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ORIGINAL CONTRIBUTION

Human Capital Formation, Foreign Direct Investment Inflows, and Economic Growth: A Way Forward to Achieve Sustainable Development

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Abstract— This research adds to the human capital and growth debate by examining the moderating role of net foreign direct investment inflows on the impact of human capital formation on growth in Pakistan while controlling renewable energy, carbon emission, and urbanization from 1990 to 2019. Furthermore, the study aims to explore the long-run and short-run interplay between human capital, physical capital, renewable energy, carbon emission, urbanization, and economic growth. The study also provides policy implications for achieving sustainable development goals. The autoregressive distributed lag framework has been used in an attempt to achieve the desired objectives. In order to assess the short-term impacts on the underlying variables, the error correction model is computed. The long-run estimations are obtained by applying the autoregressive distributed lag methodology. The findings show that foreign direct invesment, renewable energy, physical capital, and human capital formation all have positive effects on Pakistan's economic growth over the long and short terms. Foreign direct invesment greatly increases human capital, and this promotes economic growth. At the same time, urbanization and carbon emissions have negative effects on growth over the long and short terms. The study offers policy recommendations for the stakeholders based on the empirical findings, which will support sustainable development and equitable growth. To achieve sustainable development goal 4, which aims to protect inclusive and equitable quality education and promote lifetime learning opportunities as essential for human capital development, Pakistan should prioritize investing in the development of human capital through health and education. Prioritise policies that encourage the use of renewable energy sources to lower CO_2 emissions to achieve environmental sustainability and inclusive growth. The government should also put policies in place that encourage foreign direct invesment inflows. SDGs 8 and 9—decent work, economic growth, support industry, innovation, and infrastructure—can be accomplished with the aid of attracting foreign direct investment and enhancing human capital.

Index Terms— Economic growth, Human capital, Foreign direct investment, Sustainable Development Goals (SDGs), Urbanization, Renewable energy, Carbon emission

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Introduction

Economic growth is an indication that a country or region's economy is growing smoothly when it can generate more money or beneficial effects for society within a specific time frame (Mukti, Setyowati, & Faridatussalam, 2024). Almost every nation aspires to reach the maximum rate of growth. However, it is not an easy task. Rather, it is a long-lasting and sustainable process, which generally takes many decades to achieve the objective of higher growth (Sadiq et al., 2023). Growth is influenced by several economic indicators (Zhou, Zhu, & Luo, 2022). Enormous theoretical and empirical frameworks to explain the economic growth process have emerged in the literature. Solow (1956) provides a benchmark to account for economic growth. According to Solow (1956), Foreign Direct Investment (FDI) only has a short-term growth effect even when physical capital increases. The reason for this is that returns on new capital will decline as overall capital accumulation rises. Nonetheless, endogenous growth theory contends that Foreign Direct Investment (FDI) boosts Human Capital (HC) via increased education and knowledge transfer, in addition to its provision of physical capital (Lucas, 1988). Labor and capital, along with knowledge, drive innovation and accelerate economic expansion (Lucas, 1988; Uzawa, 1965).

An economy's production function is reflected in its human capital, which includes knowledge, skills, abilities, ideas, and health. More productivity, adaptability, and inventiveness for long-term economic growth can, therefore, result from enhancing people's knowledge, skills, capacities, health, and resilience (WorldBank, 2018). HC and FDI inflows can be vital to long-term economic progress by advancing capital, generating foreign exchange, importing technology, and increasing overall productivity (Anetor, 2019; Rashid, Jehan, & Kanval, 2023; Saha, 2023; Su & Liu, 2016). Over the past three decades, the international economy has become more globalized. FDI has increased more quickly than a lot of other economic activity. New avenues for developing nations to engage in global production have been made possible by the rapid rise of FDI (Ramzan, Sheng, Fatima, & Jiao, 2019). It plays a significant role in growth, from early stages to industrialization, modernization, and knowledge-based economies (Raihan, 2023). Possible advantages of FDI for host nations are HC formation and higher wages (Maher, 2001). FDI inflows increase the capital stock of host countries. An essential component of growth and development is capital (Jan Mišun, 2002). Hence, capital accumulation is extremely low in developing countries (Sucubasi, Trenovski, Imeri, & Merdzan, 2021). Which causes multiple problems by hindering the growth process and human capital formation, mounting poverty, and exacerbating social and economic injustice (Wang, Xu, Deng, & Shi, 2024).

