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Exploring the heterogeneous influence of social media usage on human development: The role of carbon emissions and institutional quality

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ABSTRACT

Social media has grown in importance as a means of social connection and provides a significant avenue for learning about sustainability and related issues. This study aimed to reveal the long-run heterogeneous relationship between social media usage, institutional quality, carbon emissions and human development. We employ second generation techniques, namely augmented mean group (AMG) and common correlated effects mean group (CCEMG) estimators to ensure that cross-sectional dependence and heterogeneity are captured. In addition, the system generalized method of moments (GMM) dynamic panel data estimator was used to deal with the issue of endogeneity and serial correlation. The analyses were categorized into three: all sample groups, advanced economies, and transition and developing economies. Our findings show that there is a positive relationship between social media usage, institutional quality, carbon emission and human development. However, social media usage in transition and developing economies is more pronounced than in advanced economies and likewise for institutional quality. With regard to carbon emissions, the impacts are symmetric. Overall, the interaction between social media and carbon emissions adversely affects human development, while the interaction between social media and institutional quality proportionally lead to human development. Most importantly, the impact of social media on human development is not economically beneficial and may be more promising in transition and developing countries.

Contribution/Originality: This study provides fresh evidence of the link between social media usage and human development at the macro level. To the best of our knowledge, no study has examined the social media–human development nexus. The study employs advanced econometric techniques with the statistical strength to deal with cross-sectional heterogeneity, endogeneity, and serial correlation.

1. INTRODUCTION

People have been identified as the wealth of a nation by enjoying healthy, long and creative lives through an enabling environment, which is the basic objective of development (Shaw, 1991). Most often than not, economic growth has been pinpointed as the sole factor which reliably serves to eliminate poverty and create wealth to improve environmental protection and human wellbeing. Nonetheless, the pertinent factors such as health, life expectancy and education which are linked to societal wellbeing are ignored; therefore, economic growth does not warrant improvement in living standards (Ouedraogo, 2013). It has long been believed that human development is dependent on economic growth, which in turn necessitates increasing energy use and, as a result, increased greenhouse gas emissions at the national level (Brand-Correa & Steinberger, 2017; Chaaban, Irani, & Khoury, 2016; Steinberger, Roberts, Peters, & Baiocchi, 2012).

Environmental issues have become important to people, with greater awareness of planetary imbalances becoming more mainstream due to media attention and the dissemination of information about the negative effects caused by human activities (Conceição, 2020). According to Baumann (2021), apart from formal education, people learn about environmental issues through a variety of channels such as social interaction (including social media), the workplace (seminars, training) or government policies and communication (political discourse or governmental awareness campaigns). Social media has grown in importance as a means of social connection and now provides a significant avenue for learning about sustainability and related issues (Conceição, 2020). Young people and adults can benefit from social media, but it can also contribute to societal polarization and create barriers to learning the truth; for instance, YouTube, Twitter, and Facebook have been cited for echo chamber building and polarization platforms where content shared by users are commented on and liked by like-minded subscribers (Pineda, 2012). Consequently, confirmation bias due to the algorithms used for content promotion — responsible for providing more insights on cognitive factors — could explain echo chamber building regarding such platforms (Pineda, 2012). According to Ali, Conte, and Routley (2020), social media has infiltrated almost every area of modern life. The social media universe today has almost 3.8 billion users across all platforms, accounting for almost half of the world's population; it is feasible that the social media world will expand more in the future, with an extra billion internet users expected to come online (Ali et al., 2020).

Over the last century, industrialization and economic development activities have been defined by the increased discovery and usage of energy-consuming technology, resulting in increased energy consumption per capita (Steinberger & Roberts, 2010). The necessity for data centers is becoming increasingly obvious as technology advances. This also means that data centers are being pushed to their limits more than ever before. On certain levels, technological advancement will always be welcome, but discovering how to be more energy efficient is more of a global concern (Masanet, Shehabi, Lei, Smith, & Koomey, 2020). Given that data centers are the backbone of information in an increasingly digitized world, social media usage has been on the increase, culminating in the demand for data center expansion.

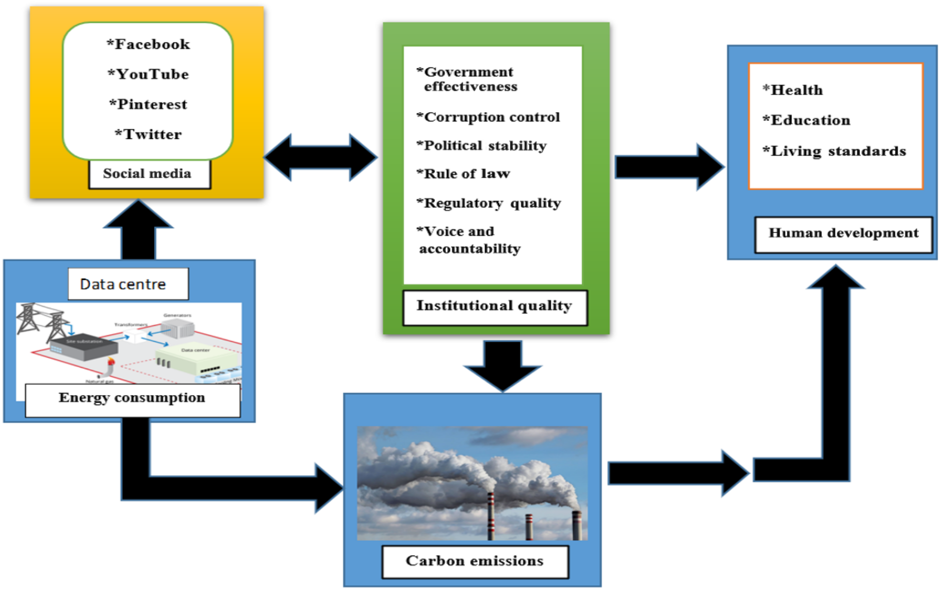

Figure 1. Conceptual framework of social media, institutional quality, carbon emissions and human development.

Globally, data centers account for about 1% of electricity use, which significantly contributes to the world's energy use resulting in surging carbon emissions through non-renewable energy use. This figure is expected to reach 3.2%

by 2030 (Azam, Hunjra, Bouri, Tan, & Al-Faryan, 2021). Our social media lives, as well as businesses and the internet, rely heavily on data centers, which use a lot of power. As the population rises, it becomes increasingly vital to make them more energy efficient and environmentally friendly. In recent years, Facebook's electricity consumption has risen as additional data centers have been put into operation (Pineda, 2012). The corporation used 5.1 terawatt hours of electricity in 2019, up significantly from the previous year's 2.1 terawatt hours. Because data centers require a lot of electricity, carbon dioxide (CO_2) emissions are also an issue. It is currently impossible to estimate total CO_2 emissions properly due to a lack of data on the locations of most data centers worldwide and the emissions' intensity of their electricity sources.

Azam et al. (2021) contend that much work needs to be done in emerging economies to build the structures and legal support needed to balance environmental resource management with long-term development goals. The majority of developing countries face efficiency and productivity issues when it comes to environmental resource management due to poor anthropogenic governance. Given their potential to function as a balancing force between economic and environmental policy, institutional structures related to democracy and legal enforcement should be prioritized. This can be accomplished by adjusting policies and placing an emphasis on institutional quality (Acemoglu & Johnson, 2005; Hussain, Ye, Bashir, Chaudhry, & Zhao, 2021). Conventionally, to improve environmental quality and human development, legislative measures have a substantial role to play. Most importantly, proper policy formulation and implementation ought to be the focal point in ensuring sustainable development through human development and environmental quality (Dwumfour & Ntow-Gyamfi, 2018). Institutional quality is crucial for the proper execution of human development policies to ensure sustainable development. Strong institutions, on the other hand, can contribute to better resource development in resource-rich countries. Furthermore, a strong rule of law, low corruption, government effectiveness, political stability, voice and accountability, property rights protection, regulatory quality and an appealing investment profile can all encourage stakeholders to create an environment that can turn natural resources into advantages and vice versa (Acemoglu & Johnson, 2005; Hussain et al., 2021).

