Exploring the Impact of Sustainable Development on Social-economic, and Science and Technological Development in Selected Countries: A Panel Data Analysis

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Citation: Singh. A. K. & Kumar, S. (2022). Exploring the Impact of Sustainable Development on Social-economic, and Science and Technological Development in Selected Countries: A Panel Data Analysis. *Society & Sustainability 4 (1)*, 55-83. https://doi.org/10.38157/ss.v4i1.405.

Research Article

Abstract

This study examined the construct and latent factors of social, economic, and environmentally sustainable development and Science & technological progress across 39 economies from 2000 to 2016 using a Confirmatory Factor Analysis (CFA). The linear production function model was used to explore the influence of sustainable development on social-economic development and Science & technological progress using country-wise panel data. The age dependency ratio, education expenditure, female labor force, life expectancy, and gender equality were detected as crucial factors of social development. Further, FDI net inflows, gross capital formation, per capita GDP, total employers, and labor force participation rate were found to be valuable variables for increasing economic development. The use of electricity, renewable energy, and green technology in production activities would be helpful in diminishing CO2 emissions and improving environmental sustainability. High-technology exports, ICT goods exports, and R&D expenditure were perceived as essential drivers of increasing Science & technological progress. Sustainable development, Science & technological progress, environmental technology, and job creation in all sectors appeared to be vital indicators to increase social-economic development. Science & technological progress was positively associated with social-economic development, sustainable development, the share of the industrial sector in GDP, and green technology. It was noticed that factors positively related to economic, social, environmental, Science & technological development seemed beneficial to increasing sustainable development. The global economies should implement integrated policy in the social, economic, Science & technology, and environmental sectors to achieve sustainable development. Otherwise, global economies cannot reach the 17 sustainable development goals of the United Nations by 2030.

Keywords: Sustainable development, Social-economic development, Science & technological progress, Environmental sustainability, Environmental and green technology

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1. Introduction

The concept of "Sustainability" was presented at the United Nations Conference on Human Environment in Stockholm in 1971 (Khan & Khan, 2012). It was used to explain economic development, environmental development, and social justice (Duran et al., 2015). The World Commission on Environment and Development (1987) emphasized reducing the adverse impact of high population growth, industrialization, food insecurity, quality of species and ecosystem, urbanization, energy insecurity, and environmental degradation on development (Awan, 2013). In 1987, the World Commission on Environment and Development (WECD) initiated the concept of sustainable development in the Brundtland report (Hammond et al., 1995). Sustainable development is defined as systematic development that "meets the needs of the present generation without compromising the needs of future generations" (Ahmed & Stein, 2004; Pisani, 2006; Ivascu, 2013; Misztal & Kowalska, 2020). Sustainable development is also explained as an integration of social and economic systems that are helpful to increasing real income, educational standards, the health of people, and quality of life (Pearce et al., 1989). Furthermore, Koirala & Pradhan (2019) suggested that a nation is on a sustainable development path when its adjusted net saving is positive in the long term. However, prior studies could not deliver a universally acceptable and uniform definition of sustainable development and sustainable development indicators (Gavin, 2015). Achieving sustainability in available resources such as human, capital, social, economic, saving-investment, and ecosystem services are essential to nurturing a path of sustainable development (Koirala & Pradhan, 2019; Misztal & Kowalska, 2020; Lopuschnyak et al., 2021; Ozili, 2022). Earlier studies have estimated the sustainability of various sectors such as agriculture, food, livelihood, water, and environment (Kumar et al., 2017; Singh & Issac, 2018; Singh et al., 2019a; Misztal & Kowalska, 2020; Singh et al., 2022a, b).

Furthermore, sustainable development has multiple interconnections with economic, environmental, Science & technological, and institutional development. Thus, sustainable development may not be described by a single indicator of a nation (Singh et al., 2019a; Singh et al., 2021). Accordingly, the scientific research community applied index-based estimation to explore sustainable development performance across countries (Singh et al., 2020a). Several indexes, such as the global sustainable development index, sustainable development goals index, and national sustainable development index, have been developed by the scientific research community to identify the comparative status of sustainable development across countries (Boulanger, 2008; Nagy et al., 2018; Guijarro & Poyatos, 2018; Singh et al., 2020a; Jin et al., 2020; Singh et al., 2020a). Singh et al. (2020a) also estimated the global sustainable development index (GSDI) as a composition of the social-economic development index (SEDI), environmental sustainability development index (ESDI), and Science & technological progress index (STPI). However, Singh et al. (2020a) could not assess the impact of sustainable development on social-economic development and Science & technological progress. Therefore, the present study extends the Singh et al. (2020a) and addresses the three crucial issues, i.e. (i) What is the performance of various factors that are significantly associated with social, economic, and environmentally sustainable development and Science & technological progress? (ii) What is the interconnection of sustainable development with social-economic development and Science & technological progress? (iii) How are using environmental and green technology in production activities conducive to increasing sustainable development? Accordingly, this study aims to achieve the following objectives:

a) To examine the performance of social, economic, and Science & technological progress associated variables in selected economies using a confirmatory factor analysis (CFA).
b) To assess the influence of the global sustainable development index (GSDI) on the socio-economic development index (SEDI) and Science & technological progress (STPI) using a linear production function model.

The objective (a) helps identify the variables that determine a specific country's social, economic, and Science & technological development. Therefore, the same variables can be considered in policy formulation to increase sustainable development in low-ranking countries. The objective (b) is related to a concrete understanding of the association of estimated indexes. Subsequently, national, and global policymakers can take policy initiatives to develop a systematic path to sustainable development.

2. Review of Literature

Sustainable development has a multidimensional association with its components. Preceding studies claimed that sustainable development might not be visible by a single indicator. However, few studies used adjusted net savings to define sustainable development across countries (Koirala & Pradhan, 2019). Many studies argue that sustainable development is an integration of economic, social, environmental, and science & technological development (Tampakoudis et al., 2014; Boulanger, 2008; Nagy et al., 2018; Guijarro & Poyatos, 2018; Singh et al., 2020; Jin et al., 2020; Singh et al., 2021). Thus, index-based estimation would be rational for explaining sustainable development. In this perspective, several studies developed a global sustainable development index to identify sustainable development performance (Nagy et al., 2018; Guijarro & Poyatos, 2018; Singh et al., 2020; Jin et al., 2020; Singh et al., 2021). Accordingly, existing researchers examined the interaction between sustainable development and its components. For instance, Singh et al. (2020a) developed the global sustainable development index in selected countries. Singh et al. (2021) created the global sustainable development index. Singh et al. (2020a) and Singh et al. (2021) also made the social development index, economic development index, environmental sustainability index, and Science & technological progress index. It was also observed that these are crucial components of sustainable development. Furthermore, economic, social, environmental development and Science & technological development have been estimated to integrate various variables, essential to increasing the mentioned indicators' performance.

Existing literature argued that social development depends upon several factors such as literacy rate, gender ratio, female labor force, female infant mortality rate, public expenditure on the education sector, and public expenditure in social development (Singh et al., 2021; Singh et al., 2022a). Gender equality and participation of female workers in economic activities are also indispensable drivers of increasing social development (Singh et al., 2022b). Furthermore, education levels significantly contribute to increasing social development. The low infant mortality rate reflects medical facilities' quality and good practices (Kumar et al., 2015; Singh & Issac, 2018; Lopuschnyak et al., 2021). Accordingly, the infant mortality rate can be used to explain social development. Better communication among the people is also a vital driver to increasing SD. Thus, social development is a multi-dimensional concept that can be detected by integrating social development associated variables. Accordingly, several studies developed social development index (Singh et a., 2020a; Singh et al., 2020b; Singh et al., 2021; Singh et al., 2022a,b).

Economic development is also a crucial variable that depends upon several variables such as per capita gross domestic product, inflation, waged and salaried workers, employers, foreign direct investment, capital formation, labor force participation rate, consumption of goods and services, unemployment rate, business opportunities, demand of goods and services, and foreign trade. Therefore, it would be reliable to compile the variables mentioned above in an index to observe the economic development performance. Singh et a. (2020a); Singh et al. (2020b); Singh et al. (2021); Singh et al. (2022a, b) also developed economic development index for selected set of economies.

Existing studies used different factors such as CO_2 emission, environmental quality index, environmental sustainability index to define environmental development (Akbostanci et al., 2009; Jafari et al., 2012; Mukherjee & Chakraborty, 2013; Duasa & Afroz, 2013; Gallego-Álvarez et al., 2014; Streimikiene, 2015; Baydoun & Aga, 2021; Singh et al., 2021). CO_2 and GHGs emissions are caused to increase the high possibility of climate change and environmental degradation (Kumar & Sharma, 2013; Kumar et al.,

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2014; Kumar & Sharma, 2014; Kumar et al., 2015; Kumar et al., 2016; Singh & Singh, 2020; Jyoti & Singh, 2020; Baydoun & Aga, 2021; Singh & Jyoti, 2021; Singh & Singh, 2021; Singh et al., 2022a). Moreover, CO_2 and GHGs emissions have a negative impact on human health; thus, they negatively affect *ESD* (Misztal & Kowalska, 2020). The use of electricity and renewable energy in production activities positively contributes to increasing *ESD* (Singh et al., 2019a; Ozili, 2022). Forest area is crucial to maintaining ecosystem services' sustainability (Singh et al., 2019; Singh et al., 2021). Changes in land-use patterns in the agricultural sector have a negative impact on *ESD* (Singh et al., 2022b). Moreover, overwhelming population growth, fertility rate, population density, and urbanization increased additional pressure on ecosystem services (Lopuschnyak et al., 2021; Baydoun & Aga, 2021; Singh et al., 2022b). Water generation and sustainable water management practices positively impact *ESD* (Singh et al., 2021). Application of environmental and green technology in production activities would be helpful to abate the CO_2 emission and mitigate the negative consequences of socio-economic activities on *ESD* (Nuringsih et al., 2020; Singh et al., 2020a; Baydoun & Aga, 2021; Singh et al., 2021). Thus, variables related to air quality and pollution, electricity and renewable energy, forest area and biodiversity, land use pattern and agricultural sector, population pressure, water generation, management practices, and environmental and green technology can be used to observe environmental sustainability development. Hence, it can be concluded that environmental sustainability development (*ESD*) cannot be described by a single indicator in a nation (Singh et al., 2021). Therefore, prior researchers estimated the environmental sustainability index to explain the relative performance of economic development across economies (Singh et al., 2019a; Singh et al., 2020b; Singh et al., 2021).

Science & technological progress (*STP*) has a multi-dimensional association with variables that significantly impact science and technological development (Singh et al., 2020b; Singh et al., 2021). Thus, variables associated with Science & technological development can be used to assess the performance of *STP*. Also, it would be better to integrate Science & technological associated indicators in an index to observe STP progress across economies. Previous studies, therefore, develop science & technological indexes in global countries (Singh et al., 2020b; Singh et al., 2021).

