	Total Count	Mean	SE Mean	St. Dev.	Variance	Minimum	Maximum
GDPPC	166	19,112.18	1,555.61	20,042.61	401,706,054.85	731.06	110,261.16
HDI	166	0.72	0.01	0.15	0.02	0.39	0.96
NATCAP	166	48.71	0.78	9.99	99.72	26.48	72.81
RESINT	166	50.21	0.65	8.44	71.16	29.24	70.05
SOCCAP	166	44.73	0.64	8.30	68.83	28.65	65.37
INTCAP	166	38.81	1.08	13.86	192.10	11.90	74.80
GOV	166	50.13	0.71	9.17	84.03	28.63	69.36

Source: the author´s calculation with Minitab.

As it is noticeable from Table 3, the scale of $GDPPC$ data is very different from those of the other variables, as the annual GDP per capita ranges from 731.06 to 110,261.16 USD as minimum and maximum values respectively, with a mean of 19,1112.18 USD while the HDI ranges from 0.39 to 0.96 as minimum and maximum values, with a mean of 0.72. The five independent variables – $NATCAP, RESINT, SOCCAP, INTCAP, GOV$ – range between 11.90 as the lowest to 74.80 as the highest, given that these variables are aggregate indexes that fluctuate between 0 and 100, 100 being the best score, indicating higher competitiveness in the respective pillars of the GSCI.

Other noteworthy observation is the large value of the standard deviation of the mean (20,042.61 USD) of the $GDPPC$, indicating a large spread from the mean in the sample, while the standard error of the mean is much smaller (1,555.61), reflecting on the reliability of the sample´s mean compared to that of the population. Consequently, the variance for the same variable $GDPPC$ is a very large value (401,706,054.85) in column 7, indicating a very big dispersion among the expected individual observations for the sample´s mean. For the other variables the variance is used for further assessment of the regression models. Among the regressor variables, it can be observed that $RESINT$ and GOV variables have the highest and similar mean (50.21 and 50.13 respectively), the lowest mean can be seen for the variable

$INTCAP$ (38.81), with the highest standard deviation (13.86) and variance (192.10), showing a greater dispersion among the expected values of the independent variables.

Regression models

The following regression models in Table 4 below were estimated with the software Minitab, using the equations from [2] to [5], obtaining Models 1 to 4:

Table 4. Four polynomial regression models

Model 1	$LnGDPPC = -3.11 + 0.197 LnNATCAP_i - 0.893 LnRESINT_i + 0.893\ LnSOCCAP_i + 1.421\ LnINTCAP_i + 1.704\ LnGOV_i$
Model 2	$LnGDPPC = -2.61 - 0.833\ LnRESINT_i + 0.928\ LnSOCCAP_i + 1.403\ LnINTCAP_i + 1.695\ LnGOV$
Model 3	$HDI_{100} = 21.69 + 0.0522\ NATCAP_i - 0.2060\ RESINT_i + 0.2123\ SOCCAP_i + 0.5582\ INTCAP_i + 0.5394\ GOV_i$
Model 4	$HDI_{100} = 23.47_1 - 0.1916 RESINT_i + 0.2216\ SOCCAP_i + 0.5530\ INTCAP_i + 0.5360\ GOV_i$

Source: the author´s calculation with Minitab.

For models 1 to 4 in Table 4 the regression model characteristics such as the coefficients, model summary and variance analysis are presented for all five models in Annex B through Annex F.

In the following step the assumptions of OLS method are assessed in Annex G if the linear regression models meet the ten criteria as described by Guajarati (2003). Based on summary table displaying the assessment for Model 1 - 4, it is shown that all four models meet the criteria of the OLS assumptions.

Next, each model´s statistical information – from Annex B through F - is assessed and compared. In Annex B displays the analysis of Model 1, in which the estimated value of the $\hat{\beta}_1$ constant parameter fall within the acceptance interval of -6.32 and 0.11 at 95% of confidence level ($\hat{\beta}_1 = -3.11$), while the partial coefficient ($\hat{\beta}_2$) for variable $NATCAP_i$ shows that if there is a unit change in the Natural Capital Competitiveness score, then that leads to an average of 0.197% increase in GDP per capita (positive impact), holding the other four competitiveness scores equal. Similarly, other three variables also have a positive relationship to the $GDPPC_i$. Second, the variables $SOCCAP_i, INTCAP_i, GOV_i$ also show positive relation to the $GDPPC_i$, in other word, if one of these variables increase one unit while holding the others equal, the GDP per capita will increase by 0.89%, 1.421%, and 1.70% respectively. Conversely, one percent increase in Resource Intensity Competitiveness Score will lead to on average 0.89% decrease in GDP per capita (negative relationship, as it was expected due to the definition of this variable: the greater is the resource intensity, the worse the economic and human development can be expected), while holding the other four variables equal. In Models 1 to 4 the estimators of five or four variables the following hypotheses are tested: $H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$ *y* $H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0$ for which the calculated *T*-values indicate the associated probabilities of the *p*-values are lower than 0.05 at 95% significance level for four out of the five independent variables, the exception being variable $NATCAP_i$ (*p* = 0.364 for $GDPPC_i$, and *p* = 0.298 for HDI_100_i). This signals that the models including this variable, one of the estimators are statistically not significant and therefore H_0 cannot be rejected.

