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An Empirical Investigation of the Impact of Human Development on Economic Complexity: Evidence from Pakistan

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ABSTRACT

Purpose - Competing in a globalized world is the main issue, which can be accomplished when a country has uniqueness resources. Besides focusing on other factors, e.g. financial development index, natural resources' rents, and trade openness, this study places particular emphasis on the impact of human development (HD) on economic complexity (EC).

Design/ Methodology/Approach - The study uses the 30-year annual data set spanning the years 1990 to 2019. This research used the Autoregressive Distributed Lag methodology to determine the long-run association between human development and economic complexity in Pakistan.

Findings - Based on the findings, the human development index (HDI) has significantly and positively impacted Pakistan's economic complexity index (ECI).

Practical Implications - It is suggested that the Ministries of Health and Education should improve education and health quality by offering skill training programs and better health facilities. Considering that Pakistan's primary trade sectors encompass textile and agriculture, it is essential to underscore the necessity of specialized training in these domains. Providing comprehensive information technology (IT) skill training would yield substantial benefits to the trade sector, leveraging cutting-edge technological advancements for enhanced productivity and competitiveness.

ملخص

الغرض - المنافسة في ظل العولمة هو الهدف الرئيسي الذي لا يمكن تحقيقه إلا عندما يتمتع بلد ما بموارد فريدة. تركز هذه الدراسة على مؤشر التنمية المالية وريع الموارد الطبيعية والانفتاح التجاري، كما تدرس بشكل خاص تأثير التنمية البشرية (HD) على التعقيد الاقتصادي (EC).

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التصميم/المنهجية/النهج - تستخدم الدراسة مجموعة البيانات السنوية تمتد على مدى 30 عامًا (من 1990 إلى 2019). استخدم هذا البحث منهجية اختبار الانحدار الذاتي للإبطاء الموزع لتحديد الارتباط طويل المدى بين التنمية البشرية والتعقيد الاقتصادي في باكستان.

النتائج - بناء على النتائج، أثر مؤشر التنمية البشرية (HDI) بشكل كبير وإيجابي على مؤشر التعقيد الاقتصادي (ECI) في باكستان.

الآثار العملية - يقترح البحث أن تقوم وزارتا الصحة والتعليم بتحسين نوعية التعليم والصحة من خلال تقديم برامج للتدريب على المهارات وتوفير مرافق صحية أفضل. وبما أن قطاعات التجارة الرئيسية في باكستان هي قطاع المنسوجات والزراعة، من الضروري التأكيد على ضرورة التدريب المتخصص في هذه المجالات. ومن شأن توفير تدريب شامل على المهارات في مجال تكنولوجيا المعلومات أن يحقق فوائد كبيرة لقطاع التجارة، ويعزز التقدم التكنولوجي المتطور من أجل تعزيز الإنتاجية والقدرة التنافسية.

RÉSUMÉ

Objectif - La compétitivité dans un monde globalisé est l'enjeu principal, qui peut être atteint lorsqu'un pays dispose de ressources uniques. En plus de se concentrer sur d'autres facteurs, tels que l'indice de développement financier, les rentes des ressources naturelles et l'ouverture commerciale, cette étude met particulièrement l'accent sur l'impact du développement humain (DH) sur la complexité économique (CE).

Conception/ Méthodologie/Approche- L'étude utilise un ensemble de données annuelles sur 30 ans couvrant les années 1990 à 2019. Cette recherche a utilisé la méthodologie Autoregressive Distributed Lag pour déterminer l'association à long terme entre le développement humain et la complexité économique au Pakistan.

Résultats - D'après les résultats, l'indice de développement humain (IDH) a eu un impact significatif et positif sur l'indice de complexité économique (ICE) du Pakistan.

Implications pratiques - Il est suggéré que les ministères de la santé et de l'éducation améliorent la qualité de l'éducation et de la santé en proposant des programmes de formation professionnelle et de meilleures installations sanitaires. Étant donné que les principaux secteurs commerciaux du Pakistan englobent le textile et l'agriculture, il est essentiel de souligner la nécessité d'une formation spécialisée dans ces domaines. Une formation complète aux technologies de l'information (TI) apporterait des avantages substantiels au secteur commercial, en tirant parti des avancées technologiques de pointe pour améliorer la productivité et la compétitivité.

Keywords: Economic Complexity Index (ECI), Human Development Index (HDI), Natural Resource Rent (NRR), ARDL, ECM

JEL Classification: C32, E60, F16, F41, F43

1. Introduction

The most pressing issue confronting developing countries in the present era revolves around the issue of uneven economic growth, giving rise to a dichotomy between rich and poor countries (Harvard Growth Lab, 2013). Moreover, the attainment of stable economic growth has become a challenging task for global economies. According to the World Bank, the United States ranks first among 190 countries with a 24.08% share of the global GDP followed by China in the second position with a share of 15.08%, and Japan ranks third with a share of 6.02%. (Worldometers, 2017). Pakistan, on the other hand, ranks 40th with a share of 0.38%, which is significantly lower than the top countries. Many countries, including Kiribati and Tuvalu, continue to have a negligible share of the global GDP (Worldometers, 2017).