Furthermore, existing studies also examined the cause-and-effect relationship among the estimated indexes and other variables. For instance, Mukherjee & Chakraborty (2013) observed the influence of the human development index on the environmental performance index across economies. Duasa & Afroz (2013) evaluated the relationship between environmental performance and human development indices. Twesige & Mbabazize (2013) assessed the relationship between environmental accounting, macroeconomic indicators, and sustainable development. Tampakoudis et al. (2014) estimated the association between sustainable development and per capita GDP growth. Gallego-Álvarez et al. (2014) explored the environmental performance index affecting factors in 149 economies. Streimikiene (2015) observed the effect of the environmental quality index on quality of life. Lee et al. (2017) estimated the pro-environmental consumption index and its association with specific socio-economic indicators. Singh et al. (2019a) examined the causal relationship between the environmental sustainability index, human development index, and other variables in Asian countries. Singh et al. (2020a) explored the causal relationship between sustainable development and environmental sustainability using the social-economic development index (*SEDI*), environmental sustainability development index (*ESDI*), and Science & technological progress index (*STPI*) as dependent and independent variables in 39 countries. Singh & Ashraf (2020) investigated the impact of per capita GDP and science & technological variables on the entrepreneurship ecosystem index in selected developed and developing countries. Singh et al. (2020b) assessed the impact of the intellectual property protection index, Science and technological development index, and social-economic development index on the manufacturing sector in 41 countries. Jin et al. (2020) proposed a new national sustainable development index based on the human development index in 163 economies. Singh et al. (2021) observed the influence of the social development index, economic development index, environmental technology, and forest area on the global sustainable development

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index in 39 economies. Ranjan & Panda (2021) observed the impact of development spending on the human development index in low-income states of India.

3. Methods and Materials

3.1. Data Sources

Required data of *GSDI*, *SEDI*, *ESDI*, and *STPI* for purposively selected 39 economies (i.e., Japan, South Korea, Croatia, Greece, Portugal, Austria, Czech Republic, Hungary, Luxembourg, Poland, Slovak Republic, Spain, Norway, Switzerland, USA, Canada, Estonia, Australia, Finland, Sweden, Netherlands, United Kingdom, New Zealand, Belgium, Denmark, France, Germany, Moldova, India, China, Latvia, Lithuania, Romania, Russia, Argentina, Brazil, Mexico, South Africa, and Tunisia) during 2000 – 2016 were adopted from Singh et al. (2020)'s study. Information on variables associated with social-economic development, environmental sustainability development, and science & technological progress for countries mentioned above during said periods were derived from the World Development Indicators (World Bank), World Intellectual Property Right Organization.

3.2. Explanation of Social Development (*SD*) Associated Variables

Aged people have a high capacity to sustain social relationships than young people (Singh et al., 2021). Sex ratio at birth (male births per female births), ratio of female to male labor force participation rate (%), female labor force (% of the total labor force), female unemployment (% of the female labor force), female infant mortality rate (per 1,000 live births), total life expectancy at birth (years), education expenditure (% of GNI), age dependency ratio (% of working-age population) and fixed telephone subscriptions (per 100 people) is used to develop social development index (Singh & Issac, 2018; Singh et al., 2019b; Singh et al., 2019a; Misztal & Kowalska, 2020; Singh et al., 2021; Lopuschnyak et al., 2021; Singh et al., 2022a).

3.3. Explanation of Economic Development (*ED*) Associated Variables

Per capita gross domestic product (GDP) is a vital indicator of *ED* (Koirala & Pradhan, 2019). Also, per capita GDP and financial indicators contribute to sustainable development. Economic and sustainable development are likely to decrease as inflation increases (Koirala & Pradhan, 2019). Per capita GDP depends upon GDP per person employed (constant 2011 PPP $), wage and salaried workers total (% of total employment), foreign direct investment net inflows (% of GDP), inflation GDP deflator (annual %), exports of goods and services (% of GDP), gross capital formation (% of GDP), total labor force participation rate (% of total population ages 15+), total employers (% of total employment), final consumption expenditure (% of GDP), total unemployment (% of the total labor force) were considered to explain *ED* (Kumar et al., 2015; Singh et al., 2019a; Koirala and Pradhan, 2019; Singh et al., 2019b; Singh et al., 2020; Misztal and Kowalska, 2020; Baydoun & Aga, 2021; Singh et al., 2021; Ozili, 2022). Hence, the abovementioned factors are used to develop economic development index associated variables.

3.4. Explanation of Environmental Sustainability Development (*ESD*) Associated Variables

Following variables were used to develop the environmental sustainability development index in this study: percentage of patent applications files in environmental technology (*PPAFET*), access to clean fuels and technologies for cooking (% of population) (*ACFTC*), CO_2 emissions from transport (% of total fuel combustion) (*COET*), CO_2 emissions from manufacturing industries and construction (% of total fuel combustion) (*COEMIC*), CO_2 emissions from electricity and heat production (% of total fuel combustion) (*COEEHP*), CO_2 emissions (metric tons per capita) (*PCCOE*), CO_2 emissions from gaseous fuel consumption (% of total) (*COEGFC*), CO_2 emissions from liquid fuel consumption (% of total)

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(*COELFC*), CO_2 emissions from residential buildings and commercial and public services (% of total fuel combustion) (*COERBCPS*), CO_2 emissions from solid fuel consumption (% of total) (*COESFC*), CO_2 emissions (kg per 2010 US$ of GDP) (*COEKPGDP*), CO_2 intensity (kg per kg of oil equivalent energy use) (*COIKPKOEU*), CO_2 emissions from other sectors, excluding residential buildings and commercial and public services (% of total fuel combustion) (*COEOS*), PM2.5 air pollution mean annual exposure (micrograms per cubic meter) (*PMAPMAPCM*), PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total) (*PMAPPELE*), total natural resources rents (% of GDP) (*TNRRGDP*), electric power consumption (kWh per capita) (*EPCPC*), access to electricity (% of population) (*AEPP*), renewable electricity output (% of total electricity output) (*REO*), electricity production from natural gas sources (% of total) (*EPNGS*), electricity production from coal sources (% of total) (*EPCS*), electricity production from hydroelectric sources (% of total) (*EPHS*), electricity production from nuclear sources (% of total) (*EPNS*), electricity production from oil sources (% of total) (*EPOS*), electricity production from oil, gas and coal sources (% of total) (*EPOGCS*), combustible renewables and waste (% of total energy) (*CRW*), fossil fuel energy consumption (% of total) (*FFEC*), energy use (kg of oil equivalent per capita) (*EUKOEPC*), renewable energy consumption (% of total final energy consumption) (*REC*), forest land (1000 ha) (*FLHa*), forest rents (% of GDP) (*FR*), percentage of arable land equipped for irrigation (*PALEI*), agricultural land (% of land area) (*AgLPLA*), arable land (hectares per person) (*PPArL*), fertilizer consumption (kilograms per hectare of arable land) (*FCPHAL*), population growth (annual %) (*PGR*), total fertility rate (births per woman) (*TFR*), population density (*PD*), urbanization (ratio of urban population with rural population) (*UR*), renewable internal freshwater resources per capita (cubic meters) (*RIFWRPC*), people using at least basic sanitation services (% of population) (*PUBSS*), people using at least basic drinking water services (% of population) (*PUBDWS*) (Akbostanci et al., 2009; Khan & Khan, 2012; Awan, 2013; Kumar et al., 2015; Singh & Issac, 2018; Armeanu, Vintila & Gherghina, 2018; Nagy et al., 2018; Singh et al., 2019a; Singh et al., 2020; Ozili, 2022; Singh et al., 2021; Baydoun & Aga, 2021; Singh et al., 2022b).

3.5. Explanation of Science & Technological Progress (*STP*) Associated Variables

Following factors were used to develop the science & technological progress index in this study: research and development (R&D) expenditure (% of GDP) (*RDEPGDP*), researchers in R&D (per million people) (*RRD*), high-technology exports (% of manufactured exports) (*HTEPME*), ICT goods exports (% of total goods exports) (*ICTGE*), R&D expenditure per researcher (current US$) (*RDEPR*), patent applications files per 1000 researcher (*PAFPTR*), high-technology exports per researcher (current US$) (*HTEPR*), charges for the use of intellectual property payments per researcher (current US$) (*CUIPPPR*), charges for the benefit of intellectual property receipts per researcher (current US$) (*CUIPRPR*) (Singh et al., 2019b; Misztal & Kowalska, 2020; Singh et al., 2020b; Singh, 2020; Singh et al., 2021; Singh & Kumar, 2022; Ozili, 2022).

4. Descriptive Analysis

4.1. Theoretical Background of Confirmatory Factor Analysis (*CFA*)

This study includes 9, 11, 42, and 9 variables to examine the latent and construct variables in *SD*, *ED*, *ESD*, and STP. *CFA* technique helps detect the latent variables based on variation in the prearranged set of indicators (Fan et al., 2016). It is also beneficial to observe the association between the latent variable and multiple variables. Thus, it reduces the number of variables to explain the linear combination of variables that have the most information based on existing variances and eigenvalues. Hosseini & Eghtedari (2013); Karakas et al. (2017); Syan et al. (2019); Laurett et al. (2021); Narmilan et al. (2020); Jamshidi et al. (2021) used the *CFA* technique to examine the performance of various indicators in agricultural and other sectors. It is mentioned that social-economic development, environment development, and Science & technological progress depend upon several

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activities that also have a significant association. Thus, it is essential to examine the most important sustainable development indicators. *CFA* technique is highly effective in reducing the dimension among the variables and proposing the most relevant variables essential to increase sustainable development. Therefore, the *CFA* technique was applied to assess the most consistent variables to increase the social-economic development, environmental development, and Science & technological progress.

4.2. Validity of *CFA* Results

Kaiser-Meyer-Olkin (KMO) test was used to check the validity of the results, which were estimated through the *CFA* technique (Hosseini & Eghtedari, 2013; Maciel et al., 2013; Luu et al., 2019; Syan et al., 2019; Laurett et al., 2021; Singh et al., 2022b). If the KMO value is greater than 0.5, then the set of indicators has the consistency to apply the *CFA* technique. The reliability coefficient of individual and groups of indicators was estimated through *Cronbach's Alpha test* (Karakas et al., 2017; Hosseini & Eghtedari, 2013; Maciel et al., 2013; Luu et al., 2019; Pakmehr et al., 2020).

4.3. Adopted Method to Develop *EDI, SDI, ESDI, STPI,* and *GSDI*

Prior studies used different techniques such as composite Z-score, principal component analysis, and factor analysis to develop various indexes (Sarma, 2008; Kumar & Sharma, 2015; Singh et al., 2017; Singh, 2018; Ashraf & Singh, 2019; Singh et al., 2021). The composite Z-score method has more excellent reliability in creating an index as it provides the relative comparison for a specific variable across entities based on the normalization index. Normalization-index converts all values for a particular variable between 0 to 1 to compare across entities (Singh et al., 2017). The method is also applicable when variables have two categories, i.e., positive and negative. Accordingly, the normalization index can be estimated for further development of an index. Therefore, this study used a composite Z-score method to develop *EDI*, *SDI*, *ESDI*, and *STPI*. If a variable has a positive impact on expected output (as per the existing literature and theories), then the composite score is estimated as (Sarma, 2008; Singh et al., 2021):

$$CS_{ict} = \{[X_{ict} – Min(X_{ict})]/[Max(X_{ict}) – Min(X_{ict})]\} \quad (1)$$

Here, *CS* is the *composite score* for a *i* variable, *c* is cross-sectional countries, and *t* is time. X_{ict} is the actual value; $Min(X_{ict})$ is the minimum value; $Max(X_{ict})$ is the highest value for a specific variable across countries in a year. If a factor has a negative impact on expected output, then the *composite score* is assessed as (Singh et al., 2021; Singh et al., 2022b):

Here, $$CS_{ict} = \{[X_{ict} – Max(X_{ict})]/[Min(X_{ict}) – Max(X_{ict})]\} \quad (2)$$

The linear average sum of all composite-score of respective categories of variables was used to develop *EDI*, *SDI*, *ESDI*, *STPI*, and *GSDI*.