In case of the models 2 and 4 as all the parameter estimators are statistically significant according to the calculated *T*-values which indicate the associated probabilities of the *p*-values that in these models are lower than 0.05 at 95% significance level for all independent variables and therefore the estimated parameters are different from zero (in model 2: $\hat{B}_1 = -2.61$, $\hat{B}_2 = -0.833$, $\hat{B}_3 = 0.928$, $\hat{B}_4 = 1.403$, $\hat{B}_5 = 1.695$, while in model 4: $\hat{B}_1 = 23.47$, $\hat{B}_2 = -0.1916$, $\hat{B}_3 = 0.2216$, $\hat{B}_4 = 0.5530$, $\hat{B}_5 = 0.5360$), hence, the H_0 is rejected, accepting H_1 that the estimated parameters are different from zero. According to model 2, if the Social Capital competitiveness score increases one unit, holding all else equal, the GDP per capita would increase on average by 0.93 percent, which is a significant impact for a country. Moreover, if the Intellectual Capital Competitiveness score increases by one unit holding all else the same, the GDP would be impacted even more, by 1.4% on average; and the if Governance Competitiveness increases one unit, the increase would be the highest, 1.7% on average. With respect to Resource Intensity score, if it decreases by one unit, the GDP per capita would increase by 0.83% on average; in other words, becoming less resource intensive, a country will increase its GDP per capita.

Considering the impact on HDI according to model 4, the impact of the any of the four variables is more modest: if the Social Capital competitiveness score increases one unit, holding all else equal, the HDI would increase on average by 0.22% holding all else equal; if the Intellectual Capital Competitiveness score increases by one unit holding all else the same, the HDI would be impacted more, by 0.55% on average; and the if Governance Competitiveness increases one unit, the increase would be 0.53% on average, holding the other variables equal. With respect the Resource Intensity score, if it decreases by one unit, the HDI would increase by 0.2% on average. The impact on human development measured by HDI is smaller than on the GDP per capita, which makes sense, given this variable includes indicators related no non-social issues of development.

Next, the variance analyses (in Annex A to F) show that the four variables explain 75.4% the change in GDP per capita and 83.3% in the HDI. According to the model summaries, the coefficient determinations of R^2 signal the sample regression model´s fitness to the observed dataset, as detailed in Table 4. Considering the four models, from Model 1-4, Table 4 below resumes the most relevant data:

Table 4. Summary table for the assessment of Models 1-4

	Model 1	**Model 2**	**Model 3**	**Model 4**
$\boldsymbol{R^2}$	76.10%	75.98%	83.82	83.71%
$\boldsymbol{R^2 adj}$	75.35%	75.38%	83.31%	83.30%
ESS	164.5	164.3	31,287.6	31,246
RSS	51.7	51.9	6,040.2	6,081
TSS	216.2	216.2	37,328	37,328
***p*-values**	Not all <0.05	**All <0.05**	Not all <0.05	**All <0.05**

Source: the author´s calculation with Minitab.

Given that there are differing number of variables in the models (models 1 & 3 contain 5 independent variables, while models 2 & 4 four variables), the assessment considers both the R^2 and R^2 adj values. Based on these values in Table 4, it is revealed that the fitness of the regression models with the same dependent variable are very similar (between models 1 and 2, and between 3 and 4, there is less than 1% points are the differences).

The obtained values of the total sum of squares (TSS) are the same for models 1 and 2 (TSS=216.2) and for models 3 and 4 (TSS=37,328). Considering the explained sums of squares (ESS) are also very similar among the models with the same dependent variables (models 1 & 2: 164.5 and 164.3 for models 3 & 4: 31,287.6 and 31,246). It is important to observe that the scale of TSS and ESS for models 1 and 2 is smaller given that these models use logarithmic scale, while models 3 and 4 do not. The large numbers in the case of models 3 & 4 are attributed to the fact that there are 166 countries in the sample and the scale of the four or five variables is between 0-100. Models 1 and 2 show that the explanatory variables contribute approximately 75.4% to these models according to their $R^2\,adj$ values, while for models 3 and 4 almost 83.3%, showing less than one decimal difference among them. The values of the residual sum of squares (RSS) are also very similar for the two logarithmic models, however, for the non-logarithmic models there is a greater difference in absolute number (6,040.2 vs. 6,081) even though in percentage the difference is about 1%. Considering the associated probabilities for each variables´ parameters within the four models, the calculated T-values at 95% confidence level for similar hypotheses tests for all models from 1 to 4 ($H_0\colon \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ and $H_1\colon \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$), only in Models 2 and 4 we can find that all included variables are statistically significant as the *p*-values are below 0.05; the other two models 1 and 3 include one variable estimate which is not statistically significant ($p > 0.05$), hence the null hypothesis cannot be rejected in these two cases. As a consequence, only the models 2 and 4 can be considered as acceptable from a statistical point of view, according to all the assessments presented.

Conclusion

Based on the analysis of four multivariable linear regression models it can be concluded that the four pillars - Resource Intensity, Social Capital, Intellectual Capital and Governance Performance - of the GSCI have a statistically significant impact on GDP per capita (model 2) and on HDI (model 4) as these two models contain variables that are all statistically significant while the other two models (1 and 3) include one variable $NATCAP_i$ – natural resource competitiveness that is statistically not significant at 95% confidence level. This finding indicates that natural resource depletion pillar does not have an impact on neither the GDP per capita nor the HDI that is statistically significant at 95% confidence level. This result coincides with the findings of other authors (Janković-Milić & Jovanović, 2019), who found the same variable less important among the five variables, using different methodology (principal component analysis). Furthermore, the mentioned authors suggest a different weighting method for the pillars of GSCI to have a more accurate measure for the overall sustainable competitiveness.