Evidence suggests that international trade can serve as engine for economic growth, and boost the global share of GDP (Rahman et al., 2023). Therefore, improving trade is essential for increasing the global share of GDP specifically for developing countries. As evident, developed countries produce a wide range of diversified goods and services ranging from simple to complex whereas less developed countries, on the other hand, produce fewer goods and export fewer complex goods than developed nations (Cristelli et al., 2013). Several national and international organizations launched a variety of initiatives aimed at boosting global trade and economic growth. The World Trade Organization (WTO), for example, lowers trade barriers between trading economies and governments. (WTO, 2021). Likewise, the World Bank (WB) collaborates with the national government to lower trade barriers by developing and enforcing policy initiatives that boost competitive strength, interconnection, and trade facilitation (World Bank, 2018). Similarly, "United Nations Conference on Trade and Development" (UNCTAD) endeavors to help developing and transitioning economies by facilitating their active participation in international discussions and policy debates (Canton, 2021). Nations differ in terms of the quantity and type of abilities they possess, whereas the production of goods requires a mix of capabilities. Goods diversification is determined by a country's capabilities. If a country has more accumulated knowledge and capabilities, it produces more diverse goods (Hausmann and Hidalgo, 2010). Therefore, economic complexity (EC) reflects the development of a country as well as how it manufactures and exports sophisticated goods to a greater extent (Lapatinas, 2019).

The amount of knowledge inserted in a community is not solely determined by the amount of knowledge held by everyone. Instead, it is dependent on the diversity of individuals' knowledge and their ability to aggregate and apply that knowledge through a complex web of mutual action (Hausmann et al., 2014). Given the aforementioned information, it comes as no surprise that human development (HD) has positively and significantly affected economic growth (Boozer et al., 2003; Rahman et al., 2020; Akar et al. 2021).

EC is an emerging area of study, both fundamental as well as applied (Hidalgo, 2021; Hidalgo, 2023). Most research examined the impact of EC on HD; however few studies documented the role of HD in enhancing EC. Therefore, the literature addressing the connection of HD with EC is not only limited but also mainly revolves around the case studies of developed cuntries such as (Lapatinas 2016; Ferraz et al. 2018; Le Caous et al. 2020 and Arica and Kurt (2021), Yaprakli and Ozden (2021). Furthurmore, previous studies give inconsistent results between HD and EC, such as Soyyigit et al. 2019 and Mostolizadeh and Salimi (2021).

Therefore, the current study seals the lacuna in existing literature by examining the impact of HD on EC in Pakistan, that is less evident. So, the purpose of this study is to empirically examine the impact of HD on EC in the context of an emerging economy like Pakistan.

The current study's novelty is that although addressing the issue of uneven growth through EC is gaining popularity in the world economies (Erkan & Yildirimci 2015), very limited studies have investigated the HD's impact on EC by employing time series analysis, specifically in the case of a developing country like Pakistan to the best of researchers' knowledge. Therefore, the current research serves as an effort at filling a research gap by empirically investigating the impact of HD on EC in the context of Pakistan using yearly time series data ranging from 1990-2019.

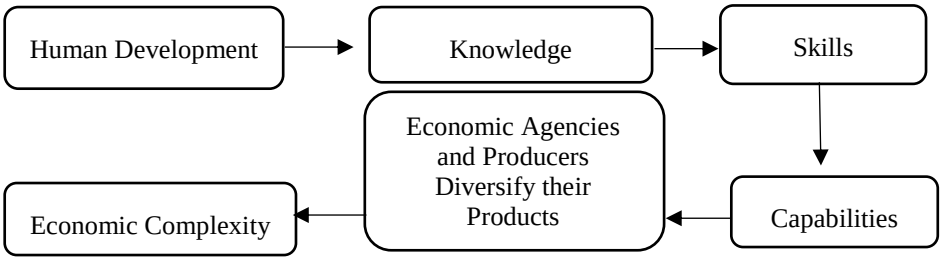
The choice of a single country, "Pakistan" is motivated by a factor that it has a low rank in EC but has the potential for development and growth. The remainder of the paper is organized as follows: Section 1.1 and 1.2 presents the theoretical and conceptual frameworks, respectively. Section 2 outlines the data along with the research methodology, Section 3 displays the results of empirical findings of the econometric methodology, and Section 4 summarizes the entire research as well as presents some suitable policy suggestions.

1.1. Theoretical Framework

This study used an indicator that measures future economic growth known as the economic complexity index (ECI). This index, originally created by Hidalgo and Hausmann in 2009, serves as a quantitative indicator that gauges the extent of complexity and diversity within an economy. The fundamental premise upon which the ECI is based asserts that EC reflects a country's ability for producing a broad variety of goods and services, particularly those of a more sophisticated nature i.e., production of which requires the use of advanced knowledge and capabilities. Depending on the comparative advantage theory and its contemporary variants Hidalgo et al. (2007) discovered that a country's export basket improves more quickly if it produces goods in which it specializes.