4.4. Formulation of Linear Production Function Model

Previous studies have been used estimated indexes as dependent and independent variables to examine cause and effect relationships among them (Samimi et al., 2011; Mukherjee & Chakraborty, 2013; Duasa & Afroz, 2013; Ye et al., 2013; Gallego-Álvarez et al., 2014; Streimikiene, 2015; Lee et al., 2017; Sharma & Singh, 2017; Kumar et al., 2017; Singh & Issac, 2018; Singh et al., 2019a; Singh et al., 2020a; Ranjan & Panda 2021; Baydoun & Aga, 2021; Singh et al., 2021; Singh et al., 2022a). Samimi et al. (2011); Mukherjee and Chakraborty (2013) used the environmental performance index as a dependent variable to explain its association with the human development index and other variables across economies. Gallego-Álvarez et al. (2014) explored the environmental performance index affecting factors in 149 economies. Streimikiene (2015) examined the influence of the environmental quality index on quality of life. Kumar et al. (2015) explored the impact of socio-economic variables on the global food security index in 31

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countries. Sharma and Singh (2017); Kumar et al. (2017) used the food security index as a dependent variable in India. Singh and Issac (2018) used the sustainable livelihood security index as the dependent variable to explore its association with climatic factors in Gujarat. Misztal & Kowalska (2020) considered synthetic indicators of the financial situation of enterprises and synthetic macroeconomic indicators of the economy to assess the impact of internal and external determinants for the sustainable development of industrial enterprises in Poland. Singh et al. (2022a) examined the influence of climatic factors on the agricultural sustainability index in Indian states.

As per the existing studies, it can be concluded that estimated indexes can be used as dependent and independent variables for empirical investigation. As this study was envisioned to examine the influence of global sustainable development and environmental sustainability development on social-economic development and Science & technological progress. Therefore, two separate regression models were applied in this study. In the 1st regression model, the socio-economic development index (*SEDI*) was used as a dependent variable. While global sustainable development index (*GSDI*), environmental sustainability development index (*ESDI*), Science & technological progress index (*STPI*), employment in agricultural sector (*EMPAGSE*), employment in industrial sector (*EMPINSE*), employment in service sector (*EMPSESE*), share of agricultural sector in GDP (*SHAGGDP*), share of industrial sector in GDP (*SHINGDP*), share of service sector in GDP (*SHSEGDP*), total vulnerable employment (*VUEMTO*), forest area (*FA*), and environmental technologies (i.e., the ratio of patent applications files in environmental technologies with total patent applications files in all sector of technologies) (*PPAFET*) were included as explanatory variables. These are crucial variables to improve the social-economic development of a nation. This study, therefore, assumes that *SEDI* is a linear function of *GSDI*, *ESDI*, *STPI*, *EMPAGSE*, *EMPINSE*, *EMPSESE*, *SHAGGDP*, *SHINGDP*, *SHSEGDP*, *VUEMTO*, *FA* and *PPAFET*. The above function was applied in following linear production function model:

$$(SEDI)_{ct} = \alpha_0 + \alpha_1 (GSDI)_{ct} + \alpha_2 (ESDI)_{ct} + \alpha_3 (STPI)_{ct} + \alpha_4 (EMPAGSE)_{ct} + \alpha_5 (EMPINSE)_{ct} + \alpha_6 (EMPSESE)_{ct} + \alpha_7 (SHAGGDP)_{ct} + \alpha_8 (SHINGDP)_{ct} + \alpha_9 (SHSEGDP)_{ct} + \alpha_{10} (VUEMTO)_{ct} + \alpha_{11} (FA)_{ct} + \alpha_{12} (PPAFET)_{ct} + \mu_{ct} \quad (3)$$

Here, c is the cross-sectional country, t is the time period, α_0 is a constant coefficient, $\alpha_1, \alpha_2, \alpha_3, \ldots, \alpha_{12}$ are the regression coefficients of corresponding variables, and μ_{ct} is the error-term in equation (3). In the 2nd regression model, *STPI* was considered as a linear function of *SEDI*, *GSDI*, *ESDI*, *EMPINSE*, *SHINGDP*, *PPAFET*, and *VUEMTO*. The aforementioned function is used in the following linear production function model:

$$(STPI)_{ct} = \beta_0 + \beta_1 (SEDI)_{ct} + \beta_2 (GSDI)_{ct} + \beta_3 (ESDI)_{ct} + \beta_4 (EMPINSE)_{ct} + \beta_5 (SHINGDP)_{ct} + \beta_6 (PPAFET)_{ct} + \beta_7 (VUEMTO)_{ct} + \lambda_{ct} \quad (4)$$

Here, β_0 is a constant coefficient; $\beta_1, \beta_2, \ldots \beta_7$ are the regression coefficients of associated independent variables, and λ_{ct} is the error term in equation (4). The description of the remaining variables is given earlier with equation (2).

4.5. Process to Select a Valid Model

This study is considered country-wise panel data of *SEDI*, *STPI*, *GSDI*, environmental technology and other explanatory variables. Hence, the existence of panel data of a specific variable shows the non-stationarity of data (Kumar et al., 2017). Therefore, the Im-Pesaran-Shin test was applied to check the stationarity of the time series of a separate variable (Baydoun & Aga, 2021; Singh et al., 2022a). The panel unit root test results with Im-Pesaran-Shin estimation are given in Table 1. The estimates imply that most variables were observed in non-stationarity form. The 1st difference between *ESDI*, *STPI*, employment in the agricultural sector, employment in the industrial sector, employment in the service sector, the share of the industrial sector in GDP, share of the service sector in GDP, and total vulnerable employment were incorporated to convert these time series in stationarity form (Kumar et al., 2017; Singh & Kumar, 2021). Thereupon, the *Ramsay RESET* test was applied to check the suitability of the functional

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form of the proposed regression models. Variance inflation factor (*VIF*) values were also estimated to identify the presence of multi-correlation among the explanatory variables. After that, random and fixed-effect models were applied to check the consistency of the regression coefficient of explanatory variables. The random effect model is applicable when there is no significant variation among the uncorrelated entities with the explanatory variables (Sharma & Singh, 2017; Koirala & Pradhan, 2019). Also, the model accepts that the entity's error term is not correlated with the predictors. The fixed-effect model explores the association among the predictor and outcome variables within a specific country. The model is highly effective in controlling for all time-invariant differences among the individual entities. If the error term has a significant association with output, then a fixed effect model may not be helpful. A Hausman test was applied to check the feasibility of the random and fixed-effect models. The test assumes that the preferred model is a random effect. The Chi^2 values under the Hausman test were found statistically significant for both models (Table 2). It approves that random or fixed effect models cannot be applied. Breusch-Pagan Lagrange multiplier (LM) test was used to check the cross-sectional dependence across entities (Singh & Ashraf, 2020; Baydoun & Aga, 2021).

Table 1: Panel unit root test results with Im-Pesaran-Shin estimation

Variables	*t-bar*	*t-tilde-bar*	*Z-t-tilde-bar*	*p-value*	*Critical values at* 1% significance level
SEDI	-2.6847	-2.2531	-7.2895	0.0000	-1.820
GSDI	-2.1558	-1.9263	-4.5995	0.0000	-1.820
ESDI	0.4437	0.4493	14.9516	1.0000	-1.820
DESDI	-3.6712	-2.6339	-10.5483	0.0000	-1.820
STPI	-1.3453	-1.2915	0.6245	0.7339	-1.820
DSTPI	-3.6770	-2.6468	-10.6554	0.0000	-1.820
EMPAGSE	-1.6313	-1.4040	-0.3008	0.3818	-1.820
DEMPAGSE	-3.7223	-2.6215	-10.4460	0.0000	-1.820
EMPINSE	-1.3065	-1.2256	1.1672	0.8784	-1.820
DEMPINSE	-3.4530	-2.5023	-9.4605	0.0000	-1.820
EMPSESE	-1.1195	-1.0181	2.8746	0.9980	-1.820
DEMPSESE	-3.6204	-2.5742	-10.0550	0.0000	-1.820
SHAGGDP	-2.1416	-1.8862	-4.2695	0.0000	-1.820
SHINGDP	-1.3591	-1.2391	1.0562	0.8546	-1.820
DSHINGDP	-3.7484	-2.6530	-10.7068	0.0000	-1.820
SHSEGDP	-1.5590	-1.3892	-0.1798	0.4287	-1.820
DSHSEGDP	-3.9018	-2.7080	-11.1612	0.0000	-1.820
VUEMTO	-1.5779	-1.2466	0.9944	0.8400	-1.820
DVUEMTO	-3.9807	-2.6183	-10.4199	0.0000	-1.820
FA	-2.5654	-2.0342	-5.4879	0.0000	-1.820
PPAFET	-2.5654	-2.0342	-5.4879	0.0000	-1.820

Note: critical values are at 1% significance level

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization.

The Chi^2 values under this test also appeared statistically significant. Hence, the estimates suggested that panel data have cross-sectional dependence. The Wooldridge test was applied to check the existence of autocorrelation in the panel data (Singh & Ashraf, 2020). The *F*-values for this test was observed statistically significant, which means autocorrelation. A Modified Wald test was also applied to recognize the presence of heteroskedasticity. The Chi^2 values under this test were also detected as statistically significant. Thus, the estimate indicates that panel data has heteroskedasticity. Pesaran's test was also used to identify the cross-sectional dependence in the panel data (Sharma & Singh, 2017). The statistical values under this test also appeared statistically significant; thus, the estimates show that panel data has cross-sectional dependence. The panel data has cross-sectional dependence, autocorrelation and heteroskedasticity. Therefore, simple ordinary least square estimation and random and fixed effect models were found inappropriate for producing rational regression coefficient of explanatory variables. Thus, the regression coefficients of independent variables were estimated using a cross-sectional time-series feasible generalized least squares (FGLS) estimation model, reducing the impact of cross-sectional dependence, autocorrelation, and heteroskedasticity in panel data (Sharma & Singh, 2017). STATA and SPSS statistical software were used to run the *CFA* technique and proposed regression model.

Table 2: Results of hypothesis testing

Dependent Variables	*SEDI*	*STPI*
Applied Test	Model 1	Model 2
Hausman test for fixed or random effects [Chi^2 Value]	12.33*	17.47**
Breusch-Pagan Lagrange multiplier (LM) test [Chi^2 Value]	1497.12*	0.000*
Pesaran's test for cross-sectional dependence	1.10*	0.1484*
Modified Wald test for heteroskedasticity [Chi^2 Value]	186.68*	6485.64*
Wooldridge test for autocorrelation [*F*-Value]	1028.88*	9.016*

*, **, and *** indicates the significance level at 1%, 5%, and 10%, respectively.
Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization.

5. Results and Discussion

5.1. Results Based on Confirmatory Factor Analytical (CFA) Technique

The eigenvalues and proportion of each factor and cumulative share of joint factors in *SD*, *ED*, *ESD*, and *STP* related variables are given in Table 3, Table 5, Table 7, and Table 9, respectively. The 1st three variables were found retained factors that have the most significant variation in *SD* associated variables. The percentage variation is observed in terms of the proportion of individual and cumulative proportion of all factors. Accordingly, the first three factors have a 71% contribution and can be considered as construct factors among the *SD*-associated factors.

Table 3: Proportion of factors in *SD* associated variables

The number of obs.	663	Retained factors	3	
Number of components	9	Chi^2	4460.53	
Factor	Eigenvalue	Difference	Proportion	Cumulative
*Factor*1	3.34519	1.66829	0.3717	0.3717
*Factor*2	1.6769	0.26992	0.1863	0.558
*Factor*3	1.40697	0.48083	0.1563	0.7143
*Factor*4	0.92614	0.2051	0.1029	0.8172
*Factor*5	0.72104	0.26697	0.0801	0.8974
*Factor*6	0.45407	0.08595	0.0505	0.9478
*Factor*7	0.36812	0.28166	0.0409	0.9887
*Factor*8	0.08646	0.07135	0.0096	0.9983
*Factor*9	0.01511		0.0017	1

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization.