Given the above highlights regarding the nexus between social media usage and human development by considering the intervening roles of institutional quality and carbon emissions, the study understands the need to uncover the long-run relationship among them. Many analysts claim that data centers currently consume 1% of global electricity for storage and transmission. Although the number of internet users has more than doubled and global internet traffic has increased by a factor of 15, this percentage has stayed constant since 2010. However, this is not the case in Europe. In 2010, data centers in the EU's 28 member states utilized 53.9 terawatt hours of electricity. This increased to 76.8 terawatt hours in 2018, accounting for 2.7% of the EU's total electricity consumption. Global consumption, the study found, will account for 3.2% of the total demand by 2030. The widespread use of social media brings with it a slew of issues. Some firms, such as Facebook, have found themselves in the crosshairs of political opponents on both sides of the aisle. As concerns about privacy and data become more widespread, social media will play a larger role in defining the future of government, industry, and politics, which will influence the human development process and sustainable development (Ali et al., 2020). Therefore, the purpose of this study is to reveal the long-run heterogeneous relationship between social media usage, institutional quality, carbon emissions and human development. This is against the backdrop of Vygotsky's sociocultural perspective and Bronfenbrenner's ecological systems theory, which contend that there is a physical environmental influence of human development relative to the ecological systems in existence (Berk & Petersen, 2004; Ettekal & Mahoney, 2017). Moreover, the novelty of this study stems from the linkage between social media usage and human development at the macro level as no study has been done in that direction, to the best of our knowledge. With regard to methodology, the study employs augmented mean group (AMG) and common correlated effects mean group (CCEMG) to ensure that the cross-sectional dependence and heterogeneous nature of the panels are accounted for. To ensure robustness of the findings, the system generalized method of moments (GMM) dynamic panel data estimator was utilized to resolve the issues of endogeneity and serial correlation that the estimated model may suffer in the regression analysis. Finally, the analyses were performed for all sample groups, advanced economies, and transition and developing economies.

The rest of the paper is organized as follows: Section 2 comprises the theoretical background and literature review; Section 3 explains the empirical methodology, data and empirical model; the findings are presented and discussed in Section 4; and Section 5 contains the conclusion and policy implications.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1. Theoretical Background

According to Vygotsky's sociocultural perspective, human development happens when there is an interaction between a social environment and its people. The theory underscores the important connections between the sociocultural context and the people who interact through shared experiences (Berk & Petersen, 2004). On the other hand, Bronfenbrenner's ecological systems theory states that there is a mutual accommodation between the physical environment and developing individuals. Moreover, Vygotsky posits that an individual could learn to use and develop higher mental processes to employ tools such as education, career development through interaction with the environment, people with higher skill levels, and society. Similarly, Bronfenbrenner's theory complements Vygotsky's theory as it highlights that the interaction of an individual with a variety of ecological, cultural, and social contexts enable them to learn and understand self-regulation (Ettekal & Mahoney, 2017). From the ecological systems theory, five systems exist, namely microsystem, mesosystem, ecosystem, macrosystem, and chronosystem. Under the macrosystem, an individual has less influence on the macrosystem in which they find themselves. The macrosystem encompasses the relative freedoms and culture allowed by the government, the economy, cultural values, wars, environmental degradation, and pollution, etc. Also, it labels the culture in which people live to consist of socioeconomic status, ethnicity and poverty (Berk & Petersen, 2004).

Based on the above theoretical proponents, human sustainability wholly depends on the implementation of proper policies and systems within an economy. Therefore, ensuring improved institutional quality, environmental quality and proper communication as well as rapid information dissemination could significantly contribute to human development. It is on this tenet that this study investigates the relationship among social media usage, institutional quality, carbon emissions and human development.

3. LITERATURE REVIEW

3.1. Social Media and Human Development

The advent of social media and related technology has transformed the interactions between people, especially internet- and technology-savvy individuals. Additionally, the current social perspective permits people to follow their role models and celebrities, keep in touch with friends, and learn about emerging information and technology products (Moncrief, Marshall, & Rudd, 2015). Since the evolution of social media, numerous definitions have been proposed, but the most relevant one can be expressed as networking interactions and digital content that are developed and sustained by and between individuals (Cohen, 2020).

The nexus between social media and development is evolving into an exciting new phase due to increasing internet connectivity and the wide availability of cell phones. Essentially, development agencies have adopted the use of social media to propagate their developmental agendas and policies to reach out to the masses, such that the United Nations International Children's Emergency Fund, the United Nations High Commissioner for Refugees, the United Nations Refugee Agency and the World Food Programme, among many others, are the most liked and followed on Facebook and Twitter (Baumann, 2021). According to Bruns, Enli, Skogerbø, Larsson, and Christensen (2016), social media usage improves the capability of poor populations to make their voices heard by channeling their priorities and concerns to authorities through and perhaps propagating their purpose and vision. Ideally, self-advocacy is a sort of empowerment which does not usually follow the conventional development process. Although social media has technological limitations regarding usage by disadvantaged people, it still can be used by developing countries to promote political coordination, history and culture preservation, and accountability, which lead to development (Bruns et al., 2016).

Some recent studies have delved into the relationship between social media and economic growth (Vitenu-Sackey, 2020 and Amrouche and Hababou, 2022). One study discovered both positive and negative effects of social media on economic growth. Perhaps what drives social media the most is access to fixed broadband, a large user base, and dependable internet servers. The study found that Facebook and Pinterest have a negative effect on economic growth, supporting the second hypothesis about the relationship between social media and economic growth. The positive correlation supports the first hypothesis, which states that social media can positively affect economic growth if entry barriers are removed, allowing users to freely publish and disseminate information with the help of a proper and efficient internet and broadband. This is due to the fact that a variety of media, such as wikis, blogs, pictures, videos, and other forms of expression, greatly enhance the potential of social media in this regard (Vitenu-Sackey, 2020). Meanwhile, Amrouche and Hababou (2022) investigated the impact of Facebook penetration on a country's ability to improve its gross national income (GNI) per capita (purchasing power parity) ranking, which centers on the contribution of information communication technology (ICT) to socioeconomic development. They gauge the socioeconomic standing of countries using Facebook penetration per capita and four macro factors (political, demographic, economic, and technological). Their research demonstrates that, although the impact varies depending on the classification, Facebook penetration has a positive impact on a country's economic status. Therefore, policymakers must consider the intricate dynamics of each nation, as evidenced by a marginal declining effect.

Empirically, we found that no study has yet been conducted on the linkage between social media and human development even though they offer intriguing relationships in sustainable development. It is against this backdrop that this study endeavors to explore the relationship between social media and human development and offers direction for future studies.

3.2. Carbon Emissions and Human Development

Our societies are being put to test in volatile environments where hazards linked with planetary pressures, such as climate change and biodiversity loss, are overplayed on imbalances in human development (Conceição, 2020). To measure development, a plethora of studies have argued that the best yardstick is the human development index due to its encompassment of health, education, and per capita income indicators. Some scholars have asserted that the growth hypothesis exists in some Organisation for Economic Co-operation and Development (OECD) countries, citing countries such as Ireland, Denmark, Italy, Israel, Poland, Korea, Spain, Luxembourg, the United States of America, Turkey, and Slovakia (Bedir & Yilmaz, 2016; Martínez & Ebenhack, 2008; Niu et al., 2013; Steinberger & Roberts, 2010). But contrary to that, their studies also found that neutrality and conservative and feedback hypotheses are present in other OECD countries. The implication is that high living standards because of human development proportionally relate to carbon emissions, but the implementation of conservation policies could significantly reduce these emissions. Moreover, conservation policies can affect human development or the standard of living through economic growth from the industrial use of fossil fuels (coal, oil, and natural gas). Steinberger and Roberts (2010) emphasized that most OECD members are high income countries and have high levels of human development. However, these countries pollute more than necessary to maintain their high standards of living.

Steinberger et al. (2012) explored the relationship between energy consumption, human needs, and carbon emissions in a longitudinal study from 1975 to 2005. In their conclusion, they reiterated that low energy consumption is required for high human development such that increasing energy demands resulting in high carbon emission levels does not contribute to the high standard of living. On the contrary, numerous studies are of the view that technological advancements are not essential to emission abatement and energy conservation other than changes in lifestyle and consumption patterns (Brand-Correa & Steinberger, 2017; Chaaban et al., 2016). Nonetheless, emission reduction requires great effort at the consumption stage, and often, increasing consumption is akin to improving human development. In contrast, in this modern era, consumption is harmful to human psychology and the environment, and perhaps human beings can abate consumption significantly without hampering their standard of living or wellbeing (Jackson, 2005; Li & Chen, 2021).

3.3. Institutional Quality and Human Development

Human development and institutional quality are virtually inseparable in the improvement of socioeconomic institutions to better allocate and distribute resources equitably (Boström et al., 2018). Stronger institutions ensure protection of the sovereignty of a nation by strengthening the rule of law, controlling corruption, enhancing governance effectiveness, ensuring political stability, promoting voice and accountability, protecting property rights, and improving regulatory quality (Acemoglu & Johnson, 2005; Hussain et al., 2021; Jackson, 2005; Nguyen & Dinh Su, 2021; Vitenu-Sackey & Alhassan, 2019).

