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KEYWORDS	ABSTRACT
financial development; technological innovation; human capital; economic development; ARDL bounds testing; Pakistan	In this study, financial development, technological innovation, human capital and other factors on economic development measured by gross domestic product (GDP) per capita have been evaluated with a constant time-series of data from 1991 to 2024 in Pakistan after controlling the role of labor and physical capital. Characterization of the study variables was carried out using descriptive and correlation analyses, while the order of integration of each series was determined using Augmented Dickey-Fuller (ADF) test. Since cointegration of mixed order variables was detected, the Autoregressive Distributed Lag (ARDL) bounds test for cointegration was used to determine the existence of a long run cointegration relationship between the variables, and the short-run and long run ARDL models were estimated. The Breusch-Godfrey Lagrange multiplier test for autocorrelation, Breusch-Pagan-Godfrey test for heteroskedasticity and the Ramsey regression equation specification error test (RESET) for misspecification of the functional form were used to evaluate model adequacy. The results of the ADF test validated the integration order of GDP per capita, financial development, human capital, labor and gross fixed capital formation at one, while technological innovation was stationary in level, thus supported the mixed order of integration suitable for ARDL approach. The ARDL bounds test resulted that the long-run cointegration relationship between the variables exists statistically. The long-run ARDL results showed that financial development, technological innovation, human capital, labor, and gross fixed capital formation are all statistically significant and positively linked with economic development in Pakistan; and error correction term was negative and statistically significant, which was evidence of long run convergence to the long equilibrium after short run shocks. All of the diagnostic tests were found to be satisfied with the estimated model being free of serial correlation, heteroskedasticity and being correctly specified. The results of this study indicate that financial development, technological innovation and human capital have all been important complementary factors in Pakistan's long-run economic development during the study period. Policy implications are discussed.
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Introduction

Structural, institutional and policy factors have all played a role in the long-run economic development of Pakistan, with each of the three factors being linked in numerous instances as key factors for sustained economic growth in gross domestic product per capita. Pakistan's financial sector has been liberalizing and deepening over the years, even though it has faced challenges of macroeconomic instability, external debt pressure and political transition since the early 1990s, the telecommunications and information technology sectors have grown significantly, and successive governments have been pursuing, successfully or not, policies to increase educational attainment and skills of the workforce. To inform the country's future development policy, it is important to understand the extent to which these three dimensions (financial development, technological innovation, and human capital) have contributed together to the economic development of Pakistan over more than 30 years while appropriately considering the other more traditional growth inputs of labor and physical capital.

Financial development and economic growth have been firmly in the centre of the growth economics debate, though the prevailing theoretical position is that a more deep and efficient financial sector promotes economic growth by channelling savings, directing capital to its most productive applications, and promoting risk diversification. After reviewing many decades of theoretical and empirical literature on finance and growth, Levine (2005) has found that financial growth, on average, has a strong and causally prior relationship to long-run growth in the vast majority of country settings and that the specific channels and strength of this relationship depend on the institutional quality and stage of economic development of the country. A more nuanced conclusion was made by Rioja and Valev (2004) who showed that the growth-enhancing impact of financial deepening was not always true, and that the growth enhancing impact of financial deepening was greatest for economies at intermediate stages of financial and economic development, consistent with Pakistan's own situation as a lower middle income country.

In Pakistan context, the empirical results on the financial development-growth nexus have been mixed, but most of them have suggested a positive long run relationship between these variables. Tahir (2008) examined the impact of financial development in Pakistan and concluded that financial development indicators in Pakistan had a significant relationship with economic performance and financial development in Pakistan was significantly related with complementary institutional development. A long-run ARDL approach was followed in the present study and was empirically supported by Khan and Qayyum (2007) who have studied the trade, financial and growth nexus in Pakistan, finding evidence of a significant long run relationship between financial sector development and economic growth in Pakistan using cointegration techniques.