Based on the current assessment with linear regression analysis, the GDP per capita and HDI are not influenced by the changes in the scores of the natural resource depletion significantly at 95% confidence level, but rather GDP per capita is influenced by approximately 76% by the four pillars of GCSI and by 84% the HDI. This is a surprising finding as it suggests that care for the natural resources (food resources, water & biosphere care, and pollution) does not impact the outcomes of higher prosperity measured by GDP per capita and better human life measured by HDI in a significant way. In fact, this observation suggests countries scoring high on the overall GSCI score may attain higher levels of development while continuing with the same level of natural resources depletion. Considering the current state of human impact on the planet, this metrics should be evaluated and assessed with more data.

Furthermore, according to model 2, investment and improvements made in the Intellectual Capital´s Competitiveness by one unit would have an impact of 1.4% on the GDP per capita and the Governance Competitions by 1.7%, holding all else equal. These are important insights considering that countries constantly try to find ways to improve the living standards of their citizens, especially for a sustained recovery from the post-pandemic economic crisis. Although the impact of these variables on the HDI appears to be more modest according to model 4, the same two pillars – Intellectual Capital & Governance Competitiveness – would have an impact of about 0.5 percentage points on the human development index. That is also good news.

To validate the findings above it is recommended to test these models using time series instead of only one year´s data. Other methods, such as principal component analysis also may shed more light on the impact of the subcomponents of the GSCI as the authors

Janković-Milić & Jovanović (2019) suggested. Additionally, other measures of sustainable development could be tested as desirable outcomes as well - for example, SGD scores, Happy Planet Index – how these are impacted by GSCI pillars, provided that the broadest aim of sustainable competitiveness is to improve the quality of human life while not undermining the conditions and opportunities for the next generations.

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Appendix

Annex A – Data available for variables in Table 1.

Country	GDPPC	HDI	NATCAP	RESINT	SOCCAP	INTCAP	GOV
Afghanistan	1,979	0.51	41.6	36.8	32.6	19.9	43.8
Albania	13,295	0.80	51.4	49.7	45.2	41.7	49.1
Algeria	10,682	0.75	41.0	39.8	41.6	35.7	47.5
Angola	6,198	0.58	55.7	55.5	35.0	21.3	34.1
Argentina	19,687	0.85	57.9	47.9	47.4	34.4	52.7
Armenia	12,593	0.78	39.3	48.9	51.6	38.4	58.1
Australia	48,698	0.94	55.5	43.0	54.5	46.4	51.6
Austria	51,936	0.92	51.2	49.1	60.9	59.7	62.5
Azerbaijan	13,700	0.76	43.6	46.3	47.9	38.2	49.4
Bahamas	30,764	0.81	46.2	40.1	41.7	33.3	54.3
Bahrain	40,933	0.85	30.3	42.4	43.3	40.2	50.4
Bangladesh	4,818	0.63	40.1	60.8	41.5	19.9	54.2
Belarus	19,148	0.82	59.7	39.0	52.0	41.7	50.5
Belgium	48,210	0.93	31.5	47.8	60.5	59.9	60.9
Belize	6,120	0.72	61.2	60.8	37.8	37.9	43.1
Benin	3,323	0.55	42.4	55.0	36.0	24.5	46.0
Bhutan	10,909	0.65	66.8	41.5	45.2	36.7	54.9
Bolivia	7,932	0.72	64.1	53.8	43.6	38.6	49.9
Bosnia and Herzegovina	14,340	0.78	60.1	42.6	52.5	43.1	54.0
Botswana	16,040	0.74	41.6	44.0	35.6	40.3	49.6
Brazil	14,064	0.77	64.8	52.0	39.8	45.6	43.0
Brunei	62,244	0.84	47.7	42.4	50.2	51.4	43.6
Bulgaria	22,384	0.82	56.1	43.2	47.2	49.4	61.9
Burkina Faso	2,161	0.45	46.1	55.9	44.3	24.5	41.4
Burma	4,544	0.58	61.1	54.6	39.0	28.2	46.8
Burundi	731	0.43	44.0	60.0	34.6	22.4	31.1
Cambodia	4,192	0.59	59.5	53.1	40.0	23.3	53.4
Cameroon	3,576	0.56	65.0	60.2	39.3	24.7	40.7