The pursuit of sustainable economic development is aided by the dynamism and interaction of factors other than FDI and HC, as suggested by an endogenous model for economic growth (Wu, Abban, Boadi, & Charles, 2022). Ali, Radulescu, and Balsalobre-Lorente (2023) found a connection between economic expansion and renewable energy. The link between FDI, HC, and sustainable economic growth may be influenced theoretically by renewable energy, while other research indicates that renewable energy directly affects economic growth (Abban & Hongxing, 2021).

Carbon emissions are closely linked to renewable energy in terms of managing sustainable growth (Hongxing, Abban, Boadi, & Ankomah-Asare, 2021). The bulk of the literature demonstrated the link between carbon emissions and renewable energy and sustainable economic growth (Amin & Song, 2023; Chen, Wang, & Zhong, 2019; Radmehr, Henneberry, & Shayanmehr, 2021; Zhang et al., 2023). Wu et al. (2022) stated consuming renewable energy lowers CO_2 emissions and boosts economic expansion considerably. Therefore, there should be a rise in the use of renewable energy in order to lessen the detrimental effects of CO2 emissions on sustainable economic growth. Studies on sustainable economic growth have been particularly concerned with urbanization in recent years since it affects energy consumption and CO_2 emissions from the rise of large cities (Wu et al., 2021).

Liu et al. (2023) expatiated upon the dynamic relationships between urbanization, consumption of renewable energy, CO_2 emissions, and economic growth. Furthermore, Acheampong, Dzator, and Savage (2021) explored the connection between renewable energy, CO_2 emissions, and growth in Sub-Saharan Africa by accounting for the moderating role of institutional quality. Although there is theoretical support for the dynamic association between FDI, HC, urbanization, renewable energy, and CO_2 as important factors in sustainable growth, empirical support for this relationship has been inconsistent. However, certain researchers, such as Wiredu, Nketiah, and Adjei (2020), Chang and Mendy (2012), and Onuoha, Okonkwo, Okoro, and Okere (2018), discovered that there is a positive association between these variables. On the other hand, (Chi, Ho, & Lin, 2022; Jam, Singh, Ng, & Aziz, 2018; Shittu, Yusuf, El Moctar El Houssein, & Hassan, 2020; Velonjara & Gondje-Dacka, 2019) revealed an inverse negative effect on economic growth. The contradictory findings highlight the need for further data and research into the connection between FDI and economic expansion. Similar findings are observed in HC and growth, where there are conflicting studies indicating a positive, negative, or neutral association (Dauda, 2010; Schultz, 1992). These contradictory findings can be the consequence of research concentrating on the direct impact of FDI or HC on economic development in a particular study. This problem may be solved by combining FDI, HC, and other factors to examine how they relate to economic growth. Furthermore, the bulk of the literature provides a link between human, capital, FDI, and other factors on growth (Anetor, 2020; Degbedji, Akpa, Chabossou, & Osabohien, 2024; Labidi, Ochi, & Saidi, 2024; Rahman, Zhang, & Musa, 2023; Raihan, 2024; Ramzan et al., 2019; Siddique, Ansar, Naeem, & Yaqoob, 2017). Hence, the study aims to provide a distinctive contribution to existing knowledge by exploring the moderating effect of foreign direct investment inflows between human capital and economic growth in Pakistan while controlling for renewable energy consumption, urbanization, and CO_2 emissions. Additionally, the study provides a way forward to achieve sustainable

development.

Understanding the interplay between growth in the economy, foreign direct investment, and human capital formation can yield significant insights for policymakers. They may use it to create more successful FDI attraction plans, allocate funds for skill-building and education, and promote long-term economic growth.

Literature Review

Numerous studies have tried to figure out the relationships between physical capital, HC, FDI, urbanization, renewable energy, CO_2, and growth. This study examines the relationships between three literary streams. The first strand looks at how HC affects growth, while the second strand assesses earlier studies on how FDI affects growth. The last body of literature reviews empirical research on HC, FDI, urbanization, carbon emissions, and the growth and use of renewable energy sources.

Long-term economic growth/expansion is primarily driven by labor and physical capital accumulation, according to neoclassical growth theory (Marimuthu, Arokiasamy, & Ismail, 2009; Solow, 1956). R. Barro (1999) is among the first academics to argue that there is a substantial correlation between real per capita growth and human capital. Studies measured HC using several proxies. Health, education, years spent in school, higher education, secondary education, and elementary education are some of these proxies, according to research by Levin and Raut (1997), there is a positive correlation between secondary school enrolment rates and growth. Knowledge acquisition is a component of human capital; it is distinct from other types of knowledge, such as creation. Because human capital is a personal asset and is thus subject to competition and vulnerability, it is a private good. Many academics have used health and education initiatives as a measure of human capital. Health and education have also been used to quantify human capital (Alam et al., 2022; R. J. Barro, 2003).