This research is based on the comparative advantage theory presented by Ricardo in 1817 (Bernhofen and Brown, 2018). A country can gain from trade, according to Ricardo, since specialization enables the world to benefit from rising commodity output (Tuano, 2017). HD leads to a gain in knowledge and skills, which leads to an increase in capabilities. If a country's capabilities improve, economic agencies and producers diversify their goods, causing the country's EC to rise. The theoretical framework of this study is given below

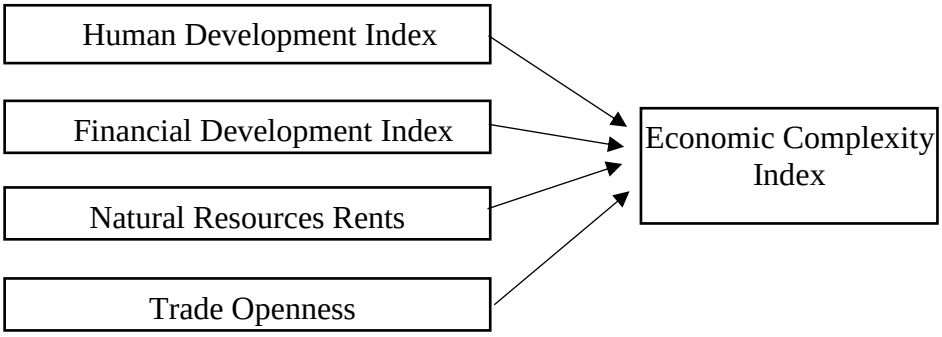
Figure 1: Theoretical Framework



1.1.1. Conceptual Framework

The conceptual framework presents the proposed relationship of the variables employed in the present research. The human development index (HDI), financial development index (FDI), natural resources rents (NRR), and trade openness (TRA), are the independent variables and the economic complexity index (ECI) is the dependent variable.

Figure 2: Conceptual Framework



2. Research Methodology

2.1. Data

This research examines the impact of the human development index (HDI), financial development index (FDI), natural resource rent (NRR), and trade openness (TRA) on the economic complexity index (ECI) in the case of Pakistan for the years 1990 to 2019. This study incorporated FDI, NRR and TRA as control variables to minimize the bias of omitted variables as all these variables influence the relationship between HD and EC. For instance, FDI controls for the influence of financial infrastructure as economies heavily relies on financial dependence (Hausmann et al. 2007). NRR is also included as control variable to capture the influence of NRR on EC following the "Dutch Disease Hypothesis" demonstrates that natural resource development may reduce development in another sector (Hoang et al. 2023). The NRR may affect economic activity and EC (Yalta and Yalta, 2021; Njangang et al., 2021; Alvarado et al., 2023). Trade openness (TRA) is also included as control variable due to the fact that trade can influence EC through exchange of resources and skills (Hausmann et al., 2007; Nguyen et al., 2020; Ndoya and Bakouan, 2023).

This study utilized Indexes for EC, HD and financial development. The dependent variable's (EC) data have been derived from the official websites of OECD and the Atlas of Economic Complexity. HD data is derived from Global Lab data UNDP. The data on NRR and TRA is collected from the official website of World Development Indicators. The data for FDI is collected from official website of International Monetary

Fund (IMF).

2.1.1. Construction of Variables

2.1.1.1. Measurement of Economic Complexity Index

The EC evaluates the global market share of trade and comprises of two key components "the diversity of production" and "Ubiquity" (uniqness) of product (Mealy et al. 2019). The composite index of EC evaluates the exports diversification and ubiquity and their worldwide share based on each product and country (Lapatinas, 2019; Bustos et al., 2012). Hausman et al. (2014) developed an integrated index based on country's products and abilities using RCA framework.

The following is the RCA formula:

$$RCA_{cg} = \frac{X_{cg} / \Sigma_c X_{cg}}{\Sigma_c X_{cg} / \Sigma_c \Sigma_g X_{cg}} \quad (1)$$

Where RCA stands for revealed comparative advantage, c represents the country, g shows the product, X is the export, Xcg is the export of product g by country, ΣcXcg is the entire export of country c, ΣgXcg denotes global export of product g, and ΣgΣcXcg shows the total global export. The numerator represents the percentage of the country c's export of product g. The denominator represents the proportion of product g in total worldwide exports. The numerator reflects the percentage of product g exported by country c. The denominator is the percentage of total worldwide exports of product g. If the RCA is more than one, it signifies that the export share of country c of product g surpasses the worldwide export share of this product g (Albeaik et al. 2017). In other words, if a nation has RCA1 (comparative advantage) in producing product g, then Mcg equals 1. In contrast, if a country has RCA1 (no comparative advantage) in producing product g, then Mcg equals 0 (Inova, 2016). Mathematically:

$$M_{cg} = \begin{cases} 0, & \text{RCA} < 1 \\ 1, & \text{RCA} \geq 1 \end{cases} \quad (2)$$

As discussed above, ECI depends on two elements e.g. diversity and ubiquity. To compute these two elements, the ECI employs a cross-country export matrix. Countries are in the table's row, whereas items are

in the columns. The value of a country's exports is shown in each cell in this table. Mcg is a matrix that shows which countries produce what.

$$M_{cg} = 1;\ \text{if country c makes product g} \quad (3)$$

$$M_{cg} = 0; if\ country\ c\ does\ not\ make\ product\ g \quad (4)$$

Adding the Mcg matrix by rows and columns to quantify the components of EC (diversity and ubiquity).

$$\mathrm{D} = \text{Diversity} = C_{c,o} = \Sigma_p M_{cg} \quad (5)$$

$$\mathrm{U} = \text{Ubiquity} = C_{g,o} = \Sigma_c M_{cg} \quad (6)$$

An interaction algorithm is used to calculate ECI:

$$\mathrm{ECIc} = \frac{C_{c\prime} - \hat{\mathrm{C}}}{\mathrm{std(C)}} \quad (7)$$

ECIc represents the EC index of country c, Cc shows the eigenvector of the matrix Mcg. $\hat{\mathrm{C}}$ and Std(C) denote the vector's average and vector's standard deviation, respectively. Because the first eigenvalue is not useful, the creators of this index employ the second greatest eigenvalue.