As per each factor's factor loadings and uniqueness onto each segment of factors, *RFMLFPR*, *FLF*, *FIMR*, *LEB*, and *FTSPPP* have higher loaded on *factor*1 (Table 4). *SRB*, *FUPFLF*, *ERPGNI*, and *ADR* have higher loaded on *factor*2. *RFMLFPR*, *FLF*, *LEB*, and *ADR* have higher loaded on *factor*3. The estimates indicate that age dependency ratio (*ADR*), education expenditure (*ERPGNI*), female infant mortality rate (*FIMR*), the female labor force (*FLF*), fixed telephone subscriptions (*FTSPPP*), female unemployment (*FUPFLF*), life expectancy at birth (*LEB*), the ratio of female to male labor force participation rate (*RFMLFPR*), the sex ratio at birth (*SRB*) have significant contribution in *SD* associated factors. Sample adequacy was tested through scale reliability coefficient under Cronbach's Alpha Test. The scale reliability coefficient was reported at 0.7266, which implies that undertaken variables have validity for

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CFA. The overall KMO value was observed to be 0.477. Hence, this group of factors may not be considered to apply *CFA*. Subsequently, *SRB*, *FLF*, *FIMR*, *LEB*, and *ADR* were dropped from *CFA* due to the low values of KMO for these factors.

Table 4: Factor loadings and unique variances in *SD* associated variables

Variable	*Factor*1	*Factor*2	*Factor*3	*Uniqueness*	*KMO*	*Cronbach's Alpha Test*
SRB	-0.2445	-0.7388	0.3636	0.2621	0.4552	0.7498
RFMLFPR	0.7982	0.1904	0.4540	0.1205	0.4842	0.6537
FLF	0.7770	0.2927	0.4870	0.0734	0.4480	0.6552
FUPFLF	-0.3593	0.5376	0.0497	0.5795	0.6794	0.7357
FIMR	-0.8804	0.0666	0.1627	0.1939	0.4669	0.6276
LEB	0.7060	-0.3349	-0.5137	0.1255	0.3852	0.6832
ERPGNI	0.2449	0.6370	0.0203	0.5339	0.6314	0.7405
ADR	-0.1875	0.3930	-0.6478	0.3908	0.2199	0.7597
FTSPPP	0.7395	-0.2083	-0.3442	0.2913	0.9033	0.6747
	Overall KMO = 0.4776			Scale reliability coefficient =0.7266		

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization.

The 1st four variables appeared to be retained factors, and these variables have a significant variation in *ED* related variables as per the proportion of variation explained by individual factors and cumulative proportion. Accordingly, these factors have crucial contributions and can be used as construct factors in *ED* (Table 5). Furthermore, it also seemed that the first four factors could explain 73%% variation in ED.

Table 5: Proportion of factors in *ED* associated variables based on *CFA* technique

Number of obs.	663	Retained factors	4	
Number of comp.	11	*Chi*^{2}	3950.83	
Factor	Eigenvalue	Difference	Proportion	Cumulative
*Factor*1	3.4624	1.37479	0.3148	0.3148
*Factor*2	2.08761	0.6866	0.1898	0.5045
*Factor*3	1.40101	0.31535	0.1274	0.6319
*Factor*4	1.08566	0.31474	0.0987	0.7306
*Factor*5	0.77092	0.10461	0.0701	0.8007
*Factor*6	0.66631	0.1059	0.0606	0.8613
*Factor*7	0.56042	0.09637	0.0509	0.9122
*Factor*8	0.46404	0.17328	0.0422	0.9544
*Factor*9	0.29076	0.11248	0.0264	0.9808
*Factor*10	0.17829	0.14572	0.0162	0.997
*Factor*11	0.03257		0.003	1

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

The statistical values of factor loading and unique variation in a specific factor loaded onto each group of elements (i.e., *factor*1, *factor*2, *factor*3, and *factor*4) in *ED*-related aspects are given in Table 6. The estimates imply that per capita GDP (*PCGDP*), per person GDP, employed (*PPGDPE*), total wage and salaried workers (*TWSW*), exports of goods and services (*EGS*), and final consumption expenditure (*FCE*) have higher loaded on *factor*1. Total wage and salaried workers (*TWSW*), gross capital formation (*GCF*), total labor force participation rate (*TLFPR)*, final consumption expenditure (*FCE*), and total unemployment (*TUPTLF*) have higher loaded on f*actors*2. Foreign direct investment net inflows (*FDINI*), exports of goods and services (*EGS*), total labor force participation rate (*TLFPR*), and total employers

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(*TE*) have higher loaded on *factor*3. Inflation GDP deflator (*AIGDPD*), gross capital formation (*GCF*), and total employers (*TE*) have higher loaded on *factor*4. Thus, these variables were found to be crucial variables of *ED*. While remaining variables have low contributions in *ED*.

Most variables (except *TLFPR*) have KMO values of more than 0.5. Furthermore, statistical values of *Cronbach's Alpha Test* were also reported as more than 0.50 for all factors and **the** scale reliability coefficient was found to be 0.7163. Thus, these variables have validity in applying the *CFA* technique. The first 10 factors were observed as retained factors and had a significant variation in *ESD* associated variables as per the proportion of variation explained by individual characteristics and cumulative proportion (Table 7). These factors capture around 82% cumulative variation among the group of elements that reflect the *ESD*. Hence, *ESD* highly depends upon the first 10 factors. The statistical values of factor loading and unique variation in a specific factor loaded onto each group of factors (i.e., *factor*1, *factor*2, *factor*3, *factor*4, and *factor*5) in *ESD* associated variables are given in Table 8. *AEPP*, *COET*, *COELFC*, *COESFC*, *COEKPGDP*, *COIKPKOEU*, *EPCPC*, *REO*, *EPCS*, *EPOGCS*, *PUBDWS*, etc. *PUBSS* has a higher loaded on *factor*1. *AEPP*, *REO*, *EPHS*, *CRW*, and *REC* have higher loaded on *factor*2. *COEEHP*, *PCCOE*, *COERBCP*, *COESFC*, *PMAPPELE*, *EPCPC*, *EUKOEPC*, *PPARL*, and *RIFWRPC* have higher loaded on *factor*3.

Table 6: Factor loadings and unique variances in *ED* associated variables

Variable	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Uniqueness*	*KMO*	*Cronbach's Alpha Test*
PCGDP	0.9127	-0.0097	-0.1802	0.1342	0.1163	0.6393	0.6206
PPGDPE	0.9376	0.1560	-0.0285	0.0593	0.0923	0.6164	0.6170
TWSW	0.5987	0.4208	-0.1243	0.3207	0.3461	0.8171	0.6823
FDINI	0.4377	0.0150	0.5988	-0.1087	0.4378	0.7963	0.7086
AIGDPD	-0.4055	-0.1192	0.3290	0.5928	0.3617	0.7999	0.7062
EGS	0.6441	0.1175	0.5917	-0.1754	0.1905	0.6660	0.6858
GCF	-0.2177	-0.7379	0.1244	-0.4224	0.2141	0.5244	0.7334
TLFPR	0.297	-0.5657	-0.5421	0.2329	0.2437	0.3733	0.7204
TE	0.1088	0.4548	-0.4742	-0.4799	0.3261	0.5781	0.7384
FCE	-0.6002	0.5435	-0.0106	0.2470	0.2833	0.5304	0.6857
TUPTLF	-0.3367	0.7007	0.0318	-0.2083	0.3512	0.6711	0.7259
Overall KMO = 0.6131				Scale reliability coefficient =0.7163			

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

Table 7: Proportion of factors in *ESD* associated variables

Number of obs.	663	Retained factors	10	
Number of comp.	42	*Chi*^{2}	48000	
Factor	Eigenvalue	Difference	Proportion	Cumulative
*Factor*1	9.83062	3.60296	0.2341	0.2341
*Factor*2	6.22766	1.49418	0.1483	0.3823
*Factor*3	4.73347	1.69910	0.1127	0.495
*Factor*4	3.03437	0.06711	0.0722	0.5673
*Factor*5	2.96727	0.76798	0.0706	0.6379
Factor6	2.19928	0.42236	0.0524	0.6903
*Factor*7	1.77692	0.30652	0.0423	0.7326
*Factor*8	1.47040	0.27229	0.0350	0.7676
*Factor*9	1.19811	0.04631	0.0285	0.7961
*Factor*10	1.15181	0.18083	0.0274	0.8236
*Factor*11	0.97098	0.08527	0.0231	0.8467
*Factor*12	0.88571	0.11507	0.0211	0.8678
*Factor*13	0.77064	0.12033	0.0183	0.8861

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Number of obs.	663	Retained factors	10	
Number of comp.	42	*Chi*^{2}	48000	
*Factor*14	0.65030	0.09731	0.0155	0.9016
*Factor*15	0.55299	0.03091	0.0132	0.9148
*Factor*16	0.52208	0.10234	0.0124	0.9272
*Factor*17	0.41973	0.02044	0.0100	0.9372
*Factor*18	0.39930	0.04494	0.0095	0.9467
*Factor*19	0.35436	0.01726	0.0084	0.9551
*Factor*20	0.33710	0.04318	0.0080	0.9632
*Factor*21	0.29392	0.07117	0.0070	0.9702
*Factor*22	0.22275	0.05196	0.0053	0.9755
*Factor*23	0.17079	0.02153	0.0041	0.9795
*Factor*24	0.14925	0.01943	0.0036	0.9831
*Factor*25	0.12982	0.01336	0.0031	0.9862
*Factor*26	0.11646	0.01175	0.0028	0.989
*Factor*27	0.10471	0.02514	0.0025	0.9914
*Factor*28	0.07957	0.0192	0.0019	0.9933
*Factor*29	0.06036	0.01234	0.0014	0.9948
*Factor*30	0.04802	0.01035	0.0011	0.9959
*Factor*31	0.03767	0.00644	0.0009	0.9968
*Factor*32	0.03123	0.00663	0.0007	0.9976
*Factor*33	0.02460	0.00223	0.0006	0.9981
*Factor*34	0.02237	0.00647	0.0005	0.9987
*Factor*35	0.01590	0.00363	0.0004	0.9991
*Factor*36	0.01227	0.00224	0.0003	0.9994
*Factor*37	0.01003	0.00203	0.0002	0.9996
*Factor*38	0.00799	0.00325	0.0002	0.9998
*Factor*39	0.00474	0.00179	0.0001	0.9999
*Factor*40	0.00295	0.00167	0.0001	1
*Factor*41	0.00128	0.00104	0	1
*Factor*42	0.00025	.	0	1

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

Table 8: Factor loadings and unique variances in *ESD* associated variables

Variable	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Factor*5	*Uniqueness*	*KMO*	*Cronbach's Alpha Test*
PPAFET	-0.0380	-0.1718	-0.0791	-0.4637	-0.2598	0.4368	0.7396	0.8850
AEPP	0.5859	-0.5123	0.0090	-0.2766	-0.0565	0.1687	0.8022	0.8771
COET	0.7561	0.1402	-0.1970	0.1275	0.2241	0.1720	0.5849	0.8747
COEMIC	-0.0607	0.4859	-0.2421	0.3466	-0.0193	0.3771	0.3140	0.8851
COEEHP	-0.6761	-0.1407	0.5224	-0.2868	-0.1565	0.1202	0.5785	0.8761
PCCOE	0.1949	-0.4890	0.6971	0.2687	0.1345	0.0845	0.5749	0.8816
COEGFC	0.2324	-0.3136	-0.2993	-0.4925	0.4170	0.1351	0.4577	0.8827
COELFC	0.7254	0.1655	-0.4149	0.1562	0.1902	0.0750	0.6712	0.8759
COERBCPS	0.2188	-0.4115	-0.5413	0.1622	-0.0867	0.2043	0.3962	0.8827
COESFC	-0.6674	0.0275	0.5529	0.1751	-0.4227	0.0293	0.6773	0.8766
COEKPGDP	-0.7983	0.2135	0.1931	-0.1900	0.0450	0.1122	0.7796	0.8735
COIKPKOEU	-0.7035	-0.2462	0.3814	0.0669	0.1388	0.1556	0.7218	0.8756
COEOS	0.1636	0.4920	-0.2359	-0.1202	0.3035	0.3722	0.3419	0.8848
PMAPMAPCM	-0.7639	0.3468	-0.2510	0.1998	0.0147	0.1134	0.8168	0.8732