Canada	45,857	0.93	60.6	37.1	50.8	55.4	52.5
Cape Verde	6,045	0.67	46.3	41.0	47.6	35.6	44.3
Central African Republic	929	0.40	58.9	48.8	29.0	13.7	34.3
Chad	1,520	0.40	48.5	54.8	35.3	18.5	28.6
Chile	23,325	0.85	54.2	51.8	46.6	46.1	54.1
China	16,411	0.76	37.9	39.6	53.5	66.2	57.0
Colombia	13,441	0.77	62.0	49.8	37.1	35.1	53.0
Comoros	3,141	0.55	43.2	50.2	34.0	23.7	41.7
Costa Rica	19,679	0.81	54.4	56.9	48.4	42.8	60.5
Cote d'Ivoire	5,174	0.54	55.2	59.8	33.7	29.6	48.0
Croatia	26,465	0.85	61.1	57.7	52.3	50.9	63.9
Cyprus	37,655	0.89	31.8	45.4	53.6	48.2	58.8
Czech Republic	38,319	0.90	48.6	40.0	56.6	61.2	69.4
Democratic Republic of Congo	1,072	0.48	65.3	70.0	32.8	16.3	38.0
Denmark	55,938	0.94	51.4	65.6	57.8	67.0	63.1
Djibouti	5,481	0.52	42.8	50.3	36.0	33.9	44.0
Dominica	9,891	0.74	47.6	56.5	38.6	33.2	50.6
Dominican Republic	17,003	0.76	45.4	46.6	41.0	33.0	56.3
Ecuador	10,329	0.76	52.6	45.5	47.0	39.3	48.5
Egypt	11,951	0.71	33.9	41.5	28.7	40.3	50.4
El Salvador	8,057	0.67	40.7	61.1	43.0	26.2	52.6
Equatorial Guinea	17,008	0.59	60.0	51.1	36.2	22.5	33.9
Estonia	35,638	0.89	63.8	49.8	59.4	55.8	68.0
Ethiopia	2,297	0.49	51.7	69.7	40.0	23.5	50.1
Fiji	10,997	0.74	61.0	50.1	39.8	34.4	48.0
Finland	47,261	0.94	60.5	55.3	61.6	64.3	60.3
France	42,026	0.90	48.8	56.7	55.6	59.7	56.7
Gabon	14,400	0.70	60.0	55.1	40.4	21.9	42.1
Gambia	2,159	0.50	46.8	53.5	39.9	20.8	46.6
Georgia	14,089	0.81	52.6	49.6	47.4	47.3	59.3

Germany	50,922	0.95	36.9	52.7	56.3	60.4	66.6
Ghana	5,305	0.61	55.6	63.8	40.6	27.3	55.1
Greece	27,287	0.89	44.7	46.0	50.0	49.9	59.1
Grenada	15,066	0.78	42.3	41.9	46.2	32.9	49.5
Guatemala	8,393	0.66	45.5	57.7	33.3	22.4	49.3
Guinea	2,671	0.48	56.4	54.6	41.9	17.6	39.4
Guinea-Bissau	1,847	0.48	56.8	54.4	34.0	18.0	33.7
Guyana	18,680	0.68	70.7	48.7	36.1	38.7	49.1
Haiti	2,773	0.51	31.1	52.5	32.4	31.3	30.5
Honduras	5,138	0.63	45.8	57.6	34.0	32.6	40.9
Hungary	31,008	0.85	53.5	48.3	46.0	57.5	59.0
Iceland	52,280	0.95	63.8	52.0	65.4	61.3	61.2
India	6,118	0.65	35.3	50.6	37.8	35.7	52.4
Indonesia	11,445	0.72	46.8	45.6	44.0	41.8	59.1
Iran	12,433	0.78	42.2	35.3	43.1	50.0	56.2
Iraq	9,255	0.67	30.6	35.6	31.6	24.4	47.3
Ireland	89,689	0.96	45.4	64.4	52.9	52.2	68.8
Israel	38,341	0.92	31.6	44.1	47.2	62.0	59.6
Italy	38,992	0.89	41.4	54.6	53.2	50.9	58.0
Jamaica	8,742	0.73	38.6	55.2	38.6	38.3	41.9
Jordan	9,817	0.73	29.1	47.4	41.4	33.1	46.6
Kazakhstan	25,337	0.83	52.3	33.0	49.0	45.5	55.7
Kenya	4,220	0.60	35.7	69.6	40.3	38.9	48.2
Kiribati	2,292	0.63	38.0	55.3	37.8	32.8	49.9
Kyrgistan	4,707	0.70	46.0	45.5	51.7	43.7	46.1
Laos	7,806	0.61	72.8	47.8	41.0	26.7	44.1
Latvia	29,932	0.87	62.1	61.5	51.8	49.4	66.1
Lebanon	11,649	0.74	26.5	39.9	44.5	35.9	42.8
Lesotho	2,280	0.53	49.3	50.6	34.7	31.9	40.1
Liberia	1,354	0.48	56.0	54.9	37.7	23.5	34.8
Libya	10,282	0.72	42.1	46.1	41.9	37.5	41.2
Lithuania	36,732	0.88	57.5	62.3	51.2	48.2	60.2