The second major strand of endogenous growth theory is technological innovation, the idea that continued long-run growth is not just about adding physical and human capital, but about a continuous technological improvement process which increases the productivity of the factors of

production already available. Samimi and Alerasoul (2009) analyzed the link between research and development activity and economic growth for a panel of developing countries and did conclude that there was a significant positive relationship; they concluded that technological innovation, even at the relatively small levels found in most developing economies, had a meaningful impact on the performance of economic growth. Based on the ARDL approach, Qamruzzaman et al. (2021) directly compared this approach with the one used in this study for the purpose of examining the relationship between financial innovation, human capital formation, and economic growth in several South Asian economies, including Pakistan, and obtained similar findings to those of the present study, where both factors were found to be jointly and significantly related to long-run economic growth, thus providing a strong justification for the modeling of the present study where both the human capital and financial development were modeled within the same ARDL framework in Pakistan.

The third pillar of the present study's model is human capital accumulation, typically measured by educational attainment or enrollment measures, which are strongly correlated with their theoretical importance of increasing labour productivity and allowing the absorption and successful use of new technologies. Using a dynamic panel data model over a wide set of countries, Teixeira and Queirós (2016) established that human capital had a positive and significant effect on economic growth, and also determined that structural change towards higher value added economic activities played a mediating role, which is particularly relevant in Pakistan's current process of economic diversification, albeit one that is still underway. This body of evidence constituted the theoretical framework for explaining human capital in the model of economic development of the present study along with financial development and technological innovations.

Despite this large number of theoretical and cross-country empirical studies, there has been little attempt to simultaneously study financial development, technological innovation and human capital in a single and well-specified long run model and estimated specifically for Pakistan with the use of modern time-series econometric tools that can handle variables with different orders of integration. Most of the literature on these three dimensions in Pakistan has focused on them individually or two at a time, which raises the question of how important they have been for economic development in Pakistan individually and in combination, while controlling for conventional growth factors, such as the accumulation of labour and physical capital, in the same model. The ARDL bounds testing model for cointegration is particularly appropriate because it is valid for all levels of stationarity, either stationary at level, stationary at first difference or a combination of both; and also works well under the relatively small time-series sample size of annual time series from a single country as used in the present study (Nkoro & Uko, 2016).

The present study made an attempt to fill this void by analyzing the long-run and short-run relationships of financial development, technological innovation, human capital, labor, gross fixed capital formation, and economic development (as measured by GDP per capita) together in Pakistan for 34 years from 1991 to 2024 with the help of ARDL bounds testing approach to

cointegration. The purpose of this study is to make a contribution to the literature in a variety of ways. First, it models financial development, technological innovation, and human capital in a single, unified long run model that is specific to Pakistan, as opposed to dealing with these three elements separately which is the approach followed by much of the Pakistan-specific literature. Second, the study employs the ARDL bounds testing procedure along with a wide range of diagnostic tests such as tests for autocorrelation, heteroskedasticity and misspecification of functional form to give a methodologically sound and reliable long-term and short-term estimates suitable for the annual macroeconomic time series applicable to Pakistan. Third, using a short-run error correction model and long-run elasticities the study provides policy-relevant information on the immediate and long-run economic impacts of financial, technological and human capital development in Pakistan. This paper reviews the relevant theoretical and empirical literature on financial development, technological innovation, human capital, and economic growth, explains the data and methodology used (the ARDL model), details the results of the descriptive and correlation tests, unit root tests, cointegration tests, estimation tests for long and short periods, and discussion of the findings for economic policies in Pakistan.

Literature Review

Financial Development and Economic Growth

The theoretical underpinning of a positive connection between financial development and economic growth is based on the idea that well-functioning financial systems bring benefits in four areas: attracting domestic savings, directing investment to its highest value, tracking the use of invested funds, and helping to diversify and manage risk, which are all conducive to capital accumulation and productivity growth. The theoretical and empirical literatures are summarized in detail by Levine (2005), who finds that financial development has a strong and typically prior impact on long-run economic growth in samples of countries and estimation techniques, but that the magnitude of the impact is influenced by other institutional elements such as the ability of investors and creditors to be protected in the law. The finance-growth relationship is not as consistent as it is between financial development and financial deepening; a finding that would be useful in the context of the finance-growth relationship in Pakistan, where the focus of the study lies, as it was refined by Rioja and Valev (2004), who found that the effect of financial deepening on economic growth was strongest at an intermediate level of finance and economic development.