Additionally, Barro, Robert J and Sala-i-Martin, Xavier (1992) discover a substantial correlation between GDP per capita growth rates and the average number of years that males and females spend in secondary and higher education. In the long run, they claimed, production per capita might expand at a consistent positive pace. Hence, findings are observed on the relationship between HC and growth, where there are conflicting studies indicating a positive, negative, or neutral association (Dauda, 2010; Schultz, 1992). Ahmed and Le (2021) revealed that while investments in human capital have a negative impact on economic growth, the stock of human capital has a favorable impact. According to Marimuthu et al. (2009), insufficient human capital endowments can account for political unpredictability, a weak external environment, and Africa's tragic 20th-century progress. Murthy and Chien (1997) found a strong, positive correlation of HC with economic growth. Few studies (Fleisher, Li, & Zhao, 2010; Rizal & Nurruhwati, 2018; Tsen, 2006) observed a negative or negligible relationship between human capital and economic growth. Furthermore, Borojo and Yushi (2015) found that the impact of human capital on output is insignificant. In a similar vein, the results of Bezabih (2018) and Folloni and Vittadini (2010) show that there is no association at all between the two macroeconomic variables.

Even while FDI may have a favorable impact on economic growth, there has been conflicting empirical research on the subject. Raihan (2024) has explored the impact of FDI and carbon emissions on growth in Vietnam. According to some research, FDI foreign direct investment significantly and favorably affects economic growth (Agrawal, 2015; Gui-Diby, 2014; Iamsiraroj, 2016; Iamsiraroj & Ulubaşoğlu, 2015; Suendarti, 2023). Others (Adams & Opoku, 2015; Mahembe & Odhiambo, 2016; Mohamed, Singh, & Liew, 2013) claimed that there was either no association at all or a negative one between FDI and economic growth.

Similarly, the short- and long-term relationships between HC, FDI, urbanization, renewable energy, CO_2, and growth have all been the subject of several research studies. The association between the development of human capital, financial innovation, and economic growth was noted by Abubakar, Kassim, and Yusoff (2015). They used FMOLS and DOLS in addition to panel cointegration. The findings showed that financial development, economic expansion, and the accumulation of human capital were positively correlated both in the short and long term. Gao, Jiang, Zhu, Aslam, and Wang (2024) examined the connections between environmental deterioration, industrial structure, financial development, economic growth, and the use of renewable energy by using Panel-Corrected Standard Errors (PCSEs) and Feasible Generalized Least Squares (FGLS).

Karimi Alavijeh, Ahmadi Shadmehri, Esmaeili, and Dehdar (2024) analyzed how the asymmetric effects of urbanization, economic growth, carbon emissions, and renewable energy affect human development in EU member states. Liu et al. (2023) examined the relationship between energy use, economic expansion, urbanization, and carbon emissions. Urbanization has no impact on environmental quality, while energy consumption has a detrimental effect. Using panel data from 1990 to 2013 using DOL and FMOLS estimators, Abdouli and Omri (2021) evaluated the effects of FDI inflows, human capital, and environmental quality on economic development. They discovered a long-term, statistically significant positive link between FDI, HC, and economic growth.

Hence, to conclude, the impact of human capital and underlying variables on economic growth may be examined from a variety of angles, as we found out while evaluating the literature. Different studies have been carried out on industrialized and developing nations. Analysis was also done on individuals and throughout the nation. We have found inconclusive results. Some studies have found positive effects of HC and FDI on growth, while other studies have found negative effects. So, it is worth analyzing the effects of underlying variables on economic growth over time for better policy implementations.

Methodology

Model specification

The neoclassical growth model provides the theoretical framework for investigating the key factors influencing economic growth (Cobb & Douglas, 1928; Solow, 1956). In this context, the primary drivers of production activities are seen to be labor and capital. Under the assumption that technology would remain constant, the Cobb-Douglas production function framework looks like this.

$$Y_{it} = K_{it}^{\alpha 1i} L_{it}^{\alpha 2i} e^{\mu it} \tag{1}$$

The output in the equation above is denoted by Y, while the subscripts i and t stand for country and time, respectively. K and L stand for capital and labor, respectively, while e is the error factor that captures unobserved variables. We have expanded this growth model by including other potential variables that might impact economic development. Thus, the following is our expanded growth model for empirical research:

$$\text{GDP}_t = \alpha_o + \alpha_1 \text{PC}_t + \alpha_2 \text{HC}_t + \alpha_3 \text{FDI}_t + \alpha_4 \text{RNE}_t + \alpha_5 \text{URB}_t + \alpha_6 \text{CO2}_t + \varepsilon_t \tag{2}$$