Luxembourg	110,261	0.92	46.8	68.3	58.9	51.8	63.9
Macedonia	15,848	0.77	51.6	49.3	51.9	43.0	56.2
Madagascar	1,510	0.53	60.7	50.9	33.6	15.0	36.0
Malawi	1,487	0.48	46.9	55.3	42.3	19.5	35.5
Malaysia	26,435	0.81	48.7	34.7	48.6	52.7	50.7
Maldives	13,049	0.74	37.4	50.7	59.6	40.0	52.4
Mali	2,217	0.43	53.8	53.3	39.3	14.5	37.3
Malta	39,222	0.90	32.4	56.0	56.2	48.7	61.0
Mauritania	4,983	0.55	41.7	40.7	36.8	19.9	36.5
Mauritius	19,470	0.80	41.5	42.6	47.4	51.1	64.6
Mexico	17,888	0.78	49.3	47.7	40.8	40.2	53.8
Moldova	12,325	0.75	41.9	57.1	51.7	41.2	57.0
Mongolia	11,471	0.74	47.0	38.2	48.6	35.3	49.8
Montenegro	18,279	0.83	49.2	45.5	51.6	42.0	52.1
Morocco	6,916	0.69	38.4	45.5	36.4	37.9	51.0
Mozambique	1,229	0.46	55.5	57.9	43.3	26.6	35.3
Namibia	8,894	0.65	44.2	48.2	36.4	33.4	40.8
Nepal	3,800	0.60	51.3	61.3	47.7	32.7	54.0
Netherlands	54,210	0.94	37.5	48.9	58.7	59.8	59.4
New Zealand	42,404	0.93	60.9	51.7	56.1	54.3	62.8
Nicaragua	5,280	0.66	55.1	58.0	40.5	29.4	37.4
Niger	1,197	0.39	46.1	58.1	43.5	18.0	36.3
Nigeria	4,917	0.54	41.4	60.0	33.4	23.6	46.2
Norway	63,586	0.96	57.5	46.4	65.0	66.7	52.8
Pakistan	4,623	0.56	32.8	43.1	39.2	25.2	40.2
Panama	25,382	0.82	52.6	46.7	42.7	36.6	52.8
Papua New Guinea	4,101	0.56	64.5	54.4	38.4	21.8	35.3
Paraguay	12,335	0.73	67.6	52.7	41.6	30.7	55.9
Peru	11,261	0.78	61.4	52.5	45.5	40.7	49.6
Philippines	7,954	0.72	39.9	55.8	40.8	31.9	55.1
Poland	32,238	0.88	44.6	42.6	53.1	58.3	65.6
Portugal	32,181	0.86	46.3	51.7	57.7	55.4	63.7

Qatar	85,266	0.85	33.7	33.0	51.0	35.0	51.8
Republic of Congo	3,449	0.57	58.3	56.5	36.3	28.6	28.9
Romania	28,833	0.83	56.9	57.5	53.7	42.7	61.7
Russia	26,456	0.82	62.4	38.8	42.0	51.5	55.1
Rwanda	2,099	0.54	46.0	57.7	39.1	21.6	43.5
Samoa	6,296	0.72	53.6	50.6	42.2	30.2	49.2
Sao Tome and Principe	4,052	0.63	50.0	52.5	43.0	37.0	42.4
Saudi Arabia	44,328	0.85	39.2	33.2	51.3	44.7	51.9
Senegal	3,300	0.51	40.7	55.6	44.6	25.7	48.4
Serbia	18,210	0.81	52.5	44.4	53.5	48.0	55.2
Seychelles	24,362	0.80	41.2	29.2	42.9	40.1	55.3
Sierra Leone	1,648	0.45	59.3	52.7	38.1	29.0	37.8
Singapore	93,397	0.94	28.6	39.0	57.8	69.4	56.8
Slovakia	30,330	0.86	50.6	50.1	53.6	53.7	66.7
Slovenia	36,548	0.92	49.3	43.1	59.6	59.4	68.1
Solomon Islands	2,483	0.57	59.6	49.0	41.7	29.5	43.1
South Africa	11,466	0.71	50.7	35.5	31.1	41.6	40.7
South Korea	42,251	0.92	35.5	31.9	56.9	74.8	57.7
Spain	36,215	0.90	45.5	52.0	56.7	46.5	58.4
Sri Lanka	12,537	0.78	39.8	50.8	48.8	38.0	53.9
St. Kitts and Nevis	23,259	0.78	41.5	38.2	39.7	37.6	54.2
Sudan	4,023	0.51	49.3	51.1	30.7	25.7	38.2
Suriname	16,130	0.74	64.4	44.6	42.0	34.8	46.9
Sweden	50,683	0.95	63.1	63.7	61.6	69.5	52.5
Switzerland	68,393	0.96	47.6	63.1	61.0	64.7	60.7
Tajikistan	3,658	0.67	45.4	50.4	47.9	36.6	43.4

Tanzania	2,635	0.53	56.2	62.9	35.9	23.4	38.5
Thailand	17,287	0.78	41.4	48.3	44.9	51.1	52.4
Timor-Leste	3,181	0.61	48.3	57.5	55.5	36.7	46.6
Togo	2,108	0.52	46.0	59.4	33.0	26.9	42.4
Trinidad and Tobago	23,728	0.80	38.5	38.8	41.1	36.2	49.2
Tunisia	9,728	0.74	28.5	45.2	43.9	44.9	46.9
Turkey	28,385	0.82	40.9	38.9	42.8	53.8	55.1
Uganda	2,178	0.54	48.3	55.0	36.4	11.9	36.1
Ukraine	12,377	0.78	47.2	41.9	44.4	47.7	52.3
United Kingdom	41,627	0.93	35.4	67.3	51.6	66.5	59.9
Uruguay	21,608	0.82	62.3	63.3	46.4	32.4	55.6
USA	60,236	0.93	54.5	47.5	41.4	62.3	52.6
Uzbekistan	6,994	0.72	45.3	47.5	49.2	43.2	56.6
Vanuatu	2,763	0.61	45.9	51.5	40.3	30.2	48.8
Vietnam	8,200	0.70	46.8	39.2	45.9	40.6	56.5
West Bank and Gaza	5,394	0.71	31.2	43.4	35.1	35.3	44.0

Zambia	3,270	0.58	57.7	61.8	35.3	14.5	36.1
Zimbabwe	2,745	0.57	45.4	59.2	36.2	30.5	41.5

Sources: data GDPCC from World Bank (2020b), HDI from UNDP (2020), and the rest of variables (NATCAP, RESINT, SOCCAP, INTCAP, GOV) and from SolAbility Sustainable Intelligence (2020).