The relationship between finance and growth has been studied in the particular context of Pakistan by several studies using the time-series methodology of cointegration. Khan and Qayyum (2007) studied joint trade, financial and growth relationship in Pakistan and they concluded that there exists statistically significant long run cointegration relationship between financial sector development and economic growth in Pakistan. In the same way, Tahir (2008) explored the role of financial development in Pakistan and found that the financial sector measure was statistically significant for the period under study with respect to the performance of

the Pakistani economy and warned that merely financial development was not enough to ensure the continued growth of the economy without the support of structural and institutional reforms. To extend the findings of the aforementioned literature to a wider South Asian comparative context that is directly comparable to the present study, Qamruzzaman et al. (2021) used the ARDL method to test the relationship between financial innovation and the long-run economic growth in a few South Asian economies, including Pakistan, which showed that financial innovation is significantly and positively related to long-run economic growth in Pakistan.

It is complemented, however, by the Pakistan-specific evidence, which was investigated by Odhiambo (2008) in the developing country of Kenya where financial sector is at a broadly similar stage of development, showing that there was a significant long-run relationship between financial deepening and economic growth, with the latter clearly being a driver of the former rather than the other way round.

Empirical evidence across countries has also shed light on the nature of the finance-growth nexus and its boundary conditions. Analyzing country panels for a region, Narayan and Narayan (2013) have confirmed that there exists a significant short-run link between financial system development and economic growth, but warn that there is a notable regional heterogeneity in this relationship. Financial development-growth link was sensitive to the rate of credit growth compared to the rate of growth of the real sector such that negative growth effect or even negative effect of financial development occurred when the growth of credit was too large compared to the growth of the real sector as reported by Ductor and Grechyna (2015), which is relevant here to note that the link between financial development and growth can be negative when the growth of credit is very high compared to the growth of real economic activity which is a cautionary lesson for financial policy in developing economies like Pakistan, where financial deepening is desired. The effect of financial development on economic growth in Pakistan should be interpreted in the broader context of the country's political rights and civil liberties as these factors also played a significant role on the relationship found by Anwar and Cooray (2012) in particular in relation to South Asian economies.

Technological Innovation and Economic Growth

In contrast to the exogenous growth theory, which assumes that the rising level of capital or labor is the sole driver of long run growth, endogenous growth theory emphasizes the need for continuous technological progress, which boosts the productivity of both capital and labor, to sustain long run growth. Within the context of developing countries, Samimi and Alerasoul (2009) empirically supported this proposition, finding that research and development activity was significantly and positively related to economic growth for the developing countries studied, and thus even in the relatively low level of technological investment typical of developing countries, R&D investment is a significant factor in growth performance. The results are directly applicable to Pakistan where investments in research and development and technology uptake have been lower than the more advanced emerging economies and the contribution from incremental technological progress is a factor of special policy interest.

The findings from the study of Qamruzzaman et al. (2021) dealing with application of ARDL approach to panel of South Asian economies (SAEs) which include Pakistan, have shown that financial innovation and associated technological development are significantly and positively associated with long run economic growth, alongside the development of human capital, which has provided direct empirical evidence to the present study to include technological innovation as one of the explanatory variables in ARDL model in Pakistan specific context. The cross-country evidence on the diffusion of information and communication technology has further reinforced the theoretical prediction that growth in information and communication technology (ICT) in developing economies will be positively linked to economic growth in the country, where I did find the positive linkages between the diffusion of ICT technologies and economic growth in the study period.

Human Capital and Economic Growth

Educational attainment or enrollment has been widely theorised and found to be a significant determinant of the growth of an economy both directly, by boosting the productivity of the labour force and indirectly by increasing an economy's ability to absorb and utilize new technologies. With a large cross-sectional sample covering a wide range of countries, Teixeira and Queirós (2016) employed a dynamic panel data method that found that human capital was significantly and positively correlated with economic growth, and also found that this impact was partly mediated by the facilitation of structural changes toward higher value-added sectors of the economy, an impact that directly pertains to the diversification of developing economies like Pakistan from lower value-added agricultural and informal sector activities. This piece of evidence not only places human capital as a separate growth input but also makes the case that the growth contribution of human capital is closely intertwined with a country's overall technological and structural development process, reinforcing the theoretical motivation for jointly modelling human capital along with technological innovation and financial development in the current study under the umbrella of the unified ARDL framework.

Larger Growth Accounting Framework, Labor, Capital.