2.1.1.1.1. Measurement of Human Development Index

The human development index (HDI) is the sum of the three main factors of HD as assessed by an index (Roser, 2019). These three fundamental factors are as follows:

• Health
• Education
• Living Standard

HDI makes use of four key matrices.

• Life expectancy
• Schooling years expected
• Schooling years average
• GNI (Gross National Income)

Two stages are required to compute the HDI:

• Creation of indices for each matric
• Matrices aggregation

First, normalize the four matrices' values from zero to one (index value). The index value is computed by subtracting a country's lower value from

its real value and dividing the result by the difference between the country's highest and lowest values. The index represents a country that obtains the most or highest value. If a country obtains a zero, the index is 0.

$$Index_v = \frac{RV - LV}{HV - LV} \tag{8}$$

Where $Index_v$ shows the Index Value, and RV symbolizes a country's real value. The lowest value (globally) is represented by LV, while the greatest value (globally) is represented by HV. Individually derived indices are aggregated using the geometric mean to generate HDI. The HDI formula is presented below:

$$HDI = (I_{\text{H}} * I_{\text{E}} * I_{\text{I}})^{1/3} \tag{9}$$

Where HDI represents the Human Development Index, I_{H} is the Health Index, I_{E} is the Education Index which is calculated by taking an average of the mean and expected year of schooling index and I_{I} represents the Income Index.

2.1.1.1.2. Measurement of Financial Development Index

Financial Development Index (FDI) is constructed in three phases (Svirydzenka, 2016). This procedure condenses multidimensional data into a single summary index. The procedure is as follows:

1. Normalization of variables
2. Create sub-indices by adding the normalized variables together.
3. Compile the final index by adding the sub-indices.

Each series should be winsorized to prevent excessive values from shifting the zero to one indication. The winsorize indicators were then standardized between 0 and 1 using min-max techniques. This approach simplifies the aggregation of variables expressed in several measurement units.

$$\mathrm{I_r} = \frac{\mathrm{r} - \mathrm{r_{min}}}{\mathrm{r_{max}} - \mathrm{r_{min}}} \tag{10}$$

$$\mathrm{I_r} = 1 - \frac{\mathrm{r} - \mathrm{r_{min}}}{\mathrm{r_{max}} - \mathrm{r_{min}}} \tag{11}$$

Where "r" represents data (raw data) and "Ir" represents the converted indicator (continuous), with values ranging from 0 to 1. Normalizing indicators in the same ranges from zero to one involves subtracting the

minimum value from the real value and then dividing the result by the minimum value minus the highest value.

The indicators are then aggregated into six sub-indices. The series' aggregate is a weighted linear average. Weights are derived via principal component analysis. Then, using equation 10, renormalize all sub-indices to have a range of 0 to 1.

$$FI_b = \sum_{a=1}^{n} w_a I_a \tag{12}$$

$$FM_b = \sum_{a=1}^{n} w_a I_a \tag{13}$$

FMb stands for FMD, FMA, and FME, whereas FIb stands for FID, FIA, and FIE. The FID, FIA, FIE, FMD, FMA, and FME are aggregated into the higher-level indexes in the same way as explained above. At the highest aggregated level, rise to the top of the FD index. The FI, FM, and FD indices are then renormalized. As a result, the range is from 0 to 1.

$$FI = \sum_{b=1}^{n} w_b I_b \tag{14}$$

$$FM = \sum_{b=1}^{n} w_b I_b \tag{15}$$

$$FD = w_{FI} FI + w_{FM} FM \tag{16}$$

2.1.1.1.3. Measurement of Natural Resources Rents

Total natural resource rents represent the aggregation of oil, natural gas, coal, mineral as well as forest rentals.

2.1.1.1.4. Measurement of Trade Openness

Trade openness represents the aggregation of trade share (exports plus imports) as a percentage of GDP. The formula of trade openness is given in equation 17.

$$TO = \frac{\sum EXP + \sum IMP}{GDP} \; X \; 100 \tag{17}$$

Table 1: Variables' Construction

Variables	Notation	Measurement	Data Sources
Dependent Variable			
Economic Complexity Index	ECI	Index through Diversity & Ubiquity	Observatory of Economic Complexity (OEC), Atlas of Economic Complexity
Independent Variables			
Human Development Index	HDI	Index through the indices of Health, Education, Income by using life expectancy, expected as well as average year of schooling and GNI	Global Data Lab UNDP, 2020
Financial Development Index	FD index	Index through the indices of Financial Market & Financial Institution in terms of access, depth, and efficiency	IMF
Natural Resources Rent	NRR	Sum of resources rents as % of GDP	WDI
Trade Openness	TRA	Sum of imports and exports as % of GDP	WDI