In recent a study, Ben and Kim (2020) demonstrated that institutional quality proportionally improves human development significantly. The study employed data from 1995 to 2015 for Southeast Asian and Sub-Saharan African countries and posited that effective governance ensures development progress. The aim of their study was to identify the long-run relationship between development performance (human development) and governance (institutional quality). Madni and Anwar (2021) employed 124 countries in a panel study to assess the role of institutional quality in financial development by emphasizing the intervening role of income inequality. According to their findings, educational attainment as a measure of human development is a significant factor in determining income inequality and possibly influences economic growth when institutional quality is at a high improvement threshold.

4. EMPIRICAL METHODOLOGY AND DATA

4.1. Methodology

The methodology of this study employs several econometric techniques. Cross-sectional dependence tests, unit root tests, a homogeneity test, a multicollinearity test, a correlation matrix, a cointegration test and long-run parameter estimations were used to reveal the long-run relationship among the independent variables and the dependent variable. Figure 2 depicts the econometric approach.

Firstly, the study conducted cross-sectional dependence tests by Pesaran (2021); Pesaran, Ullah, and Yamagata (2008) and Breusch and Pagan (1980). Also, the Hashem, Pesaran, and Yamagata (2008) homogeneity test is performed in connection with the cross-sectional dependence test to reveal the panel slopes' heterogeneity and cross-sectional reliance among the residuals. Cross-sectional dependence is an overarching statistical issue in panel data analysis, which seemingly affects the choice of an appropriate econometric approach for estimation and perhaps provides inconsistent outcomes. Evidence of cross-sectional dependence and heterogeneity witnessed from these tests suggests the adoption of second-generation unit root tests. However, the second step was the test of unit root to ascertain the stationarity of the data series. Accordingly, cross-sectional Im, Pesaran and Shin (CIPS) Pesaran (2007) and cross-sectional augmented Dickey–Fuller (CADF) unit root tests were performed. Thirdly, correlation matrix and variance inflation factor analyses were done to ensure that the study's model does not suffer multicollinearity. It is expected that no two or more variables should have correlation coefficients greater than 0.70 (Adjei Mensah et al., 2020; Gujarati, 2018). Also, regarding the variance inflation factor (VIF) values and tolerance levels, the VIF values should be less than 5 and the tolerance level should be greater than 0.2 (Adjei Mensah et al., 2020). Prior to the long-run parameter estimations, cointegration tests were performed where tests by Westerlund and Edgerton (2007) and Pedroni (2004) were performed.

With respect to the long-run parameter estimations, the study utilized the augmented mean group (AMG) and common correlated effects mean group (CCEMG). The reason for choosing these methods stems from the evidence of cross-sectional dependence and heterogeneity among the slopes of the panels. To overcome the assumption of cross-sectional independence and homogeneity as a common feature on the cross-section of the panel estimator, which have been the underlying characteristics of the first-generation panel time series technique, the study relied on second generation panel time series estimators.

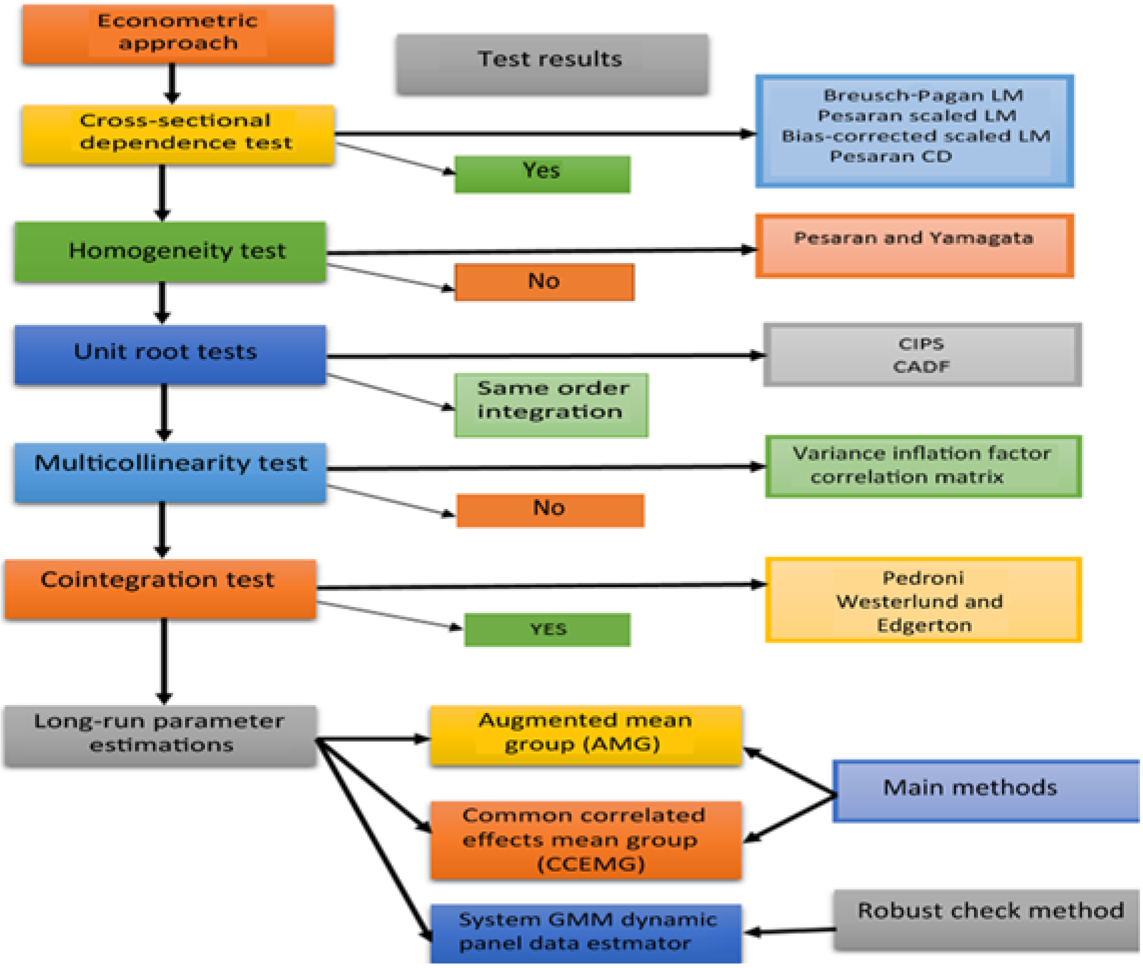

Figure 2. Econometric approach.

In recent times, by providing accurate performance in cointegrated panels, several studies suggest the use of robust estimators that have cross-sectional dependence and slope heterogeneity. The recommended methods include the AMG and CCEMG developed by Pesaran (2006) and Eberhardt and Teal (2010). The AMG estimator has the advantage of considering slope heterogeneity when cross-sectional dependence exists. In addition, in panels with nonstationary variables, whether cointegrated or not, the AMG performs similarly to the CCEMG in terms of bias or root mean square error (RMSE). It assumes that the dynamics denote a common dynamic process (c-d-p) but does not consider the unobserved common factors as irritants that can be estimated. Specifically, the interpretation of the dynamic common process could be attributed to the unobserved factors that influence human development across the countries used in the study. Similarly, the CCEMG shares common features with the augmented mean group estimator, but the latter uses OLS in the regression estimation. To test the robustness of the study's findings, the system GMM dynamic panel data estimation method was employed to check the CCEMG and AMG estimators. By using the system GMM method, the study intends to resolve the issues of endogeneity, simultaneity and cross-sectional heterogeneity which may arise in the model and are unable to be resolved by the other two methods. Specifically, the system GMM estimation method uses the exogenous variables as instruments and permits the first differenced errors of the endogenous variable to use moment conditions (Arellano & Bover, 1995; Blundell & Bond, 1998).

4.2. Data and Empirical Model

This study used data from 143 countries from 2009 to 2017 for its panel analysis. The study categorized its sample into advanced economies and transition and developing economies where 34 countries were selected under the advanced economies and 109 countries were selected under the transition and developing economies. The variables and their corresponding descriptions and data sources are outlined in Table 1. Appendix 1 lists the sample of countries used in the study.

Specifically, the study aims to investigate the heterogeneous relationship between social media usage and human development considering the intervening effects of carbon emissions and institutional quality. Therefore, the dependent variable of the study is human development, which is measured by the human development index following Vitenu-Sackey and Hongli (2020); Bedir and Yilmaz (2016); Niu et al. (2013) and Steinberger and Roberts (2010). The independent variable is social media usage, measured by the penetration rate of four major social media platforms which have a penetration rate of about 90% over the other platforms and present consistent data for the countries sampled for the study.