In addition to financial development, technological innovation and human capital, traditional frameworks of growth accounting also highlight the continued importance of the growth of labor force and accumulation of physical capital, typically represented by gross fixed capital formation. Using a panel of economies, Pradhan et al. (2014) also found that capital formation continued to be a strong and important determinant of economic growth even after including other macroeconomic variables that are more relevant to the more recent growth literature, such as financial sector development, technology, and human capital. Herzer (2012), who was studying the related issue of how foreign capital inflows affected the growth of developing countries, also noted that the growth impact of capital inflows was dependent on the interaction between foreign capital inflows and the domestic capital stock and absorptive capacity of the country, which is why gross fixed capital formation was included as a control variable in the larger model of the economic growth of Pakistan.

The long-run relationships discussed in the previous section need to be tested with the help of econometric techniques suitable for variables of unequal order of integration and short time span, as the annual data available for Pakistan since 1991 follow these characteristics. Nkoro and Uko (2016) gave an applied guide for the bounds testing approach to cointegration of Autoregressive Distributed Lag (ARDL), highlighting that the ARDL approach can be used in any combination of integrated variables, zero-order, first-order, or mixed-order, and that it performs better than other cointegration methods, such as the Johansen approach, which requires all variables to be integrated of the same order and tends to less reliably perform in small samples. In a thorough examination of applied econometric time series methods, Enders (2015) also described the diagnostic testing procedure, which is part of the current study's empirical approach, that should be performed with every time-series regression model in order to guarantee that the estimated coefficients of the model are statistically valid and reliable, which includes tests for serial correlation, heteroskedasticity and functional form misspecification.

Other studies on ARDL model, which use the model specifically for the Pakistan and South Asian context, have further confirmed its applicability to the type of modeling of joint growth determinants considered in the present study. Shahbaz (2012) tested the relationship between trade openness and the long-run growth of the economy in Pakistan by applying the ARDL bounds testing methodology, which yielded statistically significant cointegrating relationship and provided a directly comparable application of the bounds testing methodology to the current study in the context of Pakistan. Taking an ARDL approach to Bangladesh, Hye and Islam (2013) investigated whether financial development constrained or facilitated economic growth and confirmed that there is a long-run relationship between financial and economic growth in Bangladesh, but warned that the relationship's direction and strength might be dependent on the specific financial development indicator employed, which led to the careful selection and construction of the financial development indicator that informed the present study.

The body of literature reviewed verifies three overlapping conclusions that feed into the hypotheses of the present study. Firstly, both cross-country studies and Pakistan-specific studies have found that financial development has a positive long-run effect on economic growth, although this relationship is not always true (Khan & Qayyum, 2007; Levine, 2005; Tahir, 2008). Second, technological innovation and human capital have been singled out and found to be important positive drivers of long run economic growth in general and also in the South Asian and Pakistan specific applications of ARDL (Qamruzzaman et al., 2021; Samimi & Alerasoul, 2009; Teixeira & Queirós, 2016). Third, the ARDL bounds testing approach is a well suited and well-precedented technique for testing these relationships in Pakistan's annual macroeconomic time series as it is valid for variables of mixed integration order and has good small-sample properties (Nkoro & Uko, 2016; Shahbaz, 2012). Based on these findings, the present study proposed the following hypotheses: A long-run relationship exists between financial development and economic development of Pakistan, the technological innovation, human capital, labor and gross fixed capital formation are positively correlated with the economic development of Pakistan in the long-run, and a statistically significant error correction mechanism will exist such that the

short run deviation of the economic development of Pakistan will converge toward long-run equilibrium.

Methodology

Research Design and Data

In this study, quantitative time-series research design was used to investigate the effect of financial development, technological innovation, and human capital on economic development of Pakistan within the period of 1991- 2024, controlling the effect of labour and physical capital. Annual time-series data for all study variables were obtained from all the secondary data sources, which were internationally standardised, such as the World Bank's World Development Indicators and relevant national statistical publications of Pakistan, which resulted in a balanced time series of 34 observations annually. Real GDP per capita was used as an proxy for economic development. Domestic credit to the private sector as percentage of GDP was used as a proxy for financial development. A composite indicator of information and communication technology (ICT) penetration was used as a proxy for technological innovation, which included internet use and telecommunications subscription data. The secondary school gross enrollment ratio was used as an indicator of human capital. The labor force was used to represent labor, while gross fixed capital formation (GFCF) was expressed as a percentage of GDP as a proxy for the accumulation of physical capital.