2.2. Econometric Methodology

To empirically analyze the impact of human development (HD) on Pakistan's economic complexity (EC), is the major objective of this study. To achieve the stated objective, this research employs the ARDL technique for cointegration after performing stationary tests. The maximum likelihood-based Johansen (1988, 1991) along with Johansen-Juselius (1990) tests, as well as the Engle and Granger (1987) tests, have emerged as frequently used approaches for investigating the long-run connection between variables. However, all of the aforementioned

approaches require that the variables included in the model must be stationary at first difference. In addition, these methods face another limitation of poor performance with small sample sizes. In contrast, The ARDL technique for cointegration overcomes such constraints. This technique was originally created by Pesaran, Shin, and Smith (1996) and Pesaran and Shin (1999), with further advancements by Pesaran et al. (2001). Because of its econometric benefits over alternative approaches of cointegration, the ARDL methodology has acquired broad acceptance. Unlike alternative approaches, this approach doesn't necessitate that all variables be integrated in the same order. It remains effective even if the variables in the model are integrated of either I (0) or I (1), and none of the variables is integrated of I (2) (Pesaran and Pesaran, 1997). According to Pesaran and Shin (1999), the ARDL technique produces solid findings and extremely consistent estimates of long-run coefficients, even for small sample sizes. The ARDL model also provides the results of short and long run estimates at the same time, that makes it different from other methods (Hassler and Wolters, 2006). Furthurmore, the ARDL model provides the choice of suitable lags to ensure the stability of the model (Kripfganz and Schneider, 2013). The bound test for cointegration is simple and easy to estimate and variable included in the model does not impose rigid restrictions (Osuji, 2015). Furthurmore, this technique applies ordinary least square (OLS) to estimate the cointegration when the lag order is known cotrasting Johansen and Juselius's cointegration method (Isik, 2013).

The ARDL technique for cointegration solves these constraints, according to the econometric model given in the paper. This technique was created by Pesaran, Shin, and Smith (1996) and Pesaran and Shin (1999), with significant developments by Pesaran et al. (2001). Because of its econometric benefits over alternative cointegration approaches, the ARDL methodology has received widespread popularity. The econometric model proposed in the paper is as follows:

$$\ln(ECI_t) = \beta_0 + \beta_1 \ln(HDI_t) + \beta_2 \ln(FDI_t) + \beta_3 \ln(NRR_t) + \beta_4 \ln(TRA_t) + U_t \quad (18)$$

Where $\ln(ECI_t)$, $\ln(HDI_t)$, $\ln(FDI_t)$, $\ln(NRR_t)$, and $\ln(TRA_t)$ represent the natural logs of the ECI, human development index, financial development index, natural resource rent, and trade openness respectively, whereas, U_t represents the error term. The equilibrium over the long-term model has been calculated using the following equation:

$$\begin{aligned}\Delta\ln(ECI_t) = {} & \beta_o + \sum_{f=1}^{v} \beta_{1f}\,\Delta\ln(ECI_{t-f}) + \sum_{f=0}^{v} \beta_{2f}\,\Delta\ln(HDI_{t-f}) \\ & + \sum_{f=0}^{v} \beta_{3f}\,\Delta\ln(FDI_{t-f}) + \sum_{f=0}^{v} \beta_{4f}\,\ln(\Delta NRR_{t-f}) \\ & + \sum_{f=0}^{v} \beta_{5f}\,\Delta\ln(TRA_{t-f}) + \beta_6\ln(ECI_{t-1}) \\ & + \beta_7\ln(HDI_{t-1}) + \beta_8\ln(FDI_{t-1}) + \beta_9\ln(NRR_{t-1}) \\ & + \beta_{10}\ln(TRA_{t-1}) + \varepsilon_t\end{aligned} \tag{19}$$

Where Δ is the first difference operator, v denotes the optimal lag length, β_0 indicates the constant, β_1 to β_5 represents short-term elasticities, β_6 to β_{10} represents long-term elasticities and ε_t denotes the residual. It is a requirement for using a bounds test that no single variable be integrated of order 2 and that the variables are fractionally integrated at the level form and first difference or they are integrated of order 1. The Augmented Dickey-Fuller test has been used in this study, with the optimal lag choice based on Akaike's Information Criteria (AIC). The following equation has been utilized for estimating the error correction model (ECM) to analyze the short-term relationship:

$$\begin{aligned}\Delta\ln(ECI_t) = {} & \beta_o + \sum_{f=1}^{v1} \beta_{1f}\,\Delta\ln(ECI_{t-f}) \\ & + \sum_{f=0}^{v2} \beta_{2f}\,\Delta\ln(HDI_{t-f}) + \sum_{f=0}^{v3} \beta_{3f}\,\Delta\ln(FDI_{t-f}) \\ & + \sum_{f=0}^{v4} \beta_{4f}\,\Delta\ln(NRR_{t-f}) \\ & + \sum_{f=0}^{v5} \beta_{5f}\,\Delta\ln(TRA_{t-f}) + \pi_1 ECT_{t-1} + \varepsilon_t\end{aligned} \tag{20}$$

3. Results and Discussion of Empirical Findings of the Econometric Methodology

3.1. Descriptive Statistics

For analysis, this study used selected variables' data from 1990-2019. Firstly, the study has presented the descriptive analysis for the time series variables. This statistic represents that Pakistan's ECI ranged from 0.086 to 0.301 between 1990 and 2019 with a standard deviation of 0.057 and a mean of 0.188. furthermore, Pakistan's human development index ranged from 2.523 to 3.614. with a standard deviation of 0.337 and an average of 3.031. The results of the variables' descriptive analysis are shown in Table 2.