The study data begins in 2009 because Facebook, which is the largest and most used social media platform, began penetration across the world during that time. Prior to that, the landscape of social media was dominated by Hi5 and Myspace. In the early part of 2020, Facebook was adjudged as the leading social media platform in 151 out of 167 countries, representing a penetration rate of more than 90%, which indicates a tremendous increment from about thousand users in 2004 to 2.7 billion active users in a month (Baumann, 2021). Moreover, due to data availability, the span of the study is nine years, specifically from 2009 to 2017; the study avoids unevenly spaced data series to prevent estimation obstacles.

Social media penetration, which represents the average usage of Facebook, Twitter, YouTube, and Pinterest, follows the study of Vitenu-Sackey (2020), which investigated the impact of social media on economic growth. Human development, which is measured by the human development index, follows studies by Vitenu-Sackey and Hongli (2020); Steinberger and Roberts (2010); Bedir and Yilmaz (2016); Niu et al. (2013) and Martínez and Ebenhack (2008). Institutional quality measures the socioeconomic institutions' performance for which six indicators are used. These are corruption control, rule of law, governance effectiveness, regulatory quality, political stability, and voice and accountability. Numerous studies have utilized these indicators individually to measure the stability and sustainability of an economy, rightly representing the quality of socioeconomic institutions (Azam et al., 2021; Nguyen & Dinh Su, 2021; Vitenu-Sackey & Alhassan, 2019).

On the other hand, the study uses per capita CO_2 emissions from the total final energy use as a proxy for environmental harm. CO_2 emissions, as previously stated, account for the majority of greenhouse gas emissions and the planetary pressures of the physical environment following studies of Vitenu-Sackey (2020); Bedir and Yilmaz (2016); Niu et al. (2013); Steinberger and Roberts (2010) and Martínez and Ebenhack (2008).

To estimate the long-run parameters of the selected variables, the study constructs the model below:

$$HDI = f(SMP, CO_2, IQ) \qquad (1)$$

Equation 1 depicts the economic model which states that the human development index is a function of social media, carbon emissions, and institutional quality. After taking the natural logarithm of social media users, the econometric model can be written as follows:

$$HDI_{i,t} = \beta_0 + \beta_1 SMP_{i,t} + \beta_2 CO_{2_{i,t}} + \beta_3 IQ_{i,t} + \varepsilon_{i,t} \qquad (2)$$

$$HDI_{i,t} = \beta_0 + \beta_1 SMP_{i,t} + \beta_2 CO_{2_{i,t}} + \beta_3 IQ_{i,t} + +\beta_4 SMP * CO_{2_{i,t}} + \beta_5 SMP * IQ_{i,t} + \varepsilon_{i,t} \qquad (3)$$

In the model denoted by Equations 2 and 3, HDI stands for human development index and represents the dependent variable, SMP stands for social media penetration and represents social media usage, CO_2 stands for carbon emissions and represents the physical environmental effect, IQ stands for institutional quality and represents the socioeconomic environmental effect on human development, SMP*IQ denotes the interaction between social media and institutional quality, SMP*CO2 denotes the interaction between social media and carbon emissions, *i* denotes the cross-section of 143 countries, t represents the study period (2009 to 2017), and ε represents the stochastic error term or disturbance to be estimated in the model. β_0 represents the intercept, and β_1 to β_5 represent the elasticity coefficients of the variables to be estimated.

Table 1. Variables, measurements, descriptions, and sources.

Variable	Measurement	Description	Source
SMP	Social media penetration	The average number of active users of the four platforms with the highest penetration (Facebook, YouTube, Twitter, and Pinterest).	gs.statcounter.com
IQ	Institutional quality	The average score of the six indicators of institutional governance (Rule of law, corruption control, voice and accountability, political stability, regulatory quality, and government effectiveness) based on scores ranging from -2.5 to +2.5; i.e., weak to strong.	Worldwide Governance Indicators, World Bank
HDI EDI LEI GNI	Human development index Education index Life expectancy index Gross national income per capita	The human development index is a statistic composite index of life expectancy (Life expectancy index). The education index (Mean years of schooling and expected years of schooling) and per capita income indicators (GNI) are used to rank countries into four tiers of human development. A country scores a higher HDI value when the lifespan and education level are higher and the gross national income per capita is high. Scores range from 0 to 1.	United Nations Development Programme (UNDP)
CO_2	Carbon emissions	Carbon emissions in metric tonnes per capita.	World Development Indicators, World Bank

5. FINDINGS AND DISCUSSION

5.1. Descriptive Statistics

Table 2 contains the descriptive statistics of the variables adopted for the study relative to the three sample categories: all economies, advanced economies, and transition and developing economies. A total of 1,287 observations were witnessed for 143 countries, with 306 and 986 observations in the advanced economies and the transition and developing economies, respectively, for the four variables for the period between 2009 and 2017. Moreover, the table presents the mean, median, minimum, maximum, standard deviation, skewness, kurtosis, and Jarque–Bera test values for the variables with respect to the whole sample, advanced economies, and transition and developing economies.

Table 2. Descriptive statistics.

Summary statistics									
All sample	**Mean**	**Median**	**Max.**	**Min.**	**Std. dev.**	**Skewness**	**Kurtosis**	**JB test**	**Obs.**
HDI	0.71	0.74	0.95	0.31	0.16	-0.49	2.25	81.71***	1287
SMP	1.61	1.70	2.80	-1.08	0.59	-1.04	4.58	363.02***	1287
IQ	0.09	-0.12	4.02	-1.70	0.93	0.63	3.27	87.60***	1287
CO_2	4.89	3.00	62.07	0.02	6.07	3.08	18.86	15514.12***	1287
Advanced economies									
HDI	0.88	0.89	0.95	0.80	0.04	-0.36	2.12	16.57***	306
SMP	1.82	1.87	2.76	0.36	0.42	-0.54	3.29	15.89***	306
IQ	1.18	1.22	1.87	0.07	0.47	-0.34	2.12	15.52***	306
CO_2	8.28	7.52	24.01	3.38	3.92	1.57	5.61	211.06***	306
Transition and developing economies									
HDI	0.66	0.69	0.93	0.31	0.14	-0.36	2.23	45.90***	981
SMP	1.55	1.66	2.80	-1.08	0.63	-0.96	4.251	215.75***	981
IQ	-0.24	-0.33	4.02	-1.70	0.77	1.48	8.16	1443.91***	981
CO_2	3.82	1.71	62.07	0.02	6.16	3.95	24.88	22105.10***	981

Note: HDI = Human development index, SMP = Social media usage, IQ = Institutional quality, CO_2 = Carbon emissions, JB = Jarque–Bera.
*** denotes a 1% significance level.

To report the actual values, the study found that human development (HDI) has mean values of 0.714, 0.883, and 0.661 with standard deviation values of 0.156, 0.038, and 0.139 with respect to the whole sample, advanced economies, and transition and developing economies, respectively. For social media usage (SMP), the mean values are 1.605, 1.818 and 1.552 with standard deviation values of 0.593, 0.424 and 0.626, respectively, for the categorized samples. With respect to the other variables, institutional quality (IQ) and carbon emissions (CO_2) show mean values of 0.093 and 4.894 with standard deviation values of 0.933 and 6.066 for all samples, 1.178 and 8.281 with standard deviation values of 0.473 and 3.917 for advanced economies, and -0.242 and 3.820 with standard deviation values of 0.765 and 6.163 for transition and developing economies. With regard to the normality of the data series, the Jarque–Bera test suggests otherwise as all the variables showed significant values in the test results; therefore, the study rejects the normality assumption of the data series.

5.2. Cross-Sectional Dependence Tests

Cross-sectional dependence is a serious issue in panel data analysis and ignoring it could result in bias and inconsistent findings because it offers accurate information regarding the right method required for the panel analysis. In view of this, the Pesaran (2021); Pesaran et al. (2008) and Breusch and Pagan (1980) cross-sectional dependence tests were carried out. The null hypothesis of this test suggests that there is evidence of cross-sectional independence. To either reject or accept the null hypothesis, Table 3 presents the outcome of the cross-sectional dependence tests conducted, and according to the table, none of the variables depicted cross-sectional independence, leading to the rejection of the null hypothesis. Therefore, the study confirms that there is evidence of cross-sectional dependence, which signals that the panels' slopes are heterogeneous and have cross-sectional reliance among the residuals.

Table 3. Cross-sectional dependence tests.