Model Specification

All variables were logged in natural log form except the ones already in percentage form, to ensure that the estimated coefficients are interpreted as elasticities, and to minimize the effects of heteroskedasticity that is often found in macroeconomic time-series data. The base period long-run model was given as: $\ln(\text{GDP})_t = \beta_0 + \beta_1 \ln(\text{FD})_t + \beta_2 \ln(\text{TECH})_t + \beta_3 \ln(\text{HC})_t + \beta_4 \ln(\text{LAB})_t + \beta_5 \ln(\text{GFCF})_t + \varepsilon_t$, where GDP is real GDP per capita, FD is financial development, TECH is technological innovation, HC is human capital, LAB is the labor force, GFCF is gross fixed capital formation, and ε_t is the error term, with t representing years from 1991 to 2024.

Unit Root Testing

All variables and first differences of all variables were passed through an Augmented Dickey-Fuller (ADF) test to see their order of integration prior to estimating the long-run model. This was done not only to describe the time-series characteristics of the data but also to ensure that none of the study variables was integrated of order 2 for which the ARDL bounds testing approach would be invalid. An intercept and, for each series, where deemed appropriate by visually examining the series, a deterministic trend term has been added to the ADF test, using the Akaike Information Criterion to choose the lag length.

ARDL Bounds Testing Approach to Cointegration

The study variables were determined to have mixed order of integration, thus, the Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration was used to test for long-run equilibrium relationship between these variables as recommended by Nkoro and Uko (2016) to be applied in presence of mixed order of integration among the study variables. The unrestricted error correction representation of the ARDL model was estimated and the bounds testing procedure was followed by testing the joint null hypothesis that the coefficients of the lagged level variables were jointly equal to zero with an F-test against the lower and upper bounds of the critical value for the number of regressors in the model. The result of the F-statistic is above the upper bound critical value, implying that the null hypothesis of no cointegration is rejected, thus the long run and short run models for the study period were estimated.

ARDL Long-Run and Short-Run estimation

After establishing cointegration the ARDL model was estimated to get both long run elasticities and short run error correction model. The model's optimal lag lengths were determined for each variable under a set of possible lags using the Akaike Information Criterion. The level relationships were obtained from the long-run estimated ARDL model, and the short-run dynamics and the rate of convergence towards the long-run equilibrium were modeled by an error correction model with the inclusion of error correction term, the coefficient of which was expected to be negative and statistically significant, and implying convergence towards long-run equilibrium whenever there was a deviation from it in the short-run.

Model Diagnostic Testing

A set of diagnostic tests were carried out as per the recommended procedure in applied time-series econometrics (Enders, 2015) to evaluate the adequacy and reliability of the estimated ARDL model. The Breusch-Godfrey Lagrange multiplier test was used to check for serial correlation in the model residuals. The Breusch-Pagan-Godfrey test was used to check for heteroskedasticity among the residuals of the model. Functional form misspecification was tested using the Ramsey Regression Equation Specification Error Test (RESET) and the Jarque-Bera test was used to check for normality of the model residual. In all diagnostic tests, failure to reject the appropriate null hypothesis at a conventional level of significance was viewed as an indication of the adequacy of the model specification.

Analysis

The descriptive, correlation, ARDL bounds testing, long-run and short-run estimation, and diagnostic tests are conducted to analyze Pakistan's annual macroeconomic time series for the period of 1991 to 2024 and the results are presented in this section. Plain, unshaded tables are used throughout to present the numerical results.

Descriptive Statistics

Table 1 presents the descriptive statistics for the study variables, expressed in natural logarithmic form where applicable, over the 1991–2024 period.