Missing one or more data in the 2020 reports for the following countries: Cuba, Eritrea, Japan, Kuwait, Lichtenstein, Micronesia, Oman, Saint Kitts and Nevis, State of Palestine, Swaziland, Syria, Tonga, Turkmenistan, United Arab Emirates, Venezuela, Yemen.

Annex B. MODEL 1 (GDPPC & 5 regressors on natural logarithmic scale)

Regression Equation

LnGDPPC	=	-3.11 + 0.197 LnNATCAP - 0.893 LnRESINT + 0.893 LnSOCCAP + 1.421 LnINTCAP + 1.704 LnGOV

Coefficients

Term	**Coef**	**SE Coef**	**95% CI**	**T-Value**	**P-Value**	**VIF**
Constant	-3.11	1.63	(-6.32, 0.11)	-1.91	0.058	
LnNATCAP	0.197	0.217	(-0.23, 0.63)	0.91	0.364	1.10
LnRESINT	-0.893	0.278	(-1.44, -0.34)	-3.21	0.002	1.19
LnSOCCAP	0.893	0.385	(0.13, 1.65)	2.32	0.022	2.58
LnINTCAP	1.421	0.208	(1.01, 1.83)	6.83	0.000	3.26
LnGOV	1.704	0.378	(0.96, 2.45)	4.51	0.000	2.70

Model Summary

S	**R-sq**	**R-sq(adj)**

0.5682 96	76.10 %	75.35%

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	5	164.5	76.10%	164.5	32.9	101.89	0.000
LnNATCAP	1	2.2	1.03%	0.3	0.3	0.83	0.364
LnRESINT	1	20.0	9.23%	3.3	3.3	10.30	0.002
LnSOCCAP	1	101.6	47.00%	1.7	1.7	5.39	0.022
LnINTCAP	1	34.1	15.79%	15.1	15.1	46.72	0.000
LnGOV	1	6.6	3.04%	6.6	6.6	20.32	0.000
Error	160	51.7	23.90%	51.7	0.3		
Total	165	216.2	100.00%				

Annex C. MODEL 2 (GDPPC & 4 regressors on natural logarithmic scale)

Regression Equation

LnGDPPC	=	-2.61 - 0.833 LnRESINT + 0.928 LnSOCCAP + 1.403 LnINTCAP + 1.695 LnGOV

Coefficients

Term	Coef	SE Coef	95% CI	T-Value	P-Value	VIF
Constant	-2.61	1.53	(-5.64, 0.42)	-1.70	0.091	
LnRESINT	-0.833	0.270	(-1.37, -0.30)	-3.08	0.002	1.13
LnSOCCAP	0.928	0.383	(0.17, 1.68)	2.43	0.016	2.56
LnINTCAP	1.403	0.207	(0.99, 1.81)	6.78	0.000	3.23
LnGOV	1.695	0.378	(0.95, 2.44)	4.49	0.000	2.70

Model Summary

S	R-sq	R-sq(adj)
0.567991	75.98%	75.38%

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	4	164.3	75.98%	164.3	41.1	127.29	0.000
LnRESINT	1	22.2	10.25%	3.1	3.1	9.50	0.002
LnSOCCAP	1	101.6	46.98%	1.9	1.9	5.89	0.016
LnINTCAP	1	34.0	15.73%	14.8	14.8	46.01	0.000
LnGOV	1	6.5	3.00%	6.5	6.5	20.14	0.000
Error	161	51.9	24.02%	51.9	0.3		
Total	165	216.2	100.00%				

Annex D. MODEL 3 (HDI transformed & 5 regressors in original values)

Regression Equation

HDI_100	=	21.69 + 0.0522 NATCAP - 0.2060 RESINT + 0.2123 SOCCAP + 0.5582 INTCAP + 0.5394 GOV

Coefficients

Term	Coef	SE Coef	95% CI	T-Value	P-Value	VIF
Constant	21.688	4.68	(12.45, 30.92)	4.64	0.000	
NATCAP	0.052	0.05	(-0.05, 0.15)	1.05	0.298	1.09
RESINT	-0.206	0.06	(-0.33, -0.09)	-3.37	0.001	1.16

SOCCAP	0.212	0.10	(0.02, 0.41)	2.15	0.033	2.95
INTCAP	0.558	0.06	(0.43, 0.68)	8.70	0.000	3.46
GOV	0.539	0.08	(0.37, 0.71)	6.38	0.000	2.62

Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)	AICc	BIC
6.14422	83.82%	83.31%	6482.84	82.63%	1082.44	1103.51

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	5	31287.6	83.82%	31287.6	6257.5	165.76	0.000
NATCAP	1	311.0	0.83%	41.2	41.2	1.09	0.298
RESINT	1	2693.3	7.22%	428.3	428.3	11.35	0.001
SOCCAP	1	20646.2	55.31%	173.8	173.8	4.60	0.033
INTCAP	1	6098.8	16.34%	2854.6	2854.6	75.61	0.000
GOV	1	1538.4	4.12%	1538.4	1538.4	40.75	0.000
Error	160	6040.2	16.18%	6040.2	37.8		
Total	165	37327.9	100.00%				