All samples	Breusch–Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
CO_2	33539.81***	164.119***	155.1815***	6.697***
SMP	36508.49***	184.952***	176.014***	160.261***
IQ	30231.32***	140.901***	131.964***	3.450***
HDI	75982.97***	461.968***	453.03***	265.121***
Developed economies				
CO_2	2564.57***	59.815***	57.690***	42.292***
SMP	2810.994***	67.171***	65.046***	49.452***
IQ	1732.271***	34.967***	32.842***	-0.668
HDI	4084.875***	105.202***	103.077***	63.551***
Transition and developing economies				
CO_2	17223.800***	104.497***	97.684***	35.347***
IQ	17304.99***	105.245***	98.433***	6.176***
SMP	19936.370***	129.498***	122.685***	114.197***
HDI	44539.540***	356.2578***	349.445***	200.641***

Note: HDI = Human development index, SMP = Social media usage, IQ = Institutional quality, CO_2 = Carbon emissions, CD = Cross-sectional dependence, LM = Lagrange multiplier.
*** denotes a 1% significance level.

5.3. Unit Root and Homogeneity Tests

Table 4 presents the unit root and homogeneity test results at levels and first difference. All the variables in the whole sample showed stationarity, confirming that there is no evidence of unit root among the selected variables, particularly at a 1% significance level at both levels and first difference, which implies that in the presence of cross-sectional heterogeneity, correlations of all series are stationary and subsequently are the same order of integration I(0) and I(1). Relative to the cross-sectional dependence tests, the study used second generation unit root tests (CIPS and CADF proposed by Pesaran (2007)) as there is evidence of cross-sectional dependence among the variables.

Table 4. Unit root and homogeneity tests.

Unit root test	CIPS Levels	CIPS 1st Diff.	CADF Levels	CADF 1st Diff.	Homogeneity test ($\tilde{\Delta}$ Adj. test)
All sample					-3.136**
HDI	-6.190***	-6.190***	-6.190***	-6.190***	-
SMP	-6.190***	-6.190***	-6.190***	-6.190***	-
IQ	-6.190***	-6.190***	-6.190***	-6.190***	-
CO_2	-6.190***	-6.190***	-6.190***	-6.190***	-
Advanced economies					-3.144**
HDI	-5.824***	-6.190***	-4.964***	-6.189***	-
SMP	-5.297***	-6.155***	-4.304***	-5.644***	-
IQ	-5.188***	-6.190***	-3.620***	-5.978***	-
CO_2	-5.724***	-6.190***	-4.267***	-5.879***	-
Transition and developing economies					-3.160**
HDI	-6.190***	-6.190***	-6.185***	-6.190***	-
SMP	-6.190***	-6.190***	-6.161***	-6.190***	-
IQ	-6.190***	-6.190***	-6.190***	-6.190***	-
CO_2	-6.190***	-6.190***	-6.190***	-6.190***	-

Note: HDI = Human development index, SMP = Social media usage, IQ = Institutional quality, CO_2 = Carbon emissions, CIPS = Cross-sectional Im, Pesaran and Shin test, CADF = Cross-sectional augmented Dickey–Fuller test.
*** denotes a 1% significance level, ** denotes a 5% significance level.

The test for homogeneity, in which the null hypothesis assumes that the slopes are homogeneous, was rejected because the coefficient values of the cross-sectional slope exhibited p-values that are significant. This implies that there is evidence of slope heterogeneity among the variables with the proposed model. The Pesaran et al. (2008) homogeneity test was performed to that effect.

5.4. Multicollinearity Test and Correlation Matrix

Table 5 portrays the multicollinearity tests which used the variance inflation factor and correlation matrix. Conversely, correlation matrix depicts the extent of association between two variables, confirming it to be either strong or weak. Multicollinearity issues could affect the outcome of the regression analysis, causing bias and inconsistency. In view of these, the correlation matrix and variance inflation factor were computed to determine the status of the variables. No evidence of multicollinearity was found because the variable with the highest correlation coefficient was IQ with a value of 0.720, followed by CO_2 with a value of 0.594. No two variables had correlation coefficients greater than 0.70. On the other hand, the variance inflation factor values were less than 5 and their tolerance levels were greater than 0.2.

Table 5. Multicollinearity test and correlation matrix.

Variable	HDI	SMP	IQ	CO_2	VIF	Tolerance
HDI	1	-	-	-	-	-
SMP	0.331***	1	-	-	1.030	0.971
IQ	0.720***	0.204***	1	-	1.100	0.911
CO_2	0.594***	0.212***	0.435***	1	1.110	0.900

Note: HDI = Human development index, SMP = Social media usage, IQ = Institutional quality, CO_2 = Carbon emissions, VIF = Variance inflation factor
*** denotes a 1% significance level.

5.5. Cointegration Tests

According to Table 6, all indications suggest a cointegration relationship among the variables relative to all the sample groups. To be specific, the test performed with the Pedroni (2004) method confirmed that three out of seven of the individual tests in both panel and group showed 1% significance in all the sample groups. Also, the Westerlund and Edgerton (2007) bootstrapping test confirmed 1% and 5% significance levels among the various sample groups, respectively. There is a cointegration relationship between human development and the other independent variables (social media usage, institutional quality, and carbon emissions) suggesting the existence of a long-run equilibrium relationship.

Table 6. Cointegration tests.

Pedroni cointegration	Panel	Panel	Panel	Panel	Group	Group	Group
Sample group	**v-stat.**	**rho-Stat.**	**PP-stat.**	**ADF-stat.**	**rho-Stat.**	**PP-stat.**	**ADF-Stat.**
All sample	-0.592	2.698	-6.102***	-5.374***	5.543	-10.021***	-5.954***
Advanced economies	-2.544	6.981	-3.757***	-3.383***	11.208	-12.059***	-8.106***
Transition and developing economies	-2.544	6.981	-3.757***	-3.383***	11.208	-12.059***	-8.106***
Westerlund–Edgerton bootstrapping cointegration							
Sample group	Gt	Ga	Pt	Pa	-	-	-
All sample	-11.534***	-128.710***	-34.501***	-128.268***	-	-	-
Advanced economies	-3.801**	-19.235***	-11.426**	-19.266***	-	-	-
Transition and developing economies	-10.576***	-98.070***	-31.521***	-97.458***	-	-	-

Note: *** denotes a 1% significance level, ** denotes a 5% significance level. ADF = Augmented Dickey–Fuller.

5.6. Regression Analysis and Robust Estimations

The long-run parameter estimations were executed with the aid of augmented mean group (AMG) and common correlated effects mean group (CCEMG) estimators. The outcomes of the estimations are displayed in Table 7. It was observed that the models were fit enough to predict the long-run coefficients of the variables under study relative to the root mean square error, which showed values less than 0.08 in all the models (Hair, Hult, Ringle, Sarstedt, & Thiele, 2017). Moreover, the Wald chi-square values reported p-values less than 0.05 at the 1% significance level.

Table 7. Main regression analysis.

Method	AMG	AMG	AMG	CCEMG	CCEMG	CCEMG
Variable	**AS**	**AE**	**TDE**	**AS**	**AE**	**TDE**
SMP	0.0001* (0.19)	0.002** (2.51)	0.0002* (0.49)	0.0006* (0.89)	0.002** (1.31)	0.0002* (0.26)
IQ	0.018*** (74.37)	0.016*** (13.20)	0.016*** (81.61)	0.015*** (8.25)	0.008* (1.85)	0.015*** (9.19)
CO_2	0.0001*** (4.46)	0.0003*** (3.81)	0.0001** (2.31)	0.0006** (2.10)	0.0002* (0.65)	0.0006* (1.90)
HDI_avg	-	-	-	1.002*** (162.53)	0.997*** (47.04)	1.002*** (167.46)
SMP_avg	-	-	-	-0.0007 (-0.86)	-0.0004 (-0.26)	-0.0005 (-0.54)
IQ_avg	-	-	-	-0.015*** (-7.92)	-0.008 (-1.36)	-0.015*** (-8.43)
CO_2_avg	-	-	-	-0.0006 (-2.13)**	0.0002 (0.58)	-0.0006** (-1.94)
C_D_P	1.000*** (166.77)	1.003*** (54.22)	1.000*** (174.74)	-	-	-
Constant	0.765*** (170.88)	0.869*** (259.11)	0.755*** (171.36)	-0.0008 (-0.09)	0.0003 (0.01)	-0.0005 (-0.06)
Wald chi-square	7946.16***	728.16***	7233.30***	82.36***	3.65(0.301)	106.36***
RMSE	0.0055	0.0038	0.0057	0.0054	0.0036	0.0056
Observation	1287	306	981	1287	306	981

Note: *** denotes a 1% significance level, ** denotes a 5% significance level, * denotes a 10% significance level. HDI = Human development, SMP = Social media usage, IQ = Institutional quality, CO_2 = Carbon emissions, C_D_P = Common dynamic process, RMSE = Root mean square error.