Table 2: Descriptive Analysis

	lnECI	**lnHDI**	**lnFDI**	**lnNRR**	**lnTRA**
Mean	0.188	3.031	1.811	1.035	2.109
Median	0.173	3.017	1.688	1.028	2.131
Maximum	0.301	3.614	2.323	1.062	2.427
Minimum	0.086	2.523	1.409	1.019	1.791
Std. Dev.	0.057	0.339	0.265	0.013	0.187

3.1.1. Unit Root Test

The unit root test determines the level of stationarity of the study variables. We used the Augmented Dickey-Fuller test and Phillips Perron (PP) test, the results of which are shown in Table 3. Having observed the order of integration, demonstrate that all variables are integrated of order one, i.e. I (1) and none of the variable follow I (2). The ARDL methodology in this study is most appropriate.

Table 3: Result of Stationary Test

	With Constant	At level	Without Constant & Trend	At level	With Constant	At first diff	Without Constant & Trend	At first diff	
Variables	**t-stats**	**Pro-value**	**t-stats**	**Pro-value**	**t-stats**	**Pro-value**	**t-stats**	**Pro-value**	
ADF test									
LnEC	-2.295	0.180	-2.059	0.546	-4.537	0.001***	-4.608	0.005***	I(1)
LnHD	1.462	0.999	-2.993	0.153	-4.789	0.001***	-5.104	0.002***	I(1)
LnFD	-1.792	0.376	-1.820	0.668	-3.918	0.006***	-3.912	0.025**	I(1)
LnNRR	-1.683	0.429	-1.906	0.626	-4.989	0.000***	-3.430	0.070*	I(1)
LnTRA	-2.275	0.187	-2.458	0.345	-5.340	0.000***	-5.235	0.001***	I(1)
PP test									
LnEC	-2.469	0.133	-2.253	0.445	-4.529	0.001***	-4.605	0.005***	I(1)
LnHD	1.413	0.999	-1.901	0.628	-4.843	0.001***	-5.115	0.002***	I(1)
LnFD	-1.601	0.469	-1.602	0.767	-3.937	0.006***	-3.912	0.025**	I(1)
LnNRR	-1.872	0.340	-2.232	0.456	-4.989	0.000***	-4.969	0.002***	I(1)
LnTRA	-1.859	0.346	-2.337	0.403	-5.340	0.000***	-5.235	0.001***	I(1)

Note: "* indicates a 10% significance level, ** indicates a 5% significance level, whereas *** indicates a 1% significance level".

3.1.1.1. ARDL Bounds Test for Cointegration

The ARDL bounds test, which depends on the value of the f-statistic, has been used to identify cointegration between variables. Table 4's f-statistic value (8.356) is larger than the upper limit at the 1% significance level, and it is concluded that the variables are cointegrated.

Table 4: ARDL Bound Test Results

t-statistics	Value	Significance Level	Lower bound Limit I(0)	Upper Bound Limit I(1)
f-statistics	8.356	1%	3.29	4.37
		5%	2.56	3.49
		10%	2.2	3.09

Table 5 shows the impact of the variables included in the study model on the ECI in the long run. According to the findings, human development has positively and significantly (at a 1% significance level) impacted Pakistan's ECI. A 1 % rise in the human development index gives rise to 0.129% in the ECI. The current study's findings are depended on the theory of comparative advantage. It illustrates how gains in people's education, life expectancy, and living standards lead to higher productivity, which enhances exports and EC. Investment in human development such as, schooling and skill growth, plays a vital affect in boosting the intellectual capabilities of humans. Thus, knowledgeable persons can make a well equipped to participate in more complex productivity methods which stimulates the technological growth, innovation, and diversification. The result has similarities to the findings of Yaprakli & Ozden (2021) in OECD countries during 1996-2017 and Akar et al. (2021), which found human development has positively correlated with EC in 5 nations while negatively correlated in other nations. Mostolizadeh and Salimi (2021) proved that human development positively affected EC in developed countries, while only EC negatively affected human development in developing countries by taking data from 1997-2017. Moreover, Soyyigit (2019) found human development not affect EC in United States while negatively affect in all G20 countries except Australia and Canada. In Pakistan, a 1% rise in financial development significantly (at a 1% significant level) impacts and gives

rise to the ECI by 0.259%. A rise in financial development raises financial resources and strengthens the financial system, resulting in more investment in the company. The variety of goods expands as a result of these channel possibilities, which increases the economic complexity. This result differs from the findings of previous study on middle- and high-income nations such as Nguyen and Su (2021). For instance, the results proved that financial development positively affect economic complexity in short run but negatively affect in long run. While, this result is similar to Nguyen and Su (2021) and Avom et al., (2021) Hegueu et al. (2023); Olaniyi and Odhiambo, (2023); Ndoua et al. (2023). In Pakistan, a 1% rise in natural resource rent causes a 2.830% decrease but significantly (at a 5% significance level) impacted economic complexity. Except for natural resource rent, all variables have positively impacted economic complexity in Pakistan. Because, when the rent is cheap, natural resources are utilized. When the rent on natural resources rises, it makes investing more expensive and discourages investors from investing. As the rent on natural resources has risen, investors have grown deterred from developing innovative ideas. This finding of the negative impact of NRR is congruent with the finding of Yalta and Yalta (2021), who experimentally explored the factors of EC. They discovered that NRR has a negative and considerable influence on the EC of MENA nations. A 1% rise in TRA causes a 0.174% enhancement in Pakistan's EC. Based on the comparative advantage theory, openness to trade creates trading environment which stimulates interconnectedness and contribute to structural transformation. Furthermore, trade openness stimulates technology in domestic country which improves the productivity and foster innovation and economic diversification by specialized production. This result is similar to Nguyen et al (2022)'s findings.