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Variable	*Factor*1	*Factor*2	*Factor*3	*Factor*4	*Factor*5	*Uniqueness*	*KMO*	*Cronbach's Alpha Test*
PMAPPELE	-0.4339	-0.2558	-0.6800	0.0023	0.0329	0.1678	0.7777	0.8785
EPCPC	0.6362	-0.0417	0.5336	0.3181	0.0341	0.1059	0.7515	0.8747
TNRRGDP	-0.1596	0.2809	0.4068	-0.2410	0.4916	0.2213	0.6038	0.8849
REO	0.6467	0.6245	0.0395	-0.0492	0.0571	0.0729	0.7141	0.8766
EPNGS	-0.0644	-0.3203	-0.3906	-0.2800	0.6193	0.0712	0.5239	0.8851
EPCS	-0.7126	-0.0830	0.3743	0.3082	-0.1241	0.1177	0.6833	0.8760
EPHS	0.5982	0.6424	0.0419	-0.0728	0.0880	0.0745	0.8424	0.8774
EPNS	0.2681	-0.2642	-0.2232	0.1763	-0.4755	0.2123	0.5323	0.8817
EPOS	-0.1309	-0.0416	-0.2415	-0.0408	0.2100	0.2455	0.4080	0.8834
EPOGCS	-0.7646	-0.3590	0.1334	-0.0845	0.2807	0.0520	0.8467	0.8739
CRW	-0.0318	0.7697	-0.1124	-0.1020	-0.2308	0.2334	0.6082	0.8849
FFEC	-0.4633	-0.4817	-0.0574	0.0505	0.5535	0.1082	0.6378	0.8797
EUKOEPC	0.5248	-0.3374	0.5849	0.3224	0.0428	0.0587	0.6343	0.8760
REC	0.3053	0.8804	0.0811	-0.0473	-0.1499	0.0768	0.7430	0.8829
ACFTC	0.7261	-0.5467	0.0711	-0.1267	0.0262	0.1236	0.8577	0.8742
FLHA	0.0502	0.0608	0.2777	-0.0288	0.3176	0.2037	0.3173	0.8845
FR	-0.1230	0.4298	0.1721	-0.4905	-0.1972	0.3554	0.6444	0.8839
PUBDWS	0.6940	-0.4205	0.1277	0.0447	-0.1519	0.1949	0.8537	0.8746
PALEI	-0.3408	0.2011	-0.1278	0.2806	-0.0020	0.3818	0.7710	0.8806
AGLPLA	-0.5864	-0.2310	-0.3569	0.0549	0.2083	0.1601	0.7535	0.8772
PPARL	0.0539	-0.0766	0.5353	-0.3700	0.2902	0.3276	0.3895	0.8843
FCPHAL	0.1669	0.1471	0.0286	0.3312	0.0798	0.2337	0.3406	0.8836
PGR	0.0224	0.1749	0.1721	0.6281	0.5125	0.2023	0.6912	0.8851
TFR	-0.2422	0.4772	0.0343	0.3075	0.4505	0.1619	0.6213	0.8833
PD	-0.2538	-0.3073	-0.3642	0.5563	-0.1636	0.2555	0.5716	0.8827
UR	0.2317	-0.2299	-0.0711	0.3819	0.1350	0.2495	0.3947	0.8819
RIFWRPC	0.5174	0.3809	0.5085	-0.0134	0.2847	0.1315	0.6859	0.8770
PUBSS	0.6876	-0.5904	0.1545	-0.0393	-0.1326	0.0540	0.7700	0.8746
Overall KMO = 0.6515					Scale reliability coefficient = 0.8824			

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

COEGFC, *FR*, *PGR*, and *PD* have higher loaded on *factor*4. *COEGFC*, *TNRRGDP*, *EPNGS*, *FFEC*, and *PGR* have a higher loaded on *factor*5. Hence, these factors were seen as latent variables in each factor category, while the remaining variables can be considered construct variables.

Table 9: Proportion of factors in *STP* development associated variables

Number of obs.	663	Retained factors	3	
Number of comp.	9	*Chi*^{2}	4379.25	
Factors	Eigenvalue	Difference	Proportion	Cumulative
*Factor*1	3.62844	1.67808	0.4032	0.4032
*Factor*2	1.95036	0.49545	0.2167	0.6199
*Factor*3	1.45491	0.59803	0.1617	0.7815
*Factor*4	0.85688	0.34774	0.0952	0.8767
*Factor*5	0.50914	0.23809	0.0566	0.9333
*Factor*6	0.27105	0.10096	0.0301	0.9634
*Factor*7	0.17009	0.08407	0.0189	0.9823
*Factor*8	0.08601	0.0129	0.0096	0.9919
*Factor*9	0.07311		0.0081	1

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

Accordingly, *AEPP*, *COEEHP*, *COEGFC*, *COEKPGDP*, *COELFC*, *COERBCP*, *COESFC*, *COET*, *COIKPKOEU*, *CRW*, *EPCPC*, *EPCS*, *EPHS*, *EPNGS*, *EPOGCS*, *EUKOEPC*, *FFEC*, *PCCOE*, *PGR*, *PMAPPELE*, *PPARL*, *PUBDWS*, *PUBSS*, *REC*, *REO*, *RIFWRPC*, and *TNRRGDP* have the higher

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uniqueness in eigenvalues and proportion in *ESD* associated factors. Subsequently, above-mentioned factors have a more significant contribution to *ESD*. Furthermore, KMO values for *COEMIC*, *COEGFC*, *COERBCPS, COEOS, EPOS, FLHA, PPARL, FCPHAL,* and *UR* were reported to be less than 0.5. Thus, these variables were dropped from *CFA*. At the same time, the overall KMO value was 0.6515 for all variables. Subsequently, estimates propose that undertaken variables have adequacy to apply *CFA* technique. The scale reliability coefficient was also found to be 0.8824, which indicates that undertaken variables have validity.

The first 3 factors were observed as retained factors and had the capability to capture 78% variation in *STP* as per the proportion of variation explained by individual factors and cumulative proportion (Table 9). These factors have around 78% cumulative variation in *STP*-associated variables. Subsequently, the first 3 factors can be used to identify the latent and construct factors among the *STP* influencing variables. The statistical values of factor loading and unique variation in a specific factor loaded onto each group of factors (i.e., *factor*1, *factor*2, *factor*3, *factor*4, and *factor*5) in *STP*-associated variables is explained in Table 10. *RDEPGDP*, *RRD*, *HTEPME*, *RDEPR*, *HTEPR*, *CUIPPPR*, and *CUIPRPR* have higher loaded on *factor*1. *HTEPME, ICTGE, PAFPTR*, *CUIPPPR,* and *CUIPRPR* have higher loaded on *factor*2. *RRD*, *ICTGE,* and *HTEPR* have higher loaded on *factor*3. Thus, the estimates infer that *CUIPPPR*, *CUIPRPR*, *HTEPME*, *HTEPR*, *ICTGE*, *PAFPTR*, *RDEPGDP*, *RDEPR*, and *RRD* have significant uniqueness in eigenvalue and proportion in science & technological progress related variables. Accordingly, these variables have a crucial contribution to *STP*. Furthermore, KMO values for most factors (except *ICTGE*) were reported to be greater than 0.5, and it implies that undertaken variables have adequacy to apply the *CFA* technique. The scale reliability coefficient was also found to be 0.7824, confirming that variables have validity.

Table 10: Factor loading of factors and uniqueness in *STP* development associated variables

Variables	*Factor*1	*Factor*2	*Factor*3	*Uniqueness*	*KMO*	*Cronbach's Alpha Test*
RDEPGDP	0.7637	-0.3775	-0.4463	0.0751	0.6095	0.7443
RRD	0.6559	-0.1995	-0.5995	0.1706	0.6782	0.7601
HTEPME	0.6904	-0.5021	0.3375	0.1573	0.7253	0.7486
ICTGE	0.3240	-0.5137	0.6355	0.2273	0.3595	0.7947
RDEPR	0.8421	0.0593	-0.2926	0.2018	0.6560	0.7292
PAFPTR	0.0801	0.6348	0.0077	0.5906	0.5437	0.8151
HTEPR	0.6916	0.0260	0.4919	0.2791	0.6319	0.7479
CUIPPPR	0.5393	0.7154	0.1730	0.1674	0.5636	0.7630
CUIPRPR	0.7407	0.5773	0.1450	0.0970	0.6269	0.7340
Overall KMO = 0.6096				Scale reliability coefficient = 0.7824		

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

5.2. Country-wise Comparisons in Terms of *SEDI, ESDI, STPI,* and *GSDI*

The comparison across economies in social-economic development, environmental sustainability development, Science & technological progress, and global sustainable development estimated in terms of *SEDI*, *ESDI*, *STPI*, and *GSDI,* is given in Figure 1, Figure 2, Figure 3, and Figure 4, respectively. The mean values of aforesaid indexes were segregated in three time periods (i.e., 2000 – 2005, 2006 – 2010, and 2011 – 2016) to make the cross-temporal changes in the performance of respective countries in related developmental indicators. Subsequently, the ranking of cross countries based on mean values of *SEDI*, *ESDI*, *STPI*, and *GSDI* from 2001 to 2016 is given in Table 11.