Where GDP = Gross Domestic Product
HC = Human Capital
PC = Physical Capital
FDI = Net Foreign Direct Investment Inflow
RNE = Renewable Energy Consumption
URB = Urbanization
CO2 = Carbon Emissions
ε_t = Error term

Hence, our baseline model shows that foreign direct investment, physical capital, human capital, and other factors are related to economic growth, which is consistent with the theoretical and empirical literature (including (Abban & Hongxing, 2021; Ang, 2010; Arndt, Jones, & Tarp, 2015; Mallik, 2008; Nosheen, Iqbal, & Khan, 2021; Sothan, 2018) . To demonstrate the moderating effect of foreign direct investment on human capital and growth, the model is specified below:

$$\text{GDP}_t = \beta_o + \beta_1 \text{PC}_t + \beta_2 \text{HC}_t + \beta_3 \text{FDI}_t + \beta_4 (HC * FDI)_t + \beta_5 \text{RNE}_t + \beta_6 \text{URB}_t + \beta_7 \text{CO2}_t + \varepsilon_t \tag{3}$$

Where HC*FDI = interaction term between human capital and foreign direct investment

Several empirical researches emphasized the necessity of using the interaction model (Brambor, Clark, & Golder, 2006; Ehigiamusoe, 2020). When the connection between two variables depends on the value of another variable.

Method of estimation

Our study uses M. H. Pesaran, Shin, and Smith (2001) Autoregressive Distributed Lag approach to examine the link between growth and the independent variables. The benefits of the ARDL bound testing method over alternative techniques serve as the rationale behind its selection. Firstly, the ARDL specification offers workable options for policy formulations by enabling the simultaneous estimation of both long-run and short-run coefficients (Sloboda, 2004). Secondly, in contrast to alternative cointegration testing techniques, the ARDL can handle a model where certain variables remain stationary at levels I(0) and some variables remain stationary after the first difference I (1). In other words, it allows a mixed order of co-integration (Hao, 2023; Yusoff & Nuh, 2015). Thirdly, the ARDL approach allows various lag lengths for different variables in a model. Fourthly, the processing and interpretation of the data throughout the analysis process is quite straightforward, making the ARDL co-integration approach more appropriate for sequencing data with small sample sizes. Fifthly, whether or not endogenous regressors are included, the ARDL approach yields objective estimates and reliable *t*-statistics. Lastly, because the ARDL bound test can account for endogeneity and autocorrelation, it usually yields unbiased parameters and a valid *t*-statistic. Following the **?**pesaran1998structural), the ARDL equation is given below:

$$\text{GDP}_\text{t} = \alpha_i + \sum_{i=1}^{n} \text{b}_\text{i} \Delta \text{GDP}_{\text{t}-\text{i}} + \sum_{i=1}^{n} \text{c}_\text{i} \Delta \text{PC}_{\text{t}-\text{i}} + \sum_{i=1}^{n} \text{d}_\text{i} \Delta \text{HC}_{\text{t}-\text{i}} + \sum_{i=1}^{n} \text{e}_\text{i} \Delta \text{FDI}_{\text{t}-\text{i}} + \sum_{i=1}^{n} \text{f}_\text{i} \Delta (HC * FDI)_{\text{t}-\text{i}} + \sum_{i=1}^{n} \text{g}_\text{i} \Delta \text{RNE}_{\text{t}-\text{i}} + \sum_{i=1}^{n} \text{h}_\text{i} \Delta \text{URB}_{\text{t}-\text{i}} +$$

$$\sum_{i=1}^{n} \text{i}_\text{i} \Delta \text{CO}_{2\text{t}-\text{i}} + \gamma_1 \text{GDP}_{\text{t}-1} + \gamma_2 \text{PC}_{\text{t}-1} + \gamma_3 \text{HC}_{\text{t}-1} + \gamma_4 \text{HC}_{\text{t}-1} + \gamma_5 (HC * FDI)_{\text{t}-1} + \gamma_6 \text{RNE}_{\text{t}-1} + \gamma_7 \text{URB}_{\text{t}-1} + \gamma_8 \text{CO}_{2\text{t}-1} + \varepsilon_\text{t} \tag{4}$$

The parameters α_i, $b_i, c_i, d_i e_i, f_i, g_i, h_i$ and i_i represent the short-run dynamic whereas the parameters $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_5, \gamma_6, \gamma_7$ and γ_8 represent the level (long-run) relationship. To examine the level relationship we test the following null hypothesis:

$H_o : \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$ (there is no long-run relationship)

H_1 : at least one γ is not equal to zero (there is long - run relationship)

The *F* test was employed to evaluate the joint restrictions. We'll compare the Wald/*F*-statistic's computed value to the bounds and crucial values that M. H. Pesaran et al. (2001) and H. M. Pesaran and Pesaran (1997) provided. The null hypothesis should be rejected in the event that the computed F-statistic value is greater than its upper bound critical value. The test is deemed inconclusive, and we will stop here rather than continue if the F-statistic falls between the threshold levels. Decision-making would be based on the upper bound critical value when all variables were integrated into order one. The lower bound critical value, on the other hand, will be taken into consideration as the decision point if the variables are integrated of order 0. The following is a specification for the ARDL long-run model:

$$GDP_t = a_0 + \sum_{i=1}^{n} b_i GDP_{t-i} + \sum_{i=1}^{n} c_i PC_{t-i} + \sum_{i=1}^{n} d_i HC_{t-i} + + \sum_{i=1}^{n} e_i FDI_{t-i} +$$

$$\sum_{i=1}^{n} f_i (HC * FDI)_{t-i} + \sum_{i=1}^{n} g_i RNE_{t-i} + \sum_{i=1}^{n} h_i URB_{t-i} + \sum_{i=1}^{n} i_i CO2_{t-i} + \varepsilon_t \quad (5)$$

Short-run estimates are obtained by estimating an error correction model correlated with the long-run estimates. This is defined as follows:

$$\Delta GDP_t = a_o + \sum_{i=1}^{n} \varphi_{1i} \Delta GDP_{t-i} + \sum_{i=1}^{n} \varphi_{2i} \Delta PC_{t-i} + \sum_{i=1}^{n} \varphi_{3i} \Delta HC_{t-i} + \sum_{i=1}^{n} \varphi_{4i} \Delta (HC * FDI)_{t-i} +$$

$$\sum_{i=1}^{n} \varphi_{5i} \Delta RNE_{t-i} + \sum_{i=1}^{n} \varphi_{6i} \Delta URB_{t-i} \& + \sum_{i=1}^{n} \varphi_{7i} \Delta CO2_{t-i} + \varphi ECM_{t-1} + \varepsilon_t \quad (6)$$

Where, $\varphi_{1i}, \varphi_{2i}, \varphi_{3i}, \varphi_{4i}, \varphi_{5i}, \varphi_{6i}$ and φ_{7i} are the short-run coefficients of the model, which converge to equilibrium and is the speed of adjustment. Coefficient stability is tested by using CUSUM and CUSUMQ. We also check heteroskedasticity, normality, and serial correlation.

Data

The study employed secondary data from 1990 to 2019 for Pakistan; the time period was limited to 2019 because of the availability of human capital index data. Data are taken from the World Development Indicator (WDI) and Penn World Table. According to Lucas Jr (1993), on-the-job training or experience is the most likely cause of a 'miraculous' increase in labor efficiency. Advanced schooling, on the other hand, accelerates the acquisition of labor skills, as Rosen (1977) suggested. As a result, education achievement is likely to be a deciding factor in a true measure of embodied human capital. Hence, we use the human capital index based on years of schooling and returns to education; see Human capital in PWT9 as a proxy to evaluate the impact of human capital on growth. Gross fixed capital formation as a proxy for physical capital. Additional variables included in the analysis are gross domestic product growth rate and FDI as net inflows of foreign direct investment as a percentage of GDP. Carbon emissions are taken as metric tons per person. Emissions of carbon dioxide are produced when fossil fuels are burned, and cement is made. They consist of the carbon dioxide released during gas flaring and the use of solid, liquid, and gas fuels. Urbanization stands as % of the total population and renewable energy consumption (% of total final energy consumption).

Results and Discussions

We have started by testing the order of integration of each variable included in the study, namely GDP, physical capital, human capital, FDI, urbanization, renewable energy consumption, and carbon emission. For this, we have applied the Augmented Dickey-Fuller (ADF) test. In order to check the stationarity of time series data, Augmented Dickey-Fuller (ADF) was employed. Time series data should not have a unit root because when time series have a unit root this means that the mean and variance in the data are changing with time. This trend makes spurious estimates. Hence, time series should have constant mean and variance over time for good estimates from the data set.