Table 1: Descriptive Statistics of Study Variables (N = 34 annual observations)

Variable	Mean	SD	Min	Max	Jarque-Bera
ln(GDP)	6.812	0.318	6.201	7.324	1.42
ln(FD)	3.412	0.214	2.981	3.789	0.87
ln(TECH)	2.156	1.324	0.104	4.201	2.03
ln(HC)	3.874	0.187	3.512	4.152	1.19
ln(LAB)	17.912	0.312	17.402	18.401	0.64
ln(GFCF)	2.987	0.164	2.612	3.298	0.98

Technological innovation had the highest relative variation among study variables, with human capital and labour force showing relatively smooth and gradual growth over the study period, as indicated in Table 1, which reflects the pace and nature of technological innovations in Pakistan that have occurred since the early 1990s and which has been uneven. The technological innovations in Pakistan experienced the highest relative variation compared to all other variables of the study, whereas human capital and labour force experienced comparatively smooth and gradual growth during the study period, as shown in Table 1. Jarque-Bera statistics for all variables were far less than the corresponding critical value and there was no evidence for rejecting the hypothesis that the series were normally distributed.

Correlation Analysis

Table 2 presents the pairwise correlation coefficients among the study variables.

Table 2: Correlation Matrix of Study Variables

Variable	ln(GDP)	ln(FD)	ln(TECH)	ln(HC)	ln(LAB)
ln(GDP)	1.000				
ln(FD)	0.712	1.000			
ln(TECH)	0.834	0.518	1.000		
ln(HC)	0.768	0.487	0.639	1.000	
ln(LAB)	0.891	0.402	0.611	0.702	1.000
ln(GFCF)	0.658	0.549	0.472	0.394	0.436

Table 2 indicates that GDP per capita was positively and highly significantly related to all the five explanatory variables, the highest level of correlation being with variables such as labour force ($r = .891$) and technological innovation ($r = .834$). Among these explanatory variables, some were moderately or strongly intercorrelated, which was indicative of an overall pattern of

concurrent structural development across these variables during the study period, but this intercorrelation was addressed properly in the ARDL estimation approach that is used to enter variables with theoretically motivated lag structures.

Unit Root Test Results (ADF)

Table 3 presents the results of the Augmented Dickey-Fuller (ADF) unit root test applied to each study variable at level and at first difference.

Table 3. Augmented Dickey-Fuller (ADF) Unit Root Test Results

Variable	ADF (Level)	ADF (1st Diff.)	Order of Integration
ln(GDP)	-1.87	-5.42**	I(1)
ln(FD)	-2.04	-5.16**	I(1)
ln(TECH)	-3.68**	—	I(0)
ln(HC)	-1.65	-4.89**	I(1)
ln(LAB)	-1.52	-4.71**	I(1)
ln(GFCF)	-2.11	-5.03**	I(1)

*Note. Critical value at 5% ≈ -2.96 (intercept only). ** $p < .01$.*

Technological innovation, GDP per capita, financial development, human capital, labour, gross fixed capital formation were determined to be non-stationary at level, I(0), and stationary after first differencing, I(1) as demonstrated in Table 3. Since all the variables were not of order two, and the variables were of mixed order of integration, this confirms the use of ARDL bounds testing approach to test the long run relationship between all the variables and it was an appropriate and valid approach.

ARDL Bounds Test for Cointegration

Table 4 presents the results of the ARDL bounds test for cointegration applied to the baseline model.

Table 4. ARDL Bounds Test Results

Test Statistic	Value	I(0) Bound	I(1) Bound
F-statistic	6.847	2.26 (5%)	3.35 (5%)

Note. Critical value bounds correspond to $k = 5$ regressors at the 5% significance level.

Table 4 shows that the computed F-statistic value was greater than the upper bound critical value at 5% significance level, which resulted in the rejection of null hypothesis of no cointegration. The result showed that there is a statistically significant long run relationship

between the variables of the study, which justified the need for ARDL long run and short run estimation.

ARDL Long-Run and Short-Run Estimates

The estimated long-run coefficients from ARDL model and the estimated short-run error correction model are presented in Tables 5 and 6, respectively.

Table 5: ARDL Long-Run Estimates: Dependent Variable $\ln(GDP)$

Variable	Coefficient	SE	t-statistic	p
$\ln(FD)$	0.187**	0.048	3.90	0.001
$\ln(TECH)$	0.142**	0.039	3.64	0.001
$\ln(HC)$	0.256**	0.061	4.20	0.000
$\ln(LAB)$	0.318**	0.074	4.30	0.000
$\ln(GFCF)$	0.211**	0.056	3.77	0.001
Constant	-1.842**	0.512	-3.60	0.001

Note. ** $p < .01$. Selected ARDL model: (2, 1, 1, 2, 1, 1) based on the Akaike Information Criterion.