Table 5: ARDL Long Run Results (2 Lags based on AIC, (1,2,0,0,0)

Dependent Variable is ln(ECIt)

Variables	Coefficient	Std.Error	t-statistics	Prob.
ln(HDI_t)	0.129	0.045	2.849	0.009***
ln(FDI_t)	0.259	0.054	4.782	0.000***
ln(NRR_t)	-2.830	1.012	-2.797	0.011**
ln(TRA_t)	0.174	0.060	2.915	0.008***

Note: "* indicates a 10% significance level, ** indicates a 5% significance level, whereas *** indicates a 1% significance level".

Table 6 presents the Error Correction Model results. Since the model is based on the macroeconomic variables, and the macroeconomic is a long-term phenomenon, the attention is diverted towards the long-term results. The error correction term (ECT) demonstrates long-run stability of the model. The necessary condition for its coefficient value must be negative (-ve) and significant and less than 1. The results indicate that the coefficient of ECT is significant at 1%, less than 1 negative and the short-run disequilibrium is correct at a rate of 0.576%.

Table 6: ECM Results

Dependent Variable is $\Delta\ln(ECI_t)$

Variable	Coefficient	Std.Error	t-statistics	Prob.
C	1.082	0.455	2.377	0.027**
$\Delta\ln(ECI_t)$	-0.576	0.113	-5.087	0.000***
$\Delta\ln(HDI_t)$	0.074	0.023	3.286	0.003***
$\Delta\ln(FDI_t)$	0.068	0.032	2.115	0.047**
$\Delta\ln(NRR_t)$	-1.631	0.510	-3.199	0.004***
$\Delta\ln(TRA_t)$	0.100	0.036	2.741	0.012**
Coint. Eq.	-0.576***	**Adjusted R-square**	0.797	**Durbin-Watson Statistics**
R-square	0.89			2.292

Note:" * indicates a 10% significance level, ** indicates a 5% significance level, whereas *** indicates a 1% significance level".

3.1.1.1.1. Diagnostic Tests Results

Table 7 shows various diagnostic tests findings. The robustness of results checked by various alternative results. For instance, Breusch-pagan Godfrey test, Harvey and Glesier test applied for testing the possibility of heteroscedasticity in estimates. The findings indicated that all the tests have probability values of more than the 5%, proving that model has no heteroskedasticity. Furthermore, Breusch-Godfrey Serial Correlation LM Test conducted for testing the autocorrelation at different lags. The results proves that there is no evidence of serial correlation at lag 1, lag 2 and lag 3, and p value is greater than 0.05 in all models. The model stability is also tested by employing Ramsey Reset Test at various lags, the results confirmed that model is correctly specified having observed the p values greater than 0.05.

Table 7: Diagnostic Tests Results

Heteroskedasticity Test			
	R^2	**f-stat**	**p-val**
Breusch-Pagan Godfrey	4.301	0.518	0.810
Harvey	10.287	1.162	0.374
Glesier	8.157	0.822	0.604
Autocorrelation Test			
	R^2	**f-stat**	**p-val**
Breusch-Godfrey Serial Correlation LM Test: lag 1	2.296	1.518	0.235
Breusch-Godfrey Serial Correlation LM Test: lag 2	5.930	1.469	0.256
Breusch-Godfrey Serial Correlation LM Test: lag 3	4.808	1.037	0.405
Ramsey Reset Test			
	f-stat	**df**	**p-val**
Ramsey Rest Test with lag 1	0.127	(1,17)	0.725
Ramsey Rest Test with lag 2	1.325	(2,16)	0.293
Ramsey Rest Test with lag 3	1.001	(3,15)	0.419

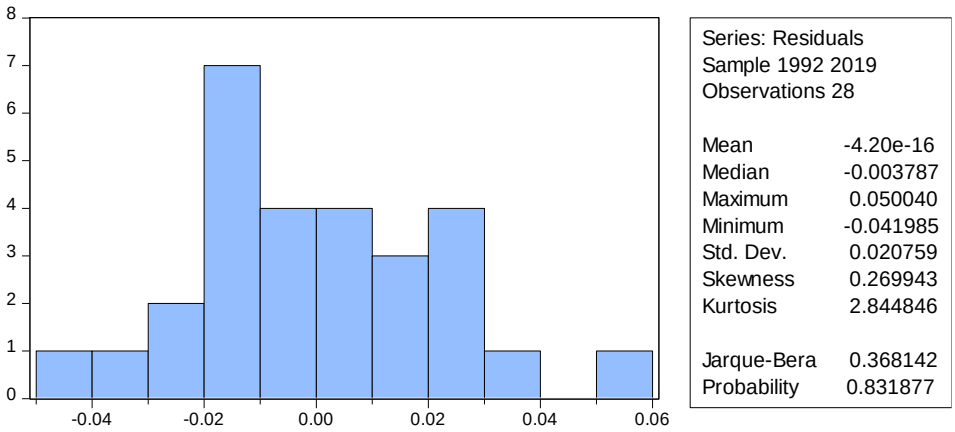
Table 8 presents the variance Inflation Factors results to estimate the chances of multicollinearity in the model. The results indicate that VIF is less than 5 for all variables that confirms the absence of multicollinearity in the model.