It was observed that all the variables showed a positive and statistically significant association with human development but with different magnitudes of coefficients. Specifically, social media usage (SMP) depicted a coefficient magnitude of 0.0001 with human development regarding the all-sample group with the augmented mean group estimator. This implies that a percentage point increase in social media usage has the propensity to improve human development by 0.0001% at a 10% significance level. However, the common correlated effects mean group estimators reported a different coefficient magnitude of 0.0006, which implies that a percentage point increase in social media usage could likely lead to an improvement in human development by 0.0006% at a 10% significance level. On the other hand, it was observed that improving institutional quality (IQ) positively leads to human development such that a percentage point improvement in institutional quality has a propensity to improve human development by 0.018% and 0.015% as reported by the AMG and CCEMG estimators, respectively. Furthermore, the study observed a positive and statistically significant relationship between carbon emissions (CO_2) and human development, suggesting that any improvement in human development proportionally leads to carbon emissions. Specifically, a percentage point increase in carbon emissions corresponds to improvements of 0.0003% and 0.0002% in human development (see Figure 3 for pictorial evidence).

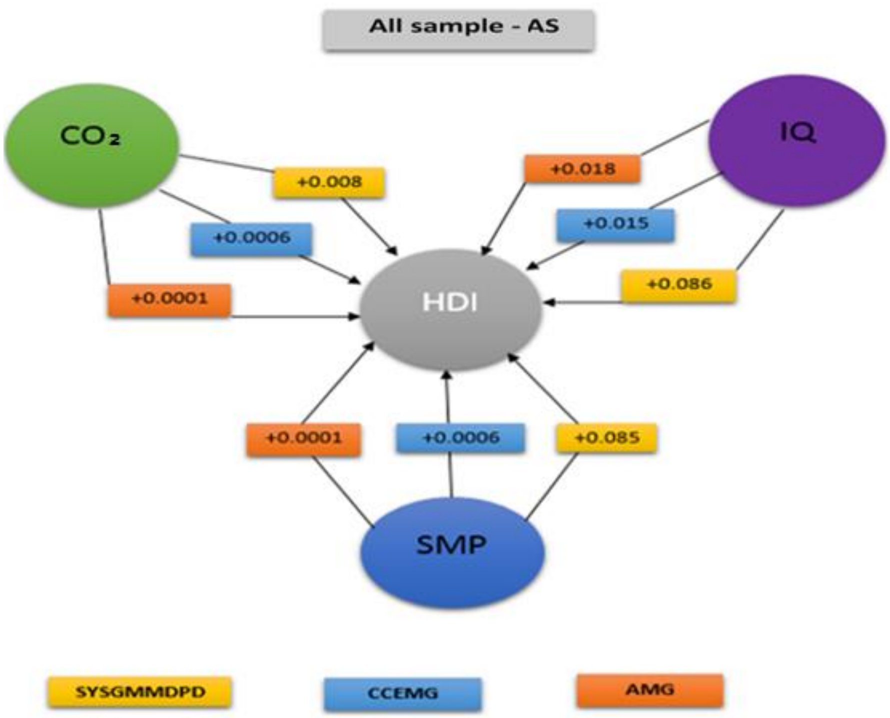

Figure 3. Pictorial display of findings for the whole sample.

To allow for cross-sectional heterogeneity, we consider the advanced and transition and developing economies. With respect to the advanced economies, it was observed that both AMG and CCEMG produced coefficients that are symmetric for the social media usage and human development nexus, i.e., a magnitude of 0.002 at the 5% significance level. Conversely, a percentage point increase in social media usage corresponds to an improvement in human development by 0.002%. With regard to institutional quality (IQ), the outcome suggests that in advanced economies, a percentage point increase could lead to an improvement in human development by 0.016% and 0.08% at 1% and 10% significance levels relative to AMG and CCEMG, respectively. Similarly, it was observed that carbon emissions (CO_2) proportionally lead to human development, suggesting that a percentage point increase in carbon emissions corresponds to an improvement in human development by 0.0003% and 0.0002% at the 1% and 10% significance levels, respectively. Figure 4 illustrates the pictorial evidence displayed in Table 7.

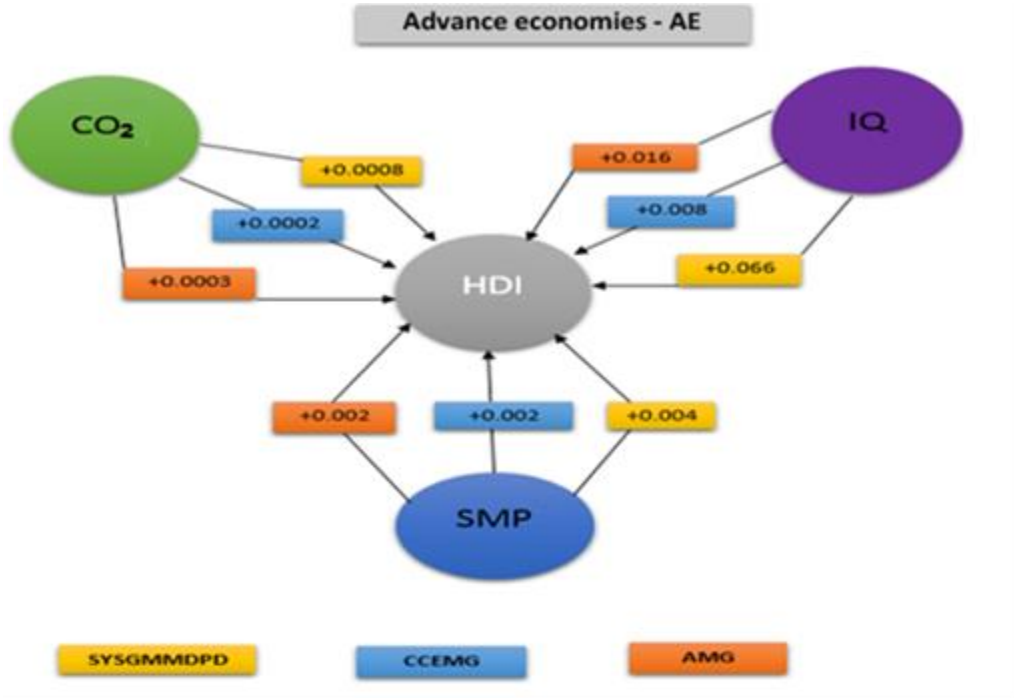

Figure 4. Pictorial display of findings for advanced economies.

Relative to transition and developing economies, the study observed positive and statistically significant relationships between the independent variables and human development symmetrical to the findings observed from all sample and advanced economies groups. Specifically, social media (SMP) reported coefficient magnitudes of 0.0002 relative to AMG and CCEMG estimations whereas institutional quality and CO2 reported coefficient magnitudes of 0.016, 0.015, 0.0001 and 0.0006, correspondingly. The results signal that a percentage point improvement in institutional quality could likely lead to an improvement in human development by 0.016% and 0.015% at 1% significance levels, respectively. Also, an increase in carbon emission corresponds to an improvement in human development by 0.0001% and 0.0006% at 5% and 10% significance levels, respectively. Figure 5 illustrates the pictorial evidence.

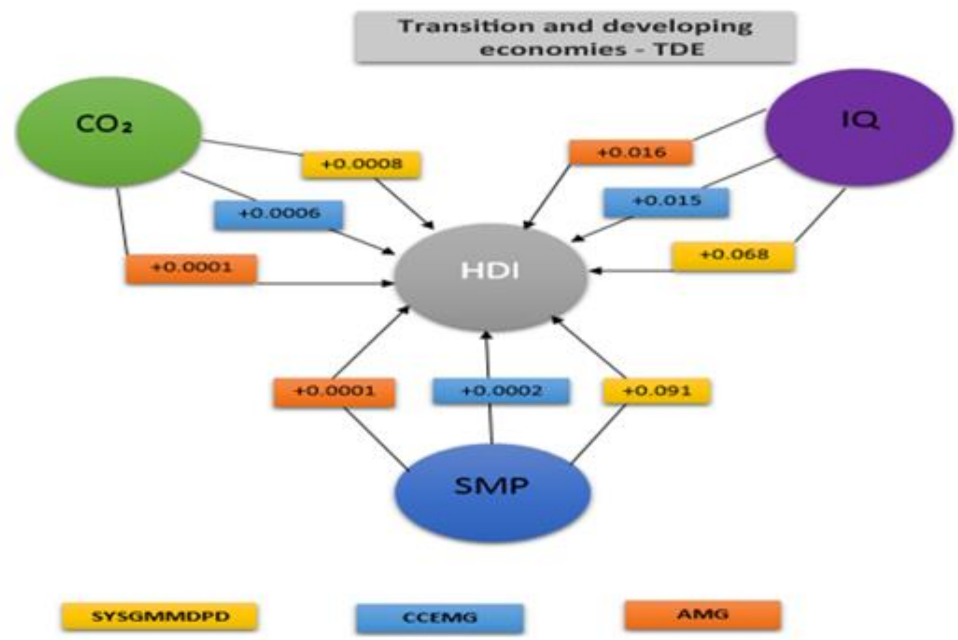

Figure 5. Pictorial display of findings for the transition and developing economies.