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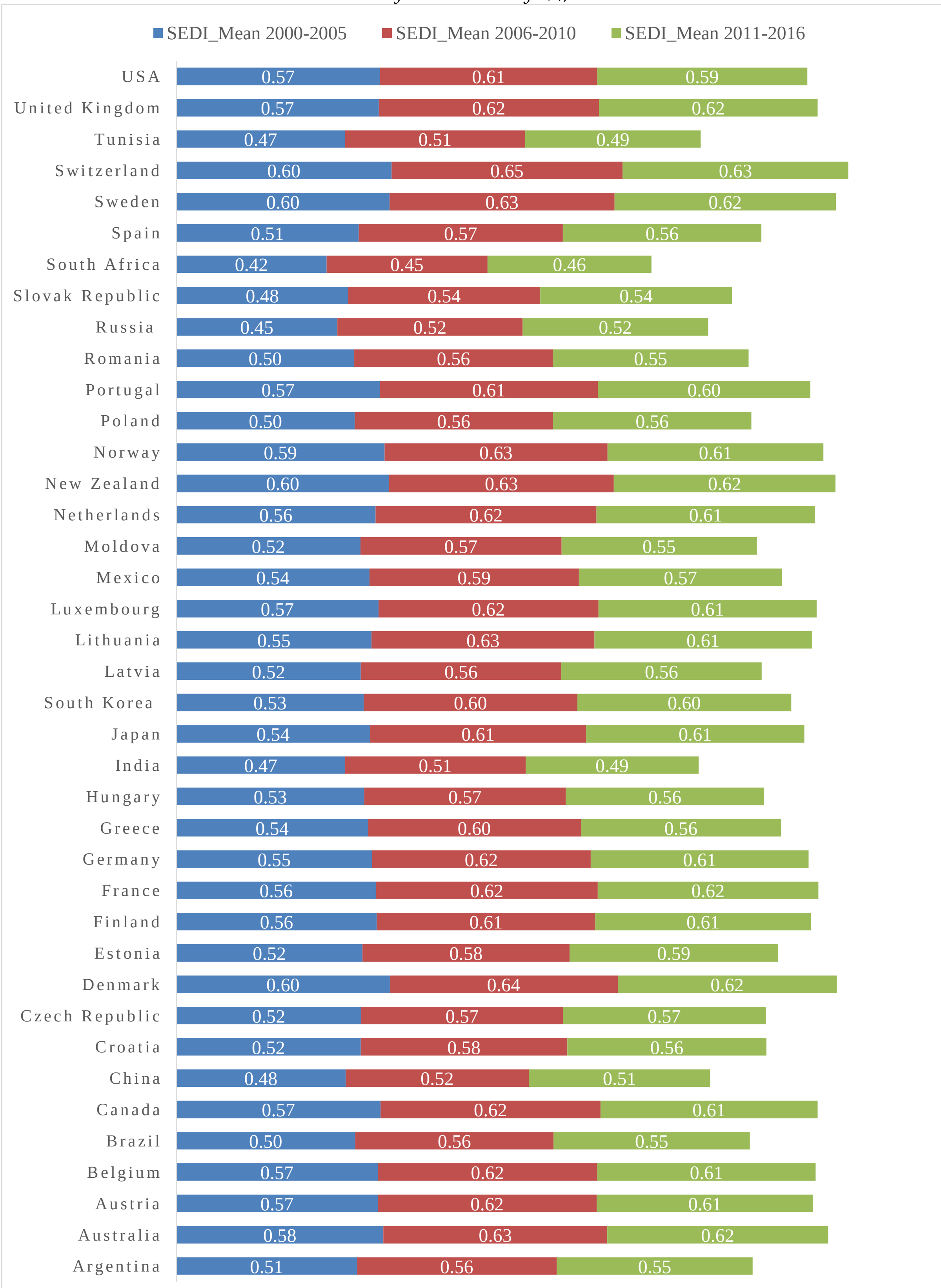

Fig. 1: Country-wise comparisons in social-economic development

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

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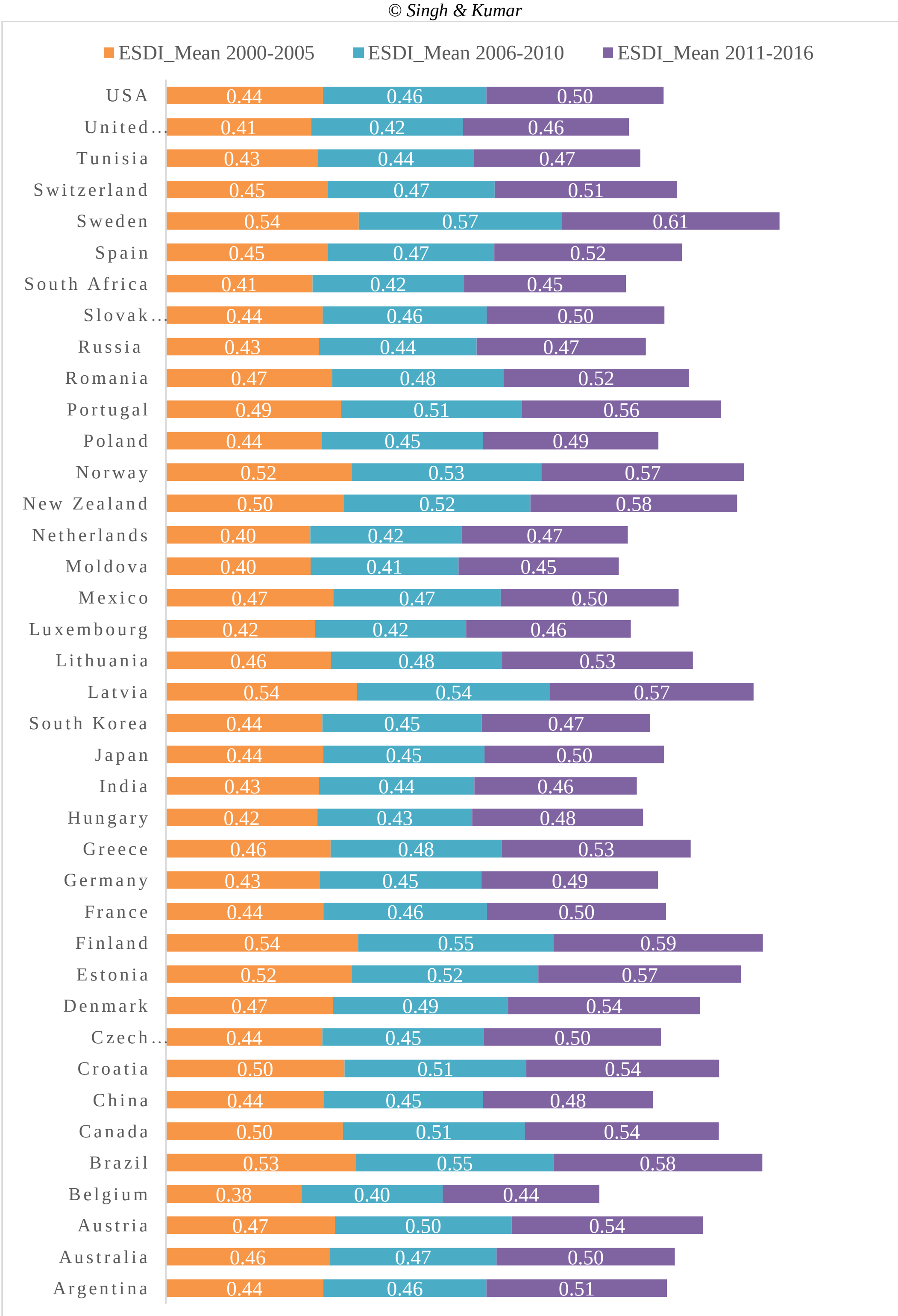