The estimates of the Augmented Dickey-Fuller (ADF) unit root test for levels and first differences are presented in Table 1. We evaluate the Augmented Dickey-Fuller (ADF) equation with and without a linear time trend. Leg length is selected through the Akaike Information Criterion (AIC). Table 1 shows that all variables are stationary at first difference except FDI and CO_2. This implies that these variables are integrated into I(1) and I(0). In other words, they are in a mixed order of integration. Hence, calculations from ADF also verify that none of the variables are integrated in an order greater than one. This is the ideal situation for using ARDL.

Table I
Augmented Dickey-Fuller test approximations for unit root

Variables	Augmented Dickey-Fuller test statistics			
	Level		First Difference	
	With Constant	With Constant and Trend	With Constant	With Constant and Trend
GDP	0.58	-2.02	-5.88***	-5.83***
HC	-2.56	-0.91	-2.66***	-13.10***
PC	-2.11	-2.34	-8.36***	6.82***
FDI	-4.04**	-0.02**	-4.78***	-4.71***
RNE	-1.75	-3.39	-3.83***	-3.97***
URB	0.49	-3.12	-3.72**	-3.5.8**
CO^2	-1.32	-4.63***	-4.58***	-4.53***

Note: *** and ** show a significance level of 1%. And 5% respectively

Following the assessment for the order of integration study, the Autoregressive Distributed Lag (ARDL) cointegration technique was applied to check the long-run relationship. The selection of optimal lag length for the ARDL model is crucial. The rationale is that bound tests (like the *F* test, *t* - test, & Wald test) are very sensitive to the lag length. Therefore, the first step is to choose the appropriate lag for the given Autoregressive Distributed Lag (ARDL) model. In this paper, the optimal lag length for the Unrestricted Conditional Error Correlation Model (UCECM) is selected based on AIC.

In addition to this, we also apply several diagnostic tests to ensure compliance with the selected lag length of the Unrestricted Conditional Error Correlation Model (UCECM). The AIC proposes lags for the approximation of the ARDL model. The estimates of the bound testing approach (*F* - statistics) are given in Table 2. The results show the existence of cointegration at 2 lags. The calculated F-stat for the model is higher than the upper bound critical value at the 5% level. Yet the null hypothesis of no cointegration is rejected, suggesting that there is long-run cointegration amongst the variables.

Table II
Bound test results for long-run relationship

F-stat	Lag	Significant Level	Critical Values (unrestricted intercept and no trend)	
			I(0)	I(1)
9.58*	2	1%	4.29	5.61
		5%	3.23	4.35
		10%	2.72	3.77

Note: * exhibits the calculated value of *F*-stat, which lies outside the upper bound values at 1%, 5%, and 10% levels of significance. Number of independent variables (k) = 6

After the determination of the long-run cointegration, the conditional ARDL long-run model can be analyzed. Tables 3 and 4 present the results of estimated long-run coefficients using the ARDL model and the results of the error correction model (ECM), respectively. The results presented in Table 3 show that, in the long run, human capital has a significant positive relationship with GDP growth rate. This implies that educated labor contributes to economic growth in Pakistan, and the return on education is significant. We take education and return on education as a proxy for human capital formation, which is consistent with the findings of (Pelinescu, 2015; Sieng & Yussof, 2014). However, this situation is expected since the endogenous theory suggests that human capital is a production factor that increases aggregate production possibilities, as well as the marginal product of physical capital, alongside the long-run growth rate.

Physical capital and foreign direct investment also demonstrate a highly significant positive relationship with GDP, which shows that physical capital is still an important determinant of economic growth in both the short run and the long run. FDI and HC provide a positive impetus for economic growth. The FDI creates huge investments to augment economic activities and facilitate the development process in an erudite way. This finding is supported by Azam and Ahmed (2015), Ahmed, Nathaniel, and Shahbaz (2021), Omri et al. (2014) and Shahbaz and Rahman (2010). At the same time, Bakari and Sofien (2019) and Belloumi and Alshehry (2018) do not support this conclusion. In a similar vein, the development of human capital boosts economic growth as highly qualified labor contributes to development initiatives more effectively. Our outcome is in line with the findings of Alataş and Çakır (2016), Azam and Ahmed (2015), Diebolt and Hippe (2019) and Fashina, Asaleye, Ogunjobi, and Lawal (2018), but does not support the results of Abubakar et al. (2015). Renewable energy consumption has a significant impact on growth. The findings are supported by studies Mohsin, Kamran, Nawaz,

Hussain, and Dahri (2021), Bhuiyan et al. (2022), Jia, Fan, and Xia (2023) and Gyimah, Fiati, Nwigwe, Vanessa, and Yao (2023), while carbon emission and urbanization show negative effects on growth.