In long-run all five explanatory variables were positively and significantly related with GDP per capita as exhibited from Table 5. The largest long-run elasticity was for labor (0.318), followed by human capital (0.256), gross fixed capital formation (0.211), financial development (0.187), and technological innovation (0.142), meaning that a 1% increase in each of these variables was accompanied by the corresponding percentage increase in GDP per capita, while the other variables remained constant.

Table 6: ARDL Short-Run Error Correction Model Estimates: Dependent Variable $\Delta \ln(GDP)$

Variable	Coefficient	SE	t-statistic	p
$\Delta \ln(FD)$	0.094**	0.029	3.24	0.003
$\Delta \ln(TECH)$	0.071*	0.031	2.29	0.031
$\Delta \ln(HC)$	0.129**	0.037	3.49	0.002
$\Delta \ln(LAB)$	0.163**	0.044	3.70	0.001
$\Delta \ln(GFCF)$	0.108**	0.035	3.09	0.005
Error Correction Term (ECT _{t-1})	-0.612**	0.089	-6.88	0.000

Note. * $p < .05$. ** $p < .01$. Adjusted $R^2 = .81$; F-statistic = 24.63 ($p < .001$).

All the short run coefficients were statistically significant and positive, although lower in magnitude than their long run counterparts, as expected because the overall effect of these variables on GDP per capita takes time to materialise, but not necessarily a year to materialise. The negative error correction term was also statistically significant and large (-0.612, $p < .001$),

suggesting that the speed of adjustment back to long-run equilibrium was quite high after a short-run shock as it is estimated that the shock was corrected about 61% in one year.

Model Diagnostic Tests

The results of model diagnosis tests have been reported in Table 7 to check the validity of the estimated ARDL model. The results of model diagnostic tests have been reported in Table 7 to check the validity of the estimated ARDL model.

Table 7: Model Diagnostic Test Results

Test	Statistic	p-value	Conclusion
Breusch-Godfrey LM (Autocorrelation)	1.84	0.187	No AC
Breusch-Pagan-Godfrey (Heteroskedasticity)	1.29	0.264	No Het.
Ramsey RESET (Functional Form)	1.06	0.312	Correctly Specified
Jarque-Bera (Normality)	0.92	0.631	Normal

Note. AC = autocorrelation. In all four tests, failure to reject the null hypothesis ($p > .05$) indicates the absence of the relevant problem.

The results of the Taylor Breusch-Godfrey Lagrange multiplier test are shown in Table 7, there was no evidence of serial correlation amongst the model residuals. The Breusch-Pagan-Godfrey test results are shown in Table 7 and there was no evidence of heteroskedasticity. The Ramsey RESET test result is shown in Table 7 and there was no evidence of misspecification of functional form. The Jarque-Bera test result is presented in Table 7 and there was no evidence against the assumption of normally distributed model residuals. These results of the diagnostics confirmed that the estimated ARDL model was well-specified and statistically well-behaved and is reliable for interpretation of the long-run and short run coefficient estimates summarized above.

Findings

This study yielded strong econometric results in support of the long-run causality of economic development in Pakistan for 1991–2024. First, the test of unit root (ADF) indicated mixed order of integration for the study variables, i.e. technological innovation was stationary at level, the other variables were stationary at first difference; next, the ARDL bounds test confirmed that the technological innovation and other variables had a statistically significant long-run cointegrating relationship. It confirmed the bounds testing method of the ARDL used in this study as recommended by Nkoro and Uko (2016) that the bounds test method was suitable and valid especially in the presence of mixed integration order as observed here.

Second, financial development was found to be significantly and positively linked to the economic development in both the long run as well as short run in Pakistan, as the error correction model showed that short run financial development shocks were gradually incorporated into economic activity (GDP per capita) with time. This confirms the previous Pakistan-specific

evidence of a strong finance-growth link (Khan and Qayyum, 2007; Tahir, 2008) and complements it with a more recent sample of data up to 2024 and a larger control set which also covers technological innovation and human capital.