Annex E. MODEL 4 (HDI transformed & 4 regressors in original values)

Regression Equation

HDI_100	=	23.47 - 0.1916 RESINT + 0.2216 SOCCAP + 0.5530 INTCAP + 0.5360 GOV

Coefficients

Term	Coef	SE	95% CI	T-Value	P-Value	VIF

		Coef				
Constant	23.47	4.36	(14.86, 32.07)	5.39	0.000	
RESINT	-0.1916	0.06	(-0.31, -0.07)	-3.21	0.002	1.10
SOCCAP	0.2216	0.10	(0.03, 0.42)	2.25	0.026	2.92
INTCAP	0.5530	0.06	(0.43, 0.68)	8.64	0.000	3.44
GOV	0.5360	0.08	(0.37, 0.70)	6.35	0.000	2.62

Model Summary

S	R-sq	R-sq(adj)	PRESS	R-sq(pred)	AICc	BIC
6.14598	83.71%	83.30%	6461.53	82.69%	1081.38	1099.53

Analysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Regression	4	31246	83.71%	31246.4	7811.6	206.80	0.000
RESINT	1	2993	8.02%	390.3	390.3	10.33	0.002
SOCCAP	1	20647	55.31%	190.8	190.8	5.05	0.026
INTCAP	1	6085	16.30%	2818.7	2818.7	74.62	0.000
GOV	1	1521	4.08%	1521.2	1521.2	40.27	0.000
Error	161	6081	16.29%	6081.5	37.8		
Total	165	37328	100.00%				

Annex F. Descriptive Statistics of Residuals (RESI_1 to RESI_4) in Models 1-4

Variable	Total Count	Mean	SE Mean	StDev	Minimum	Maximum
RESI_1	166	0.0	0.47	6.05	-18.48	13.36
RESI_2	166	0.0	0.47	6.07	-18.81	13.80
RESI_3	166	0.0	0.01	0.09	-0.25	0.27
RESI_4	166	-0.0	0.03	0.33	-0.90	1.39

Annex G. Assessment of the OLS criteria for the 4 polynomial regression models

	Assessment			
OLS Assumptions	**Model 1** (GDPPC, all 5 pillars of GSCI)	**Model 2** (GDPPC, 4 pillars of GSCI)	**Model 3** (HDI, all 5 pillars of GSCI)	**Model 4** (HDI, 4 pillars of GSCI)
1. Regression models (from Table 3)	Regression equation [2]	Regression equation [3]	Regression equation [4]	Regression equation [5]
2. The X_i values are fixed in the repeated sample.	No repeated sampling in any of the models.			
3. The mean of the residual is equal to 0.	This requirement is met for all models, as in Annex F Column 4 shows the calculus for all four models.			
4. Homoscedasticity	This requirement is met for all models, as in Table 3 Column 7 shows the variances being a positive value for all five models.			
5. There is no autocorrelation among the residuals	It does not apply as there is no repeated sampling.			
6. Covariance equals zero between cov (u_i , X_{2i}) = cov (u_i , X_{3i}) = 0	This requirement is met for all models, as Annex H shows the calculus for all four models.			
7. The number of observations (n= 166) is greater $E(u_i\|X_i) = 0$ than the parameters	Having 5 parameters, this assumption holds (166> 5)	Having 4 parameters, this assumption holds (166> 4)	Having 5 parameters, this assumption holds (166> 5)	Having 4 parameters, this assumption holds (166> 4)
8. Variability among values of X_i	This requirement is met for all models, as it is a positive finite number for all four models shown in Table 3 in column 5 and in Annex A.			

9. The regression model is correctly specified. (Assessment is based on economic development theory).	It is a linear model with five independent variables. GDP per capita and all five pillars of GSCI are considered, consistent with economic development theory**.**	It is a linear model with four independent variables. GDP per capita and four pillars of GSCI are considered, consistent with theory**.**	It is a linear model with four independent variables. Transformed HDI and the five pillars of GSCI are considered, consistent with development theory**.**	It is a linear model with four independent variables. Transformed HDI and four pillars of GSCI are considered, consistent with development theory**.**
10. There is no perfect multicollinearity	GDP per capita & the scores of the five pillars of GSCI do not have perfect collinearity and there are no repeated sample for the variables in the same years. Criteria met.	GDP per capita & the scores of the four pillars of GSCI do not have perfect collinearity and there are no repeated sample for the variables in the same years. Criteria met.	HDI & the scores of the five pillars of GSCI do not have perfect collinearity and there are no repeated sample for the variables in the same years. Criteria met.	HDI & the scores of the four pillars of GSCI do not have perfect collinearity and there are no repeated sample for the variables in the same years. Criteria met.