Table III
Long Run results from ARDL

Regression	Coefficient	*S.E*	*t* - Stat	*p*-Value.
GDP	0.64	0.16	3.83	0.00***
HC	0.12	0.03	3.80	0.00***
PC	1.66	0.89	1.85	0.06*
FDI	0.26	0.11	2.25	0.04**
HC*FDI	0.21	0.09	2.16	0.04**
RNE	1.22	0.36	3.38	0.01**
URB	-16.5	3.45	-4.79	0.00***
CO^2	-0.34	0.10	-3.19	0.01**
C	1.01	0.10	6.77	0.00***

Note: ***, **, and * symbolize significance levels at 1%, 5%, and 10% respectively

The results given in Table 4 show all variables have statistically significant effects on growth in the short term. The results reveal that CO_2 and urbanization have a negative impact on growth. The coefficient of error correlation term is negative, and it seems statistically significant at the acceptable level of significance, vindicating the adjustment to long-run equilibrium. Explicitly, the error correction coefficient is -0.30. This value reveals that any divergence from growth due to the short-run shocks would be adjusted toward the long-run equilibrium with a speed of adjustment of approximately 30% per year.

Table IV
Short-run results of Error Correction Model (ECM)

Regression	Coefficient	*S.E*	*t* - Stat	*p* - Value
D(LGDP (-1))	0.99	0.01	57.48	0.00***
D(HC)	1.40	0.14	9.82	0.00***
D (PC)	2.34	0.01	1.57	0.00***
D(FDI)	0.25	0.09	2.56	0.01**
D(HC*FDI)	0.07	0.03	2.11	0.04**
D(RNE (-1))	0.03	0.01	1.84	0.07*
D(URB)	-0.01	0.00	-21.51	0.00***
D(CO2 (-1))	-0.05	0.15	-3.31	0.00***
ECT(-1)	-0.30	0.13	-2.27	0.02**
R-squared	0.99			
Adjusted R-squared	0.99			
S.E. of regression	0.00			
F-statistic	21.55			0.00

Table 5 exhibits the diagnostic tests of the ARDL model. Results show that the model does not have problems relating to serial correlation, normality of residuals, and heteroscedasticity. Moreover, to check the stability of our estimated model, we use two different tests namely, Cumulative Sum of Recursive Residual (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUMQ).

Table V
Diagnostic tests

Test	*F* - Stat	*p* - Values
Serial Correlation	0.24	0.62
Normality	Not Applicable	
Heteroscedasticity	1.15	0.34

The CUSUM test, which is based on the cumulative sum of the recursive residuals, assesses the model's stability. Cumulative sum plots with five percent critical lines are shown. We plot the results of these tests in Figure 1 and Figure 2. The plotted lines remain within the upper and lower critical bounds. Therefore, the graph shows the long-run stability of the estimated model. This test indicates parameter

instability if any of the two critical lines on the cumulative total graph are crossed. The blue line graph does not cross the 5% significance lines. The model is, therefore, determined to be stable.

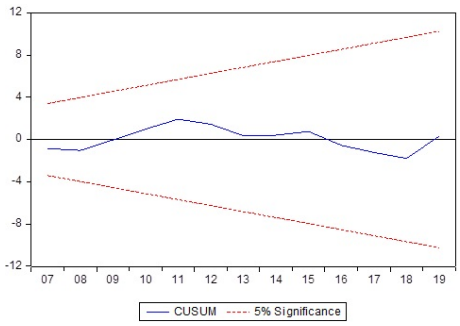

Fig. 1 *Plot of cumulative sum of recursive residuals*

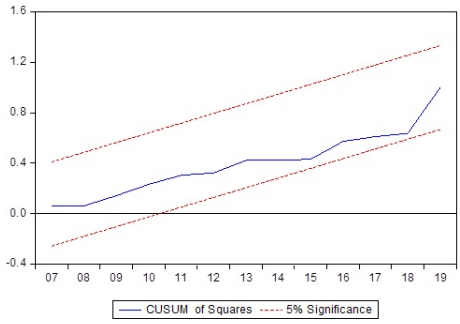

Fig. 2 *Plot of cumulative sum of squres of recursive residuals*

Conclusion

The study employs a time series analysis by investigating the interactive effect of foreign direct investment inflows between human capital growth nexus while controlling renewable energy, carbon emission, and urbanization from 1990 to 2019. The stationarity hypothesis was tested using the Augmented Dickey-Fuller (ADF) unit root test. After accounting for the first difference, all variables were determined to be stationary at the first difference, with the exception of FDI and CO_2. Due to the mixed order of stationarity at I(0) and I(1)), the ARDL approach was used in the study. The ARDL approach has the advantage of providing short-run, long-run, and adjusted-term results. The cointegration of the variables is determined by the ARDL bound test. Results indicate human capital formation, physical capital, FDI, and renewable energy are significant influences on the economic growth in Pakistan both in the short run and in the long run. While carbon emission and urbanization negatively affect growth. Furthermore, FDI significantly increases human capital formation, which contributes to economic growth. The study demonstrated that the model's predicted coefficients are consistent by using CUSUM and CUSUM square. The study also provides a policy framework aligned with SDGs to achieve sustainable development and inclusive growth.