To ensure robust results from the AMG and CCEMG, the system GMM dynamic panel data estimator was utilized. The outcomes of the robustness check are presented in Table 8. The system GMM dynamic panel data estimator shed more light on the findings observed in Table 7 and highlights the relevance of the main findings by confirming similar results. Conversely, the robustness check confirms a positive relationship between social media usage, institutional quality, carbon emissions and human development, as reported by the AMG and CCEMG estimations.

It was observed that social media usage in transition and developing economies has a greater magnitude of coefficient than advanced economies, and likewise for institutional quality, but regarding carbon emissions, the coefficients are symmetric.

Table 8. Robustness check.

Method	SYSGMMDPD	SYSGMMDPD	SYSGMMDPD
Variable	**AS**	**AE**	**TDE**
HDI_L1	0.036 (0.231)	0.170*** (10.18)	-0.002 (-0.02)
SMP	0.085*** (13.88)	0.004** (1.35)	0.091*** (11.77)
IQ	0.086*** (41.16)	0.066*** (93.84)	0.068*** (40.07)
CO_2	0.008*** (46.72)	0.0008*** (11.99)	0.008*** (21.08)
Constant	0.504*** (17.44)	0.656*** (52.14)	0.503*** (10.42)
Wald chi-square	41448.87***	63611.94***	17793.58***
Sargan test (Prob.)	8.928(1.000)	8.929(1.000)	8.852(1.000)
Observations	1,278	297	972

Note: *** denotes a 1% significance level, ** denotes a 5% significance level. HDI = Human development index, SMP = Social media usage, IQ = Institutional quality, CO_2 = Carbon emissions. SYSGMMDPD = System generalized method of moments dynamic panel data estimator.

The lagged human development with a coefficient magnitude of 0.170 at the 1% significance level implies that the eccentricity among the variables is corrected by 17% in the long-run equilibrium in advanced economies. On the other hand, the lagged human development for transition and developing economies and the whole group sample reported insignificant coefficients. The Sargan test reported a p-value greater than 0.05, which implies that the specification for the dynamic panel is reasonable for the human development model based on the GMM estimation method. It also confirms the validity of the instruments, that no overidentification restrictions in the model were detected, and rejects evidence of autocorrelation.

Further, a sensitivity analysis was performed to determine the effect of social media on the disaggregate indicators of human development, that is, the education index, the life expectancy index and gross national income per capita. Also, we incorporate the interaction term variables between social media, institutional quality, and carbon emissions; the findings are presented in Table 9. From the findings, we observed that across all the methods, social media consistently showed a positive and substantial influence on human development as well as institutional quality and carbon emissions. With regard to the interaction between social media, institutional quality, and carbon emissions, we observed that the interaction between social media and institutional quality positively affect human development, while the interaction between social media and carbon emissions is retrogressive relative to human development. Moreover, the results relative to the overall human development index are similar to the education index, life expectancy index and gross national income per capita as the disaggregate human development indexes regardless of the method (see Table 9 and Figure 6 for details).

Table 9. Decomposition of human development index.

Method	AMG				CCEMG				SYSGMMDPD			
Variable	**HDI**	**GNI**	**LEI**	**EDI**	**HDI**	**GNI**	**LEI**	**EDI**	**HDI**	**GNI**	**LEI**	**EDI**
L.1	-	-	-	-	-	-	-	-	0.013 (0.12)	-0.048 (-0.49)	-0.026 (-0.16)	0.049 (0.57)
SMP	0.0003* (0.49)	0.010* (1.27)	0.002** (1.98)	0.001** (0.52)	0.001** (1.79)	0.009* (1.21)	0.005** (2.78)	0.002* (0.83)	0.108*** (10.95)	0.599** (3.27)	0.077*** (5.58)	0.143*** (11.98)
IQ	0.017*** (17.46)	0.204*** (16.81)	0.0004* (0.33)	0.014*** (12.57)	0.014*** (5.83)	0.193*** (4.35)	0.0003* (0.13)	0.018** (2.79)	0.059*** (15.75)	0.172* (0.57)	0.051*** (19.59)	0.072*** (8.77)
CO_2	0.0002* (0.70)	0.002** (0.51)	0.0007** (2.45)	0.001 (1.50)	0.0009*** (4.20)	0.004* (0.91)	0.0006* (0.98)	0.002** (2.15)	0.019*** (6.80)	0.184*** (7.17)	0.017*** (3.34)	0.018*** (3.58)
SMP*IQ	0.0008* (1.67)	0.002* (0.33)	0.001** (3.11)	0.015** (2.47)	0.001* (1.05)	0.008* (0.47)	0.002 (1.10)	0.0006* (0.35)	0.017*** (4.48)	0.439** (3.17)	0.011** (2.52)	0.015** (3.15)
SMP*CO_2	-0.0002* (-0.22)	0.003* (1.70)	-0.001* (0.12)	-0.0004 (-0.99)	-0.004* (-0.27)	0.004** (1.91)	-0.0003* (-0.94)	-0.0003 (-0.72)	-0.007*** (-5.00)	-0.056*** (-4.31)	-0.007** (-2.97)	-0.007** (-2.81)
HDI/GNI/EDI/LEI_avg		-	-	-	1.001*** (145.76)	1.000*** (201.50)	1.000*** (32.37)	1.003*** (120.17)	-	-	-	-
SMP_avg	-	-	-	-	-0.001** (-2.02)	0.003 (0.24)	-0.004 (-1.29)	-0.003 (-1.40)	-	-	-	-
IQ_avg	-	-	-	-	-0.014*** (-8.26)	-0.178*** (-4.59)	-0.0007 (-0.03)	-0.017** (-3.11)	-	-	-	-
CO_2_avg	-	-	-	-	-0.0008** (-1.95)	0.001 (0.32)	-0.0004 (-0.05)	-0.003** (-2.50)	-	-	-	-
SMP*IQ_avg	-	-	-	-	-0.007 (-0.84)	-0.013 (-1.09)	-0.001 (-0.84)	0.0004 (0.23)	-	-	-	-
SMP*CO_2_avg	-	-	-	-	0.0002 (0.13)	-0.003 (-1.15)	-0.0001 (-0.03)	0.0005 (1.08)	-	-	-	-
C_D_P	0.999*** (157.19)	0.999*** (267.91)	0.995*** (35.44)	1.000*** (122.55)	-	-	-	-	-	-	-	-
Constant	0.765*** (179.75)	8.417*** (806.24)	0.880*** (628.95)	0.723*** (92.16)	-0.0005 (-0.06)	0.017 (0.42)	-0.001 (-0.04)	-0.0002 (-0.02)	0.485*** (5.61)	7.589*** (7.30)	0.673*** (4.21)	0.361*** (5.00)
Wald chi-square	115991.16***	2789.45***	3207.25***	2365.40***	206.38***	83.19***	29.43***	38.02***	5243.38***	73969.14***	8231.17***	18172.31***
RMSE	0.0054	0.050	0.007	0.013	0.0053	0.048	0.007	0.012	-	-	-	-
Sargan (Prob.)	-	-	-	-	-	-	-	-	8.823(1.000)	8.250(1.000)	8.764(1.000)	8.911(1.000)
Observations	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287	1,287

Note: *** denotes a 1% significance level, ** denotes a 5% significance level, * denotes a 10% significance level. HDI = Human development index, SMP = Social media usage, IQ = Institutional quality, CO_2 = Carbon emissions.