Annex H. Covariance analysis for Models 1-4

Model 1: Covariances

	LnNATCAP	LnRESINT	LnSOCCAP	LnINTCAP	LnGOV	RESI
LnNATCAP	0.0458981					

LnRESINT	0.0105590	0.0302161				
LnSOCCAP	-0.0006498	-0.0029047	0.0341350			
LnINTCAP	-0.0122192	-0.0190147	0.0524432	0.1475551		
LnGOV	-0.0038948	-0.0054121	0.0252559	0.0563633	0.0370047	
RESI	0.0000000	-0.0000000	0.0000000	0.0000000	0.0000000	0.3131737

Model 2: Covariances

	LnRESINT	LnSOCCAP	LnINTCAP	LnGOV	RESI_1
LnRESINT	0.0302161				
LnSOCCAP	-0.0029047	0.0341350			
LnINTCAP	-0.0190147	0.0524432	0.1475551		
LnGOV	-0.0054121	0.0252559	0.0563633	0.0370047	
RESI_1	-0.0000000	0.0000000	0.0000000	0.0000000	0.3147926

Model 3: Covariances

	NATCAP	RESINT	SOCCAP	INTCAP	GOV	RESI_2
NATCAP	99.7178					
RESINT	22.1697	71.1607				
SOCCAP	-1.7260	-5.3552	68.8347			
INTCAP	-17.3363	-28.6435	89.5051	192.0974		
GOV	-7.9832	-9.8317	54.9732	96.0843	84.0279	
RESI_2	0.0000	-0.0000	0.0000	0.0000	0.0000	36.6074

Model 4: **Covariances**

	RESINT	**SOCCAP**	**INTCAP**	**GOV**	**RESI_3**
RESINT	71.1607				
SOCCAP	-5.3552	68.8347			
INTCAP	-28.6435	89.5051	192.0974		
GOV	-9.8317	54.9732	96.0843	84.0279	
RESI_3	0.0000	0.0000	0.0000	0.0000	36.8573

Annex I. Description of the five pillars of Global Sustainable Index

1. Natural Capital ($NATCAP$)

Natural Capital Indicators	
Arable land (ha/capita)	Land at risk of desertification
Average rainfall (mm)	Land degradation (% of total)
Biodiversity Benefit Index (GEF)	Mineral reserves (per GNI and capita)
Cereal yield (kg per hectare)	Natural resource depletion (as percentage of GNI)
Electricity from hydropower (%)	Ocean Health Index
Endangered species	Population density
Energy self-sufficiency	Population living below 5m (% of total)
Extreme weather incidents	Potential arable land (ha/capita)
Fertilizer consumption/ha	Renewable freshwater availability/capita
Food Production Index	Tourist attractiveness
Forest area (% of total)	Land area below 5 m (% of total)
Fossil energy prevelance (% of total)	Climate extremes damages ($/1000 people)

2. Resource Intensity $\boldsymbol{RESINT}$

Resource Intensity Indicators	
Air pollution - mean particle concentration	NOx emissions per capita
Air pollution exposure - population	NOx emissions per GDP
CO2 emissions / GDP	Renewable electricity excluding hydro (%)
CO2 emissions /capita	SO2 emission per GNI
Ecological consumption footprint	SO2 emissions per capita
Electricity consumption / GDP	Steel usage efficiency per capita (T/CAPITA)
Electricity consumption per capita	Transmission losses
Electricity from coal (%)	Waste per capita
Electricity from oil (%)	Waste per GDP
Energy per capita	Water productivity
Energy per GDP	Water usage per capita
Freshwater withdrawal rate	GHG emission per capita
Hazardous waste per GDP	GHG emissions per GNI

3. Social Capital $(\boldsymbol{SOCCAP})$

Social Capital Indicators	
Aging society	Overweight
Birth per woman	Peace Index
Child mortality (below age 5, death per 1000)	Press Freedom Index
Doctors per 1000 people	Prison population rate (per 100'000 people)
GINI coefficient (income distribution inequality)	Public health expenditure of total expenditure
Homicide rate (per 100'000 people)	Civic disease risk
Hospital bed availability	Suicide rate
Human rights index	Teen moms
Income quintile ratio	Top 10 % income share
Life expectancy	Women in parliament (% of MPs)
Life satisfaction index	Violent assaults/100000
Lower middle class income share (2nd	Women in management positions

20%)	
Nurses per 1000 people	Health care efficiency index
Aging society	Drug use prevalence
Birth per woman	Freedom for and from religion
Obesity rate	

4. Intellectual Capital $(INTCAP)$

Intellectual Capital Indicators	
Cost of business start-up	R&D spending
Education spending (% of GDP)	School dropouts secondary
High tech exports	Secondary education enrolment
New business registrations per 1 million people	Spending on education (% of state expenditure)
Patent applications (per GDP)	Spending per student (% of per capita GDP)
Patent applications per 1 million people	Tertiary education enrolment
Primary education completion	Trademark applications
Primary student repetitions	Pisa Test Results
Pupil gender ratio	Females with secondary education
Pupil-teacher ratio	R&D spending
R&D FTEs per million people	School dropouts secondary

5. Governance Performance (GOV)

Governance Efficiency Indicators	
Access to electricity	Market fluctuation exposure: company value (% of GDP)
Austerity Index	Market fluctuation exposure: stock trading volume (% of GDP)
Bank capital-asset ratio	Military spending (% of total government spending)
Bribery payments - % of businesses	Mobile communication availability
Ease of doing business	Non-renewable resource income

	dependency
Employment in the manufacturing sector	Population (total)
Employment in the service sector	Poverty development
GNI (total)	Quality of public services
GNI per capita	Rail network per area & population
Government debt	TI CPI Index
Imports (% of GDP)	Unemployment
Internet availability	Debt service (% of government expenditure)
Investments	Democracy Index
Manufacturing value added	

Source: (SolAbility Sustainable Intelligence, 2020)