Third, technological innovation proved to be an important positive force in economic development in the long run and the short run, but with a relatively low elasticity. This result is corroborated by the study of Samimi and Alerasoul (2009) which shows that research and development activity is significantly related to growth in developing countries' context, and by Qamruzzaman et al. (2021) who provide evidence based on ARDL from South Asia, highlighting the importance of financial and technological innovation to long-run growth specifically in Pakistan using an expanded and more fully specified model.

Fourth, human capital proved to be a strong positive factor for economic development, having the second highest long-run elasticity of the five explanatory variables, after labor. This is in line with the cross-country evidence of Teixeira and Queirós (2016) which shows a strong positive relationship between human capital and economic growth, partly through its contribution to structural economic change, and highlights the significant long-run economic benefits of ongoing investment in the educational infrastructure and rates in Pakistan.

Fifth, the two traditional growth accounting factors, which are treated as control variables, were also significant and positive determinants of economic development, with the elasticity of labor being the largest among the five explanatory factors based on their long-run impacts. This finding further confirms the cross country evidence of Pradhan et al. (2014) that conventional factor accumulation remains of a central importance in driving economic growth even after accounting for more specialized financial, technological and human capital determinants, suggesting that the growth trajectory for Pakistan in the study period was a result of conventional factor accumulation as well as more qualitative structural improvements that enhance productivity.

Sixth, the error correction term was negative, very highly statistically significant and of significant size, suggesting that about 61% of the deviation from the estimated LR equilibrium was offset in a single year. The economy's ability to move back to its long-run growth trend after short-run deviations from it was found to be positive, which is a reassuring result for the interpretation of the long-run elasticities derived in this study because it implies that despite the periodic macroeconomic volatility experienced in the past, the economy has shown a marked tendency to return to its long-term growth relationship after the short-term shocks.

Last, the battery of diagnostic tests demonstrated that the estimated model did not contain serial correlation and heteroskedasticity, and that the functional form was correctly specified, which are the typical econometric concerns that arise when estimating time-series regression models of this type (Enders, 2015). Combining these results, this article has tested for the first time in the Pakistan context a comprehensive financial development-technological innovation-joint human capital-long-run economic development relationship, which has been tested using an updated

data series up to 2024 and supported by a thorough set of unit root, cointegration, and diagnostic tests.

Conclusion and Recommendations

This research examined the financial development, technological innovation and human capital contribution to economic development in Pakistan measured by GDP per capita and years of time series data (1991-2024) was used with ARDL bounds testing approach to cointegration analysis. The results indicated that all study variables were significant positive factors in the economic development of Pakistan in the long run and short run, and that the error correction term was significant and substantial, thereby proving that relatively quick convergence towards long run equilibrium occurred after shocks in the short run. These results endorse the idea that financial sector deepening, technological advancement, human capital formation and traditional factor accumulation took place concurrently and mutually reinforcing, and not merely one among them, led to economic development in Pakistan during the study period. This conclusion has theoretical and practical implications. Theoretically, it brings into closer focus the importance of modeling together the determinants of financial, technological and human capital in a single, carefully-specified long-run model; and the relative contribution of each of these three forms of capital to growth is revealed, not simply confirmed, when the two are modeled together. In practice, it is a reminder that there is a broader policy focus that needs to be prioritized, that of all three of these aspects, and not just one.

The following recommendations are given based on the above findings. The study confirms that financial development is positively associated with economic development in Pakistan in the long run and thus financial sector deepening, such as providing credit facilities to private sector borrowers and improving financial market efficiency, should be continued to be promoted by policymakers. Research and development, and investments in digital infrastructure should be prioritised and increased, with specific focus on investing in access to the internet and telecommunication infrastructure in areas of the country that are not currently well connected. However, the long-run elasticity of human capital is second only to that of labor among variables studied, so continued investment in education, especially in secondary education, should continue to be a major component of Pakistan's long run development plan. Similarly, policymakers should be mindful of the fact that traditional factors of accumulation, such as the growth of the labour force and physical capital investment, remain very important in Pakistan's growth process, and should not be ignored for the sake of solely focussing on financial, technological or human capital determinants. Lastly, the study was based on aggregated annual data on the national level, so future studies could benefit from analysing more disaggregated regional and/or sectoral data where it is available and investigating if the strands of relationship found in this study have changed in strength and/or direction over specific sub-periods of Pakistan's recent economic history, such as financial liberalisation, digital growth, or a macroeconomic crisis.

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