Fig. 2: Country-wise comparisons in environmental sustainability development

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

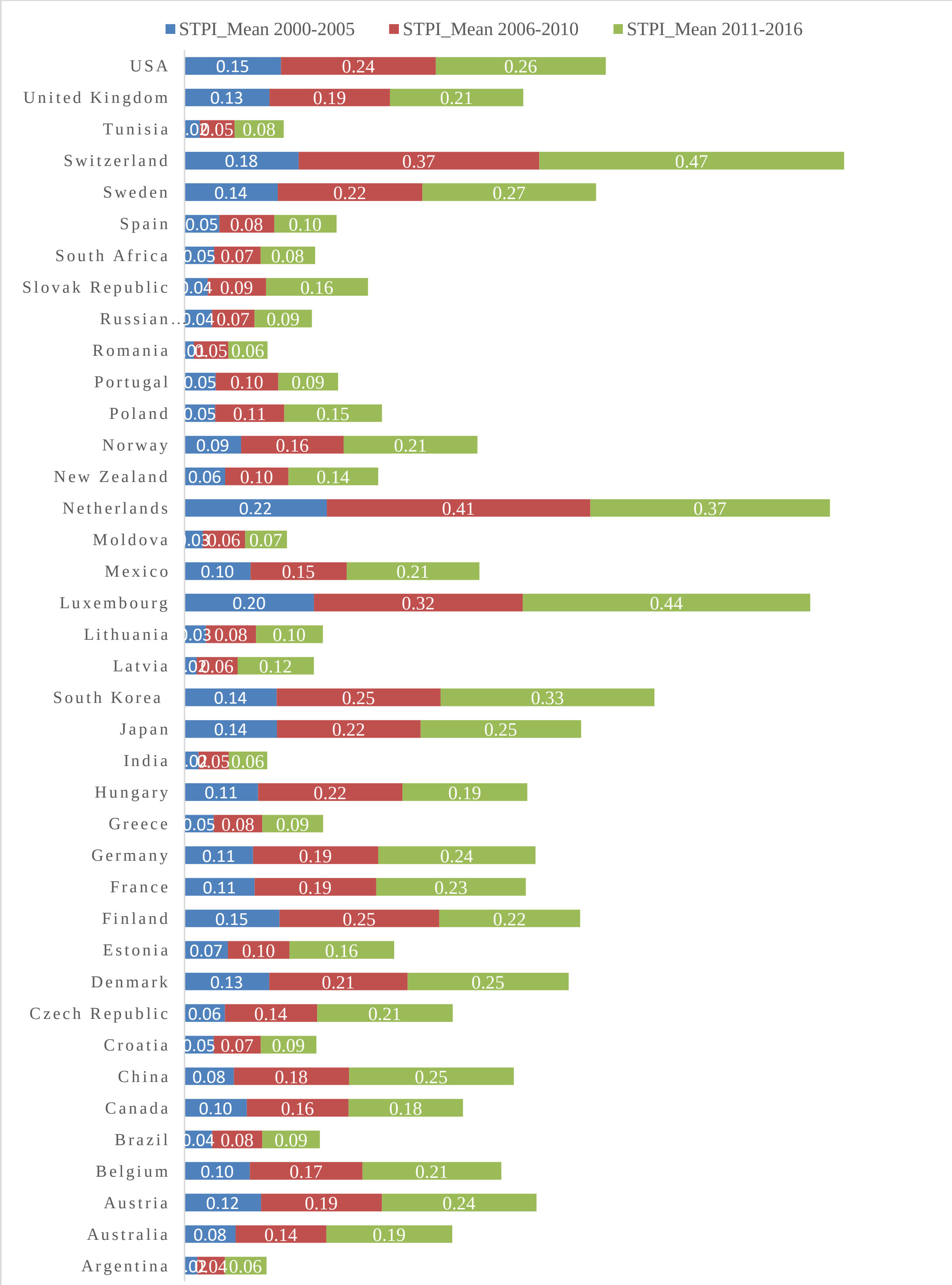

Fig. 3: Country-wise comparisons in Science & technological progress

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

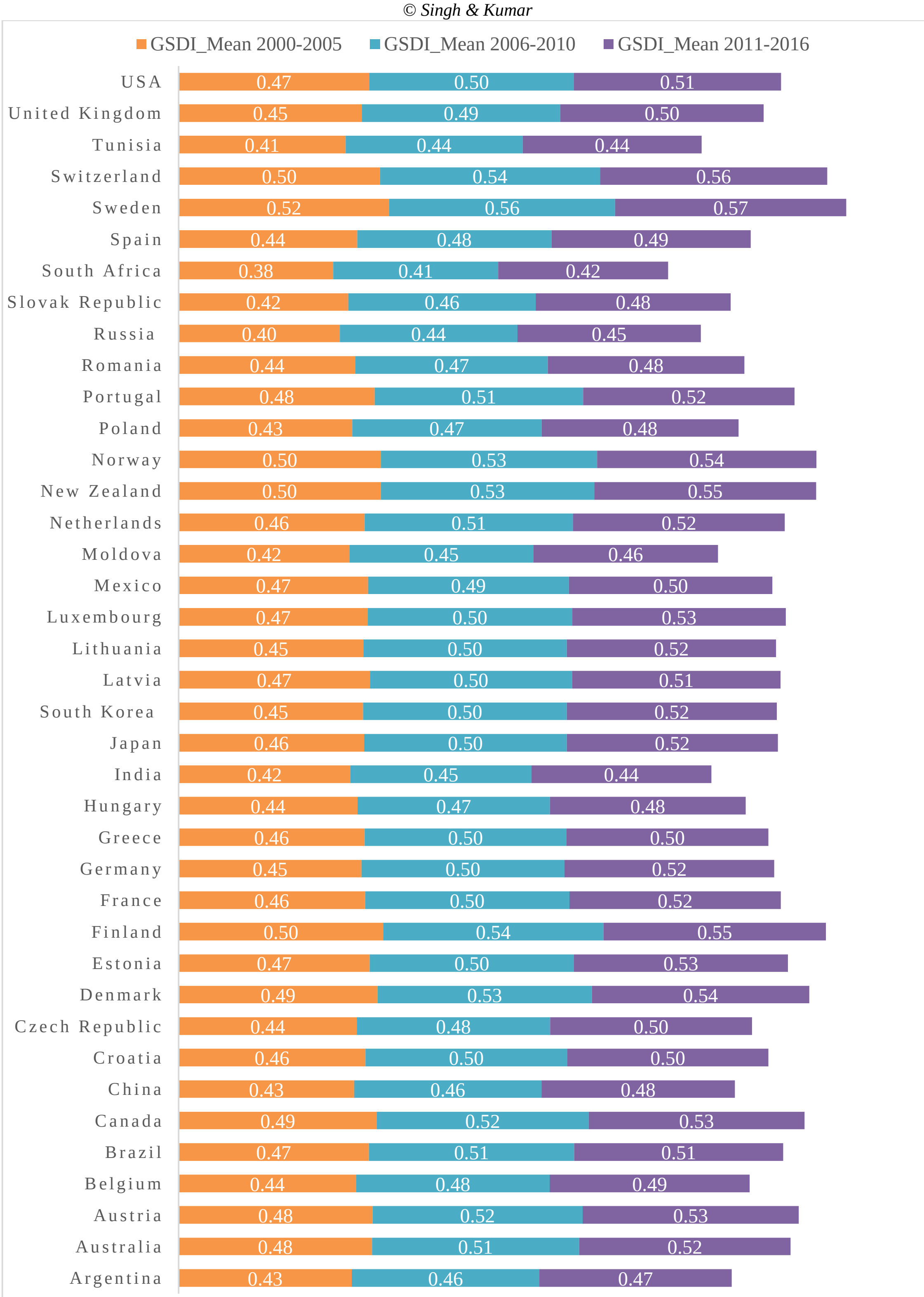

Fig. 4: Country-wise comparisons in global sustainable development

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

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Table 11: Mean values of *ESDI*, *SEDI*, *STPI*, and *GSDI* from 2000-2016

Country	ESDI		SEDI		STPI		GSDI	
	Values	Rank	Values	Rank	Values	Rank	Values	Rank
Luxembourg	0.435	34	0.599	10	0.322	3	0.548	1
Switzerland	0.478	18	0.629	1	0.338	1	0.532	2
China	0.455	28	0.500	35	0.169	15	0.531	3
South Korea	0.452	29	0.575	20	0.242	4	0.523	4
Sweden	0.573	1	0.617	3	0.211	6	0.523	5
Netherlands	0.431	36	0.597	12	0.328	2	0.517	6
Finland	0.558	2	0.594	15	0.201	8	0.513	7
United Kingdom	0.433	35	0.600	9	0.174	13	0.508	8
Belgium	0.405	39	0.598	11	0.163	16	0.505	9
USA	0.465	24	0.590	18	0.216	5	0.502	10
Poland	0.460	26	0.538	31	0.101	23	0.500	11
Austria	0.502	11	0.596	13	0.181	10	0.498	12
France	0.467	21	0.601	7	0.175	12	0.496	13
South Africa	0.430	37	0.445	39	0.067	32	0.496	14
Norway	0.540	5	0.605	6	0.151	18	0.494	15
Spain	0.482	16	0.547	28	0.078	27	0.494	16
Japan	0.466	22	0.587	19	0.203	7	0.494	17
Canada	0.517	10	0.600	8	0.143	19	0.491	18
Czech Republic	0.463	25	0.551	24	0.138	20	0.490	19
Hungary	0.446	31	0.550	26	0.174	14	0.490	20
Mexico	0.479	17	0.567	21	0.152	17	0.488	21
Australia	0.475	19	0.610	5	0.138	21	0.487	22
Slovak Republic	0.466	23	0.520	34	0.095	25	0.483	23
Estonia	0.537	6	0.563	23	0.109	22	0.483	24
Denmark	0.499	12	0.618	2	0.197	9	0.480	25
New Zealand	0.534	7	0.617	4	0.100	24	0.470	26
Greece	0.490	14	0.565	22	0.071	28	0.469	27
Germany	0.460	27	0.591	17	0.180	11	0.468	28
Portugal	0.519	8	0.593	16	0.078	26	0.465	29
Latvia	0.549	4	0.548	27	0.067	33	0.464	30
Croatia	0.517	9	0.551	25	0.068	31	0.459	31
Moldova	0.423	38	0.543	29	0.052	35	0.456	32
Brazil	0.557	3	0.536	32	0.069	30	0.453	33
Russia	0.448	30	0.497	36	0.066	34	0.453	34
Lithuania	0.493	13	0.594	14	0.071	29	0.442	35
Romania	0.489	15	0.535	33	0.042	38	0.437	36
India	0.440	33	0.488	38	0.042	37	0.429	37
Tunisia	0.443	32	0.490	37	0.051	36	0.428	38
Argentina	0.468	20	0.539	30	0.042	39	0.401	39

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

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As per the estimated values of *SEDI*, *ESDI*, *STPI* and *GSDI*, countries were divided into three categories. Switzerland, Denmark, Sweden, New Zealand, Australia, Norway, France, Canada, United Kingdom, Luxembourg, Belgium, Netherlands, Austria, Lithuania, Finland, Portugal, Germany, USA, and Japan have the best performance in social-economic development. South Korea, Mexico, Greece, Estonia, Czech Republic, Croatia, Hungary, Latvia, Spain, Moldova, Argentina, Poland, Brazil, Romania, Slovak Republic, and China have relatively good social-economic development performance. Russia, Tunisia, India, and South Africa have the poorest performance in social-economic development.

The values of *ESDI* vary from 0.405 to 0.573 across countries; hence, the estimates imply that there was a high diversity in environmental sustainability development among 39 countries. Sweden, Finland, Brazil, Latvia, Norway, Estonia, New Zealand, Portugal, Croatia, and Austria have shown better performance in environmental sustainability development. Denmark, Lithuania, Greece, Romania, Spain, Mexico, Switzerland, Australia, Argentina, France, Japan, Slovak Republic, USA, Czech Republic, and Poland have a relatively good position in environmental sustainability development. Germany, China, South Korea, Russia, Hungary, Tunisia, India, Luxembourg, United Kingdom, Netherlands, South Africa, Moldova, and Belgium have poor positions in environmental sustainability development.

The results also claimed that selected economies have a significant variation in Science & technological progress as per the values of *STPI*. Switzerland, Netherlands, Luxembourg, South Korea, USA, Sweden, Japan, Finland, Denmark, Austria, Germany, France, United Kingdom, Hungary, China, Belgium, and Mexico could maintain their better performance in science & technological development. Norway, Canada, Czech Republic, Australia, Estonia, Poland, New Zealand, Slovak Republic, Portugal, Spain, Greece, Lithuania, Brazil, Croatia, South Africa, Latvia, Russia, Moldova, Tunisia, India, Romania, and Argentina have the poorest position in science & technological development.

As *GSDI* was the integrated index of *SEDI*, *ESDI* and *STPI*. Thus, it was apparent which countries with the high values of *SEDI*, *ESDI*, and *STPI* were better positioned for sustainable development. Thereupon, it has appeared that selected economies have the critical variation in sustainable development due to high variability in factors affecting social-economic development, environmental sustainability development, and Science & technological progress. Luxembourg has the highest value of GSDI; thus, this country has shown the best performance in sustainable development. Also, as per the values of *GSDI*, Switzerland, China, South Korea, Sweden, Netherland, Finland, the United Kingdom, Belgium, the USA, and Poland have a better position in sustainable development. Thereupon, other economies have a comparatively poor position in sustainable development. Hence, it is proposed that global economies focus on all indicators essential to increase social, economic, environmental, and Science & technological development.

5.3. Correlation Coefficients among the Indexes

The correlation coefficients among the estimated indexes are given in Table 12. The correlation coefficient measures the association among the variables without assuming the dependency of a specific indicator on others. The estimates showed that *GSDI* was positively associated with *ESDI*, *EDI*, *SDI*, *SEDI*, and *STPI*. Hence, sustainable development was positively interconnected with environmental sustainability, economic and social development, and Science & technological progress. On the contrary, economic development was negatively associated with environmental development. It can be accurate that the process of economic development requires more natural resources. Hence, high economic development may be caused to increase environmental degradation. Science & technological progress was also positively associated with sustainable economic and social development. Therefore, an integrated and balanced development approach may be imperative to increase sustainable development.

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Table 12: Karl Pearson Correlation Coefficients

Variables	*GSDI*	*ESDI*	*EDI*	*SDI*	*STPI*
GSDI	1	0.673**	0.381**	0.803**	0.654**
ESDI	0.673**	1	-0.076*	0.401**	0.097**
EDI	0.381**	-0.076*	1	-0.003	0.279**
SDI	0.803**	0.401**	-0.003	1	0.565**
STPI	0.654**	0.097**	0.279**	0.565**	1

Note: **. Correlation is significant at the 0.01 level and *. Correlation is significant at the 0.05 level.
Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

6. Discussion on Regression Results

The regression results assess the association of *SEDI* with *GSDI*, *ESDI*, *STPI*, *EMPAGSE*, *EMPINSE*, *EMPSESE*, *SHAGGDP*, *SHINGDP*, *SHSEGDP*, *VUEMTO*, *FA*, and *PPAFET* is given in Table: 13. The *Wald* Chi^2 value seemed statistically significant, which specifies that the proposed model is well suited. The regression coefficient of *SEDI* with *GSDI* was observed to be positive and statistically significant. The estimate infers that social-economic development increases as sustainable development increases (Misztal & Kowalska, 2020). *ESDI* showed a negative influence on *SEDI*. The estimate can be justified that the path of environmental development prevents the use of ecosystem services in production activities. Employment opportunities and infrastructure development may be declined due to a decrease in the production of goods and services. Subsequently, policy initiatives toward *ESD* may be unproductive in increasing social-economic development. Global economies should control high industrialization, urbanization, and population growth to reduce other food and energy resources consumption to increase social-economic development.

Further, advanced technology applications to abate CO_2 and GHGs emissions from industries, urbanization, and infrastructural development would help increase sustainable development. Thus, global economies should use green and environmental technology in industrial and agricultural production activities to improve social-economic development and sustainable development (Singh et al., 2021). Furthermore, the initiation of green entrepreneurship will be helpful for sustainable development in the long term (Alwakid et al., 2021). Alwakid et al. (2021) also reported a positive and significant impact of green entrepreneurship on economic, social, and environmental development in Saudi Arabia. The result supports the positive but statistically insignificant association of *SEDI* with *PPAFET* in this study. Previous literature also argued that environmental and green technology substantially contributes to maintaining environmental development and sustainable development (Singh et al., 2021). This study also reported a positive regression coefficient of environmental technology with *SEDI*. Therefore, it indicates that environmental technology is vital to increasing social-economic development (Misztal & Kowalska, 2020; Singh et al., 2021).