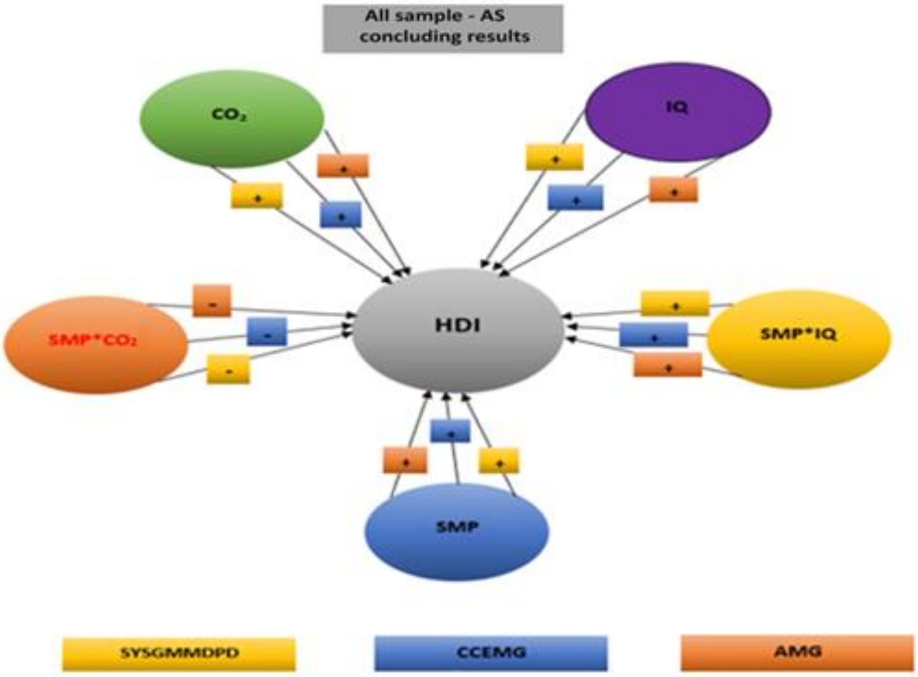

Figure 6. Pictorial display of findings (concluding results) for the whole sample.

6. DISCUSSION

Social media has grown in importance as a means of social connection, and it now provides the opportunity to learn about sustainability issues outside formal education, and people can learn about planetary pressures through a variety of other channels, such as social interaction, including social media (Conceição, 2020). With regard to the imbalances of planetary pressures, information dissemination becomes paramount for human development sustainability. However, social media usage enables people to educate themselves about the planetary pressures that put huge toll on human development and sustainable development (Bruns et al., 2016). Therefore, social media plays a positive role in ensuring human development by complementing education and providing useful information for health, education, and employment. The study's findings confirmed that social media and human development are proportionally and significantly related and are consistent with the findings of Baumann (2021). On the other hand, Vitenu-Sackey (2020) stressed the importance of social media in economic growth as their study concluded that YouTube and Twitter positively and substantially contribute to economic growth. Even though economic growth cannot solely account for the high standard of living, it can explain some level of development in an economy (Ouedraogo, 2013).

The evidence of positive influence of institutional quality on human development observed from the study's findings suggest that stronger institutions can contribute to better resource and human development in advanced, transition and developing economies (see Figures 2–4). Furthermore, a strong rule of law, low levels of corruption, political stability, effective bureaucratic practices, property rights protection, and an appealing investment profile can all encourage all stakeholders to create an environment that can turn natural resources and human capital into benefits (Hussain et al., 2021; Jackson, 2005). Azam et al. (2021) reiterated that to improve environmental quality and human development, legislative measures have a substantial role to play, and this can be accomplished by adjusting policies with an emphasis on institutional quality. In addition, institutional performance varies in transition and developing economies in that the level of institutional quality can be evaluated through their political stability, control of corruption, rule of law, voice and accountability, regulatory quality, and governance effectiveness (Kharazishvili, Kwilinski, Dzwigol, & Grishnova, 2020).

To elaborate on the positive impact of carbon emissions on human development, as depicted by the study's findings in both advanced and transition and developing economy sample groups, Bedir and Yilmaz (2016) contend that human activities as a result of an increase in income and consumption proportionally lead to carbon emissions. Further, they argue that conservational policies can affect human development or the standard of living through economic growth from industrial use of fossil fuels (coal, gas, and oil). In contrast, Li and Chen (2021) and Jackson (2005) opined that human beings can abate consumption significantly without hampering their standard of living or wellbeing by implementing conservation policies advocating the consumption of renewable energy. Moreover, in addition to technological changes, changes in lifestyle and consumption patterns also aid in the abatement of carbon emissions (Brand-Correa & Steinberger, 2017; Chaaban et al., 2016). These arguments are consistent with the study's findings and confirm the positive relationship between carbon emissions and human development.

7. CONCLUSION AND POLICY IMPLICATIONS

The purpose of this study is to reveal the long-run heterogeneous relationship between social media usage, institutional quality, carbon emissions and human development based on Vygotsky's sociocultural perspective and Bronfenbrenner's ecological systems theory, which contend that there is a physical environmental influence of human development relative to the ecological systems in existence. With regard to methodology, the study employs second generation techniques to ensure that cross-sectional dependence and the heterogeneous nature of the panels are accounted for; therefore, augmented mean group (AMG) and common correlated effects mean group (CCEMG) estimators were employed. To ensure the robustness of the findings, the system GMM dynamic panel data estimator was utilized to resolve the issue of endogeneity and serial correlation that the estimated model may suffer in the regression analysis. This study used data from 143 countries from 2009 to 2017 for its panel analysis. The sample was categorized into 34 advanced economies and 109 transition and developing economies. The dependent variable in the study is human development, measured by the human development index, and the independent variable is social media usage, measured by social media penetration rate of four major social media platforms which have about a 90% penetration rate over other platforms.

To deduce robust conclusions from the findings produced by the AMG and CCEMG, the system GMM dynamic panel data estimator was utilized. This system analyzes the findings observed and highlights the relevance of the main findings by producing similar results. Conversely, the robustness check confirms that there is a positive relationship between social media usage, institutional quality, carbon emissions and human development, as reported by the AMG and CCEMG estimations. It was observed that social media usage in transition and developing economies has a greater coefficient magnitude than advanced economies, and likewise for institutional quality, but regarding carbon emissions, the coefficients are symmetric.

The positive impact of social media on human development implies that social media serves as a tool in promoting human development activities such as health improvement, education empowerment through information dissemination and knowledge sharing, and employment through revenue generation from knowledge and content sharing as well as advertisements. However, improvement in regulatory quality could ensure proper use of social media to avoid polarization. Also, government policies and plans could easily be transmitted and disseminated through social media to most of their citizens transparently and equitably, which would ensure governance effectiveness and socioeconomic development. Moreover, citizens can easily and rapidly share their opinions using social media for better accountability. Above all, social media usage could enable people to learn and educate themselves about the planetary pressures which put a huge toll on their livelihoods hampering their development. Despite this, the increasing adoption of social media escalates energy consumption, for which most sources are non-renewable, and tends to cause a surge in carbon emissions. The increase in carbon emissions alters the average global temperature which also causes global warming to adversely affect human lives through heavy rainfalls, storms, hurricanes, etc. Notably, conservation policies should be adopted to aid the mitigation of carbon emissions that largely contribute to greenhouse gas emissions which contribute to natural disasters through climate change that impede human development by displacing people from their properties, education, and sources of livelihood.

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Appendix 1. List of sample countries.

Advanced economies		**Transition and developing economies**		**Transition and developing economies**	**Transition and developing economies**
Austria	Slovenia	Algeria	Comoros	Lao	Paraguay
Canada	Spain	Argentina	The Republic of the Congo	Latvia	Peru
Croatia	Sweden	Armenia	Costa Rica	Lebanon	Philippines
Cyprus	Switzerland	Azerbaijan	Cote d'Ivoire	Lesotho	Qatar
Czech Republic	United Kingdom	Bahamas	Cuba	Macao	Russian federation
Denmark	United States	Bahrain	Dominican Republic	Macedonia, North	Rwanda
Estonia	Belgium	Bangladesh	Ecuador	Madagascar	Saudi Arabia
Finland	Malta	Barbados	Egypt	Malawi	Senegal
France	-	Belarus	El Salvador	Malaysia	Serbia
Germany	-	Belize	Estonia	Mali	Singapore
Greece	-	Benin	Georgia	Mauritania	South Africa
Hungary	-	Bhutan	Ghana	Mauritius	Sri Lanka
Iceland	-	Bosnia And Herzegovina	Guatemala	Mexico	Sudan
Ireland	-	Botswana	Guinea	Republic of Moldova	Swaziland
Italy	-	Brazil	Honduras	Mongolia	Tajikistan
Japan	-	Brunei Darussalam	Hong Kong	Morocco	Tanzania
Latvia	-	Bulgaria	India	Mozambique	Thailand
Lithuania	-	Burkina Faso	Indonesia	Namibia	Togo
Luxembourg	-	Burundi	Islamic Republic of Iran	Nepal	Tunisia
Netherlands	-	Cambodia	Israel	Nicaragua	Turkey
New Zealand	-	Cape Verde	Jamaica	Niger	Uganda
Norway	-	Central African Republic	Jordan	Nigeria	Ukraine
Poland	-	Chad	Kazakhstan	Oman	United Arab Emirates
Portugal	-	Chile	Kenya	Pakistan	Uruguay
Romania	-	China	Democratic People's Republic of Korea	Panama	Uzbekistan
Slovakia	-	Colombia	Kyrgyzstan	Viet Nam	Venezuela
-	-	Bolivia	Cameroon	The Democratic Republic of the Congo	Zambia