Policy recommendations

Based on the results shown above, the study suggests a planned policy framework. For equitable and sustainable development, policies on FDI, economic growth, and human capital building should be in line with the Sustainable Development Goals (SDGs). In order to fulfill the SDGs, governments should use Foreign Direct Investment (FDI) to boost investments in fields such as healthcare, education, and renewable energy. A country can guarantee that economic growth and human capital development are pursued in a way that promotes social justice, environmental sustainability, and inclusive prosperity by incorporating SDG principles into policy formation.

Investing in human capital and forming policies that attract FDI will help to achieve Sustainable Development Goals (SDGs). Policy repercussions associated with the Sustainable Development Goals (SDGs)are as follows:

Education for all (GDG-4): Education-based policies that support the development of human capital are consistent with SDG 4, which is to guarantee that all people have access to high-quality, inclusive education. Governments may accelerate the achievement of

SDG 4 by decreasing inequality, increasing social inclusion, and providing opportunities for lifelong learning via investments in education and skill development.

Decent work and economic growth (SDG-8): Realizing SDG 8, which seeks to foster sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for everyone, may be facilitated by improving human capital and luring FDI. Prioritizing skill development, labor market reforms, and infrastructure investment opens doors for innovation, entrepreneurship, and job creation, which promotes economic growth and advances the achievement of SDG 8.

Industry, innovation and infrastructure (SDG- 9): SDG 9 is concerned with constructing resilient infrastructure, supporting inclusive and sustainable industrialization, and stimulating innovation. Policies that aim to leverage FDI to boost infrastructure development and innovation are in line with this goal. Governments contribute to the development of SDG 9 by encouraging Foreign Direct Investment (FDI) into technology-intensive industries and funding infrastructure projects. These actions also enhance productivity and promote economic diversity and technological innovation.

Reduced inequalities (SDG- 10): As stated in SDG 10, policies that place a high priority on inclusive growth and the development of human capital can help to lessen inequality. Governments may accelerate progress towards SDG 10 by promoting social inclusion and mitigating income, wealth, and opportunity inequities by guaranteeing equal access to education, healthcare, and economic opportunities.

Partnership for the goals (SDG-17): As stressed in SDG 17, fostering FDI inflows and the development of human capital necessitates strong alliances between corporations, governments, and civil society. To advance progress towards SDG 17, policies that encourage stakeholder collaboration and cooperation, including public-private partnerships and international cooperation, can improve the efficacy of initiatives to support economic growth, the development of human capital, and sustainable development.

Limitations and future research directions

The study suggests a phased policy framework oriented toward the SDGs, but it's important to keep in mind that it only accounts for the moderating effect of FDI inflows in human capital and growth nexus while controlling consumption of renewable energy, urbanization, and carbon emission. Adding other cultural, socioeconomic, and environmental factors can provide more in-depth insight. The link between the creation of human capital, FDI inflows, and economic growth is influenced by multiple socioeconomic environments and cultural dynamics. The efficacy of programs designed to foster human capital development and draw Foreign Direct Investment (FDI) may be influenced by variables including gender inequality, geographical discrepancies, and cultural norms. To offer context-specific insights and policy suggestions, future research should take these socioeconomic aspects and cultural quirks into account. Furthermore, FDI inflows and HC accumulation vary among sectors and regions. In order to comprehend how FDI inflows and human capital formation vary among sectors and regions, sectoral and regional studies should be the focus of future studies. Examining regional differences might shed light on the spatial dynamics of development. The achievement of national sustainable development objectives depends on comprehending the factors that contribute to regional differences and developing policies that encourage inclusive growth in all areas. Future studies should assess the success of previous and present policies to support the development of human capital, attract foreign direct investment, and boost economic expansion in Pakistan. Strict policy evaluations and impact analyses can be used to pinpoint areas in need of policy change or investment, as well as effective interventions and lessons learned. Despite the limitations, the proposed policy framework offers an appropriate degree of generalizability because the challenges covered in the study are almost universal in most developing economies. This sets this policy framework as the norm for other developing economies worldwide.

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