Table 8: Variance Inflation Factor

Variable	**Coefficient Variance**	**Centered VIF**
$ln(HDI_t)$	0.002	2.107
$ln(FDI_t)$	0.002	1.247
$ln(NRR_t)$	0.805	1.409
$ln(TRA_t)$	0.005	1.845
C	0.153	N/A

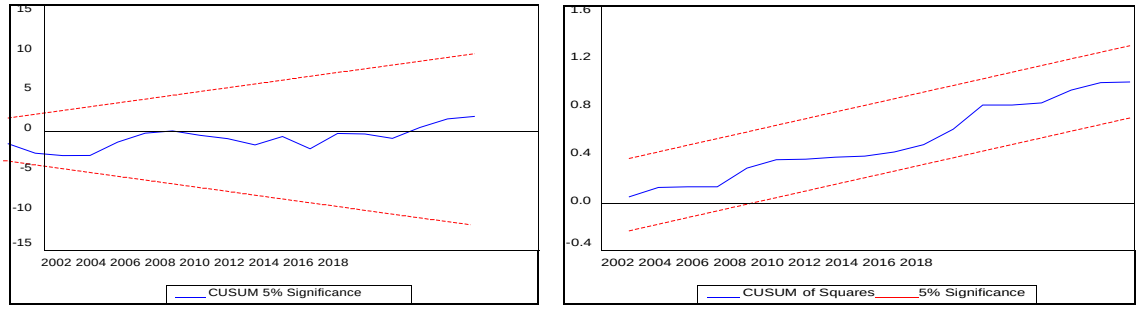
A histogram diagram is useful when there are a lot of observations. For determining residual normality, the Jacque-Bera test is more appropriate. Because the probability value is 0.832 more than 5%, the results show that the model is normally distributed. The histogram diagram is.

Figure 3: Jarque-Bera Normality



The stability tests are used to determine whether or not coefficients are stable. The blue lines in both graphs lie between the red lines and do not touch the red lines, indicating that coefficients in this research are stable at a 5% significance level. Furthermore, the model employed in this study is correct.

Figure 4.:CUSUM & CUSUMSQ



Source: Own calculation based on E-views 10

4. Conclusion

A country's development is based on export, which leads to economic growth. Pakistan is a developing country; expanding exports through product diversification is vital. As a result, this study focuses on how human development enhances economic complexity through

increasing exports. As a result, the current research helped to fill a lacuna in the present literature to some extent. Thus, the main objective of the study was to find the impact of human development on economic complexity in the case of Pakistan. To achieve the stated objective of this research, yearly time series data from 1990 to 2019 were employed. After confirming the order of integration, the cointegration technique of the ARDL bound test is then utilized to validate the cointegration between variables occurs. The result demonstrated the presence of a long-run link between variables. The ARDL approach was used to analyze the impact of HD on EC in Pakistan. The findings indicate that HD exhibits significant positive impact on ECI, a 1% rise in human development gives rise to Pakistan's economic complexity by 0.129%. Furthermore, FDI and TRA has also significant positive impact on EC, whereas NRR has significant negative impact on ECI in Pakistan. This study also used diagnostic tests to confirm the stability of selected model. The results of diagnostic tests confirms that there is no heteroscedasticity, no autocorrelation, and that the functional linear regression model is appropriate. The model has no multicollinearity since the VIF values of all variables were less than 5%.

4.1. Policy Suggestions

The current research's findings demonstrate that improvements in people's education, life expectancy, and living standards lead to increased productivity, which then boosts exports and economic complexity. Based on this finding, the Pakistani government is advised to improve human development, particularly the role of the Ministries of Health and Education in this regard may be imperative. It is suggested that the Ministries of Health and Education should improve education and health quality by offering skill training programs and improved health facilities. Pakistan's major trade sectors are textile and agriculture, so training in these areas is essential. Textile manufacturing exporting goods, making up 60.82% of overall exports, increased by 25.5% during the fiscal year 2022 compared to a 22.9% increase during the fiscal year 2021 (Pakistan Bureau of Statistics, 2023). Agriculture has become a major industry, accounting for around 20% of GDP, 38.5% of employment, and employing over 65-70% of the population (Raza et al., 2023). IT (information technology) plays a significant role in the textile industry since it has enhanced industrial efficiency and enabled sophisticated design and manufacture (Ren et al., 2023). Moreover, IT

also plays an important part in the agriculture sector since the greater farmers' capacity to accept technology innovations, the greater they can cultivate productivity land, which can boost outputs and hence farmer welfare (Ernawatiningsih et al., 2023). So, giving IT skill training will benefit the trade sector more.

The current study's limitations provide opportunities for further research. One of the limitations of the study is the availability of the data because it affects the validity of the results. ARDL approach can assist in dealing with the problem of endogeneity, but there could yet be bias issues caused by missing variables. Other variables that impact both HDI and ECI may exist, and failure for accounting such variables may result in biased conclusions. Furthermore, this study has been limited to developing countries with similar income and economic structure of Pakistan. Since we all know that each country has distinct and diverse economic, political, social, and other elements that impact the country's development. considering these differences, the findings of this study may not be applied to other developed countries in broader context. The current study based on the aggregate data of Pakistan, future research can be focuses on trading sector e.g. textile sector of Pakistan or agricultural sector of Pakistan to determine the sectoral relationship between HDI and ECI. The current study applied the composite HDI, future research can analyze the impact of sub-indices of HDI, for disaggregate analysis. For instance, impact of life expectancy index, education index, and living standard index on EC. It will be a worthful and beneficial addition to future research. The temporal scope of this study is also limited, future studies can expand the data set with inclusion of more years and countries.

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