Science & technology progress was a crucial driver of increasing social-economic development (Singh et al., 2020b). *STP* is useful for creating an innovative science & technology ecosystem supporting increasing industrialization and entrepreneurship. *STP* is also effective in increasing technology transfer from research institutions to industries. Subsequently, *STP* is essential for discovering new processes and techniques to produce new goods and services in the manufacturing sector. Consequently, it is helpful to create a new market, entrepreneurial opportunities, and additional jobs. Therefore, the regression coefficient of *STPI* with *SEDI* was detected positively and statistically significant in this study. The estimate is consistent with Singh et al. (2020)'s study, which has reported a positive impact on science and technological development on the gross value added of the manufacturing sector in selected developed and developing countries.

The estimates also demonstrate that socio-economic development was positively associated with employment in the agriculture, industrial and service sectors. Hence, creating employment in all sectors of

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an economy will be dominant in increasing social-economic development. The estimates also imply that social-economic development increases as more employment opportunities increase. Therefore, a country needs to create additional jobs for people to increase social-economic development. Singh et al. (2020); Singh et al. (2021) have also reported that employment creation will be operative in increasing social-economic development. Also, the share of the industrial and service sector in GDP positively impacts social-economic development. Global economies should increase the share of sectors described above in GDP to increase social-economic development. Since the agricultural sector is not a profitable occupation in most developing and largely agrarian economies due to climate change, natural disasters, the rising cost of cultivation, the low economic capacity of farmers to cope with climate change and ineffective support from the government towards agricultural sector (Ye at al., 2013; Kumar et el., 2017; Sharma & Singh, 2017; Singh & Issac, 2018; Luu et al., 2019; Pakmehr et al., 2020). Therefore, the regression coefficient of the share of the agricultural sector in GDP with social-economic development appeared negative and statistically significant.

Total vulnerable employment (*VUEMTO*) exhibited a negative impact on *SED*. As vulnerable employment is associated with inadequate earnings, low productivity, social insecurity and poor condition of workers. Thus, it is understandable that social-economic development is expected to decrease as total vulnerable employment increases. Forest area is a crucial component of ecosystem service which absorbs the CO_2 and GHGs emissions from various activities. Thus, forest area works as an ecosystem adaptation-based approach to abate CO_2 and GHGs emissions, reducing environmental degradation (Singh et al., 2019a; Singh et al., 2021). However, provision to control forest area may be caused to reduce in industrialization, urbanization and use of forest land for agricultural purposes. Therefore, it can be claimed that social-economic development may require more natural resources (like forest, land, water and air) to satisfy the needs (i.e., food, energy, water, air, shelter, hospitals, infrastructure, etc.) of the population. Thus, an unsustainable path of social-economic development may cause to increase in environmental degradation. Subsequently, the protection of forest areas may have negative implications on social-economic development.

Table 13: Association of *SEDI* with *GSDI*, *ESDI*, *STPI* and other explanatory variables

Number of groups	39	*Log likelihood*			1539.035	
Number of obs.	624	*Ramsey RESET* test for fitted values of *SEDI*			15.32*	
Wald Chi^2(12)	3114.08	*Ramsey RESET* test for independent variables			7.87*	
Prob > Chi^2	0.000	Mean *VIF*			3084.40	
SEDI	*Reg. Coef.*	*Std. Err.*	*z*	*P*>|*z*|	[95% Conf. Interval]	
GSDI	1.1690	0.0273	42.87	0.000	1.1156	1.2225
DESDI	-0.2724	0.1102	-2.47	0.013	-0.4884	-0.0564
DSTPI	0.1596	0.0393	4.06	0.000	0.0825	0.2367
DEMPAGSE	0.1189	0.1121	1.06	0.289	-0.1009	0.3387
DEMPINSE	0.1162	0.1122	1.04	0.300	-0.1036	0.3361
DEMPSESE	0.1196	0.1122	1.07	0.286	-0.1002	0.3395
SHAGGDP	-0.0022	0.0003	-8.38	0.000	-0.0027	-0.0017
DSHINGDP	0.0032	0.0012	2.64	0.008	0.0008	0.0056
DSHSEGDP	0.0026	0.0011	2.49	0.013	0.0006	0.0047
DVUEMTO	-0.0007	0.0014	-0.48	0.633	-0.0034	0.0021
FA	-0.0006	0.0001	-11.27	0.000	-0.0007	-0.0005
PPAFET	0.0004	0.0006	0.63	0.529	-0.0007	0.0014
Cons. Coef.	0.0285	0.0132	2.17	0.030	0.0028	0.0543

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

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The regression results which observe the association of *STPI* with *ESDI*, *SEDI*, *GSDI*, *EMPINSE*, *SHINGDP*, *PPAFET*, and *VUEMTO* are given in Table: 14. Estimates showed that science & technological progress was positively associated with social-economic development, industrial sector employment, and industrial sector share in GDP, and environmental technology. Thus, global policymakers need to give importance to increasing social-economic development and creating employment opportunities in the industrial sector to boost science & technological progress (Singh et al., 2020b). Sustainable development, environmental sustainability development, and total vulnerable employment have a negative impact on science & technological progress. Total vulnerable employment is caused to increase low productivity of workers and social insecurity of workers in a country. Therefore, science & technological progress is expected to decrease as total vulnerable employment increases. However, this study could not provide the rationality on the negative association of science & technological progress with sustainable development and environmental sustainability.

Table 14: Association of *STPI* with *GSDI*, *SEDI*, *ESDI* and other explanatory variables

Number of groups	39	Log likelihood			1532.028	
Number of obs.	624	*Ramsey RESET* test for fitted values of *STPI*			7.09*	
Wald Chi^2(12)	66.69	*Ramsey RESET* test for independent variables			2.05*	
Prob > Chi^2	0.000	Mean *VIF*			2.10	
DSTPI (DV)	*Reg. Coef.*	*Std. Err.*	*z*	*P>|z|*	[95% Conf. Interval]	
SEDI	0.1485	0.0350	4.24	0.000	0.0799	0.2171
GSDI	-0.1040	0.0464	-2.24	0.025	-0.1948	-0.0131
DESDI	-0.5895	0.1074	-5.49	0.000	-0.8000	-0.3789
DEMPINSE	0.0013	0.0012	1.10	0.269	-0.0010	0.0037
DSHINGDP	0.0025	0.0008	3.08	0.002	0.0009	0.0042
PPAFET	0.0002	0.0006	0.37	0.711	-0.0009	0.0013
DVUEMTO	-0.0004	0.0011	-0.41	0.685	-0.0025	0.0016
Cons. Coef.	-0.0234	0.0111	-2.10	0.036	-0.0453	-0.0016

Source: Estimated by authors based on data from World Development Indicators (World Bank), World Intellectual Property Rights Organization

7. Conclusion and Policy Proposals

The main aim of this study was to examine the construct and latent factors of social development, economic development, environmental sustainability development, and science & technological progress in selected 39 economies using a *CFA* technique. For the investigation mentioned above, 9, 11, 42, and 9 factors associated with social development, economic development, environmental sustainability development, and science & technological progress were considered. A linear production function model was applied to explore the impact of global sustainable development on social-economic development and science & technological progress using country-wise panel data during 2000–2016.

The results based on *CFA*, age dependency ratio, education expenditure, female infant mortality rate, female labor force, fixed telephone subscriptions, female unemployment, life expectancy at birth, the ratio of female to male labor force participation rate, and sex ratio have the significant contribution to increase social development. Economic development depends on exports of goods and services, final consumption expenditure, foreign direct investment net inflows, gross capital formation, per capita GDP, per person GDP employed, total employers, total labor force participation rate, and total wage and salaried workers. Low-ranking economies such as South Africa, China, Slovak Republic, Brazil, Russia, Romina, India, and Tunisia should focus on factors described above to increase their performance in social-economic development.

In the group of environmental sustainability development, access to electricity; CO_2 emissions from electricity and heat production; CO_2 emissions from gaseous fuel consumption; CO_2 emissions from liquid fuel consumption; CO_2 emissions from residential buildings and commercial and public services; CO_2 emissions from solid fuel consumption; CO_2 emissions from

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transport; CO_2 intensity; combustible renewables and waste; electricity production from coal sources; electricity production from hydroelectric sources; electricity production from nuclear sources; electricity production from oil, gas and coal sources; energy use; fossil fuel energy consumption; population growth; PM2.5 air pollution mean annual exposure; arable land; people using at least basic drinking water services; people using at least essential sanitation services; renewable energy consumption; renewable electricity output; and renewable internal freshwater resources per capita were reported most influencing factors. Some economies like South Africa, Hungary, Moldova, Russia, India, and Tunisia have the poorest positions in environmental sustainability development. Thus, these countries should prioritise said activities to increase their performance in environmental sustainability development.

Charges for the use of intellectual property payments per researcher, charges for the use of intellectual property receipts per researcher, high-technology exports, high-technology exports per researcher, ICT goods exports, patent applications files per 1000 researcher, R&D intensity, R&D expenditure per researcher, and researchers were found crucial determinants of science & technological development. Therefore, low ranking countries (i.e., Argentina, Romania, India, Russia, South Africa, Latvia, Croatia, Moldova, Brazil, Tunisia) should emphasise mentioned activities to increase their performance in science & technological progress.

The correlation coefficient results demonstrate that sustainable development was positively interconnected with environmental sustainability development, social-economic development, and science & technological progress. Also, economic development was negatively associated with environmental sustainability development. Science & technological progress was positively associated with sustainable development and economic and social development. Therefore, it can be argued that an integrated development approach may be conducive to increasing sustainable development in Croatia, Moldova, Brazil, Russia, Lithuania, Romania, India, Tunisia, and Argentina.

The empirical results indicate that social-economic development was positively associated with global sustainable development, science & technological progress, employment in all sectors, the share of industrial and service sectors in GDP, and environmental technology. Vulnerable employment has a negative impact on social-economic development. Social-economic development, employment in the industrial sector, the share of the industrial sector in GDP, and environmental technology positively impact science & technological progress. Science & technological progress is adversely affected due to an increase in vulnerable employment. Thus, there is an urgency to reduce vulnerable employment to increase the science & technological progress.

The application of environmental and green technology helps decrease CO_2 emissions from production activities. Environmental and green technology would be helpful to increase soil fertility, food quality, productivity, and water and cropping intensity in the agricultural sector. Industries can reduce waste materials, CO_2, and GHGs emissions in the production of goods and services using green and environmental technology. Another favourable implication of the environmental and green technology would help increase human health. Most importantly, the application of environmental technology would be helpful to increase the transformation of a nation towards green entrepreneurship. It would also prepare a path to increase sustainable development for the long term. The use of electricity and renewable energy, green and environmental technology, sustainable water management practices, and sustainable management practices in the agricultural sector will support environmental development (Baydoun & Aga, 2021; Singh et al., 2022a). Also, the adoption of renewable energy sources through technological advancement may be helpful in reducing environmental degradation.

This study used *the CFA technique to examine the latent and construct variables significantly associated with social development, economic development, environmental development,* and science & technological progress in 39 selected economies during 2000-2016. Using country-wise panel data, it

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investigated the impact of sustainable development, environmental sustainability development, and environmental technology on social-economic development and science & technological progress. Accordingly, it suggested several policy proposals to increase sustainable development. Despite that, this study's generalization of empirical findings for a specific country can be validated in further research. Also, existing researchers can be considered similar empirical exercises, including more developed and developing economies, to check the rationality of the empirical results of this study.

Acknowledgement: The authors are thankful to the DIT University Dehradun for providing the resources to write this research article.

Author Contributions: The proposal for this article was prepared by Dr. Ajay Kumar Singh. Dr. Sanjeev Kumar collected relevant data from various sources. Dr. Ajay Kumar Singh completed the formulation of empirical models and statistical inferences. The final draft of this article was written by both authors jointly.

Conflict of Interest: The authors declare no conflict of interest.

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