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FINANCIAL INNOVATION, HUMAN CAPITAL DEVELOPMENT, AND ECONOMIC GROWTH OF SELECTED SOUTH ASIAN COUNTRIES

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Abstract

This paper offers an elaborate empirical assessment related to nexus of financial innovation, human capital development and economic growth focusing on selected economies of South Asia during 1991 to 2022. Anchored in the endogenous growth literature, the current study incorporates the theoretical insights of Romer (1986, 1990) and Lucas (1988) in the quest to analyze the interplay between innovative financial systems and human capital accumulation in promoting productivity and hence, long-run growth. Using stable panel data for Bangladesh, India, Pakistan, Sri Lanka, Nepal, and Bhutan, the exploration reflects dynamics within and crosswise countries by using fixed and random effects estimators. Key control variables such as trade openness, gross capital formation, technological innovation and labor force participation are included so that the model is robust. The empirical findings show that both financial innovation and human capital have positive and statistically significant impacts on economic growth as predicted by theories of endogenous growth models. Moreover, the results imply the existence of complementarities between financial development and human capital formations are important in sustaining innovation-led growth in the emerging south Asian economies. The research also concludes that a combination policy framework to promote financial modernization coupled with human capital investments is critical to generating inclusive and sustainable economic expansion in the region.

Keywords: *Financial Innovation, Human Capital Development, Panel Data Analysis, South Asia, Sustainable Economic Growth. JEL Classification: O16, O15, O47, C23, O53*

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Introduction

Economic growth is defined as a rise to the tools and items that will be used to fulfill the human needs in any country or region of the world. A method to calculate economic growth rate involves inquiring whether there has been a real increase (excluding price increases) in GDP (Gross Domestic Product) from one year to the other as GDP represents the market equivalent of all measurable values produced by one economy Çalışkan (2015). The economic performance of countries differs because the factors that determine growth differ from one another. Growth is intricately connected to several factors in various domains, including investment in physical and human capital, foreign direct investment, financial development, inflation, and industrialization. Haouas & Yagoubi (2005).

Development economics concepts consistently emphasize the importance of high quality human resources and a well-functioning financial sector for achieving sustainable growth. Sustainable economic growth can be achieved by optimizing economic resources through the accumulation of human capital and having an efficient finance sector. In the study conducted by Abubakar et al. (2015), Financial development promotes economic growth by enhancing the efficiency and effectiveness of capital utilization and facilitating the accumulation of capital through the promotion of savings. This is achieved through the introduction of new and improved financial instruments and services as a consequence of financial innovation. Aziz & Duenwald (2002)and Mention & Torkkeli (2012) are the authors referenced. Financial innovation facilitates the growth of financial activities by introducing a wide range of assets and services into the financial system. This, in turn, promotes financial development and fosters robust economic growth Friedline & West (2016). Financial innovation acting a crucial role for sustainable financial development with innovative financial services, ensure financial transparency Richardson (2016) and financial integrity Gelb (2016) so enhance institutionalization in the financial sector. Institutionalization of financial institutions favorably effects on society, financial environment and economic development Ruiz (2018), which are the fundamental components for sustained economic growth Salampasis & Mention (2018).

Financial innovation increases financial intermediation by enhancing efficiency in financial sector, hence in turn, boost economic growth Greenwood & Jovanovic (1990); Bencivenga & Smith (1991) through financial inclusion Napier (2010), effective financial transfer and efficient mobilization of investor funds across borders Carbó Valverde et al. (2007).

Financial efficiency is the necessary prerequisite for sustainable development Dynan et al. (2006) but not sufficient, another crucial ingredient, however, in the development process is human capital. It is because excluding human capital contribution, physical capital alone cannot explain long-run economic growth Galor & Tsiddon (1997). Human capital became an important part of the development process by the establishment of growth theory in the 1950s and human capital theory proposed by Becker (1964) and Schultz (1961). Human capital refers to aggregated skills, knowledge, innovative capacities possessed by the population of the country Ugal & Betiang (2009). It is evident that by learning skills and knowledge people transform into human capital, which is occupied considerable role in the manufacturing process, especially for labor-intensive area Schultz (1961). Apart from the industrial process, the trained person is the key for economic growth by assuring productive use of human capacity as human capital in the growth equation in both developed and developing countries Lucas Jr (1988); Romer (1986). Past couple of decades, the importance of human capital in the development process is extensively noted and documented by policymakers, academics, and academicians. Contribution from human capital in economic process either as a productive factor in production or/and act as important catalyst of bringing technological innovation, spread and embracement of technologies Freire-Serén (1999); Oluwatobi et al. (2016), since inefficient human capital adversely affects by economic growth not only through loss of long-term investment but also inefficient allocation of economic resources in the economy.

Existing studies on South Asian countries often examine financial innovation and human capital separately, leaving a gap in understanding their combined impact on economic growth. Comparative and long-term analyses are also limited, especially regarding regional differences and policy influences. Moreover, the role of digital finance and finch in supporting human capital and growth remains underexplored. This study aims to fill these gaps through an integrated approach.

On the basis of the research gap the investigated study raised following research questions: what is the relationship between financial innovation and economic growth? What is the relationship between human capital development and economic growth? And what is the relationship of economic growth with control variables (trade Openness, Gross Capital Formation, Technological Innovation)? The objectives of the present study are to analyze the relationship between financial innovation and economic growth, to explore the relationship between human capital development and economic growth, and to find out the relationship of economic growth with control variables such as trade openness, gross capital formation, and technological innovation.

This research is significant as it enriches the study on the components of economic growth in South Asia by exploring how financial innovation and human capital development interact to shape economic performance. It provides practical insights for policymakers to design strategies that promote innovation, education, and health to achieve sustainable growth. The findings may also guide development organizations and the private sector in fostering balanced and inclusive economic advancement in the region. The structure of this thesis is as follows: Chapter 1 showing introduction part, Chapter 2 provides existing literature on financial innovation, human capital development, and economic growth. Chapter 3 contains theoretical back ground and model specification. Empirical findings and discussion are presented in chapter 4. Conclusion and policy recommendations are presented in last chapter.

2. Literature Review

Abubakar et al. (2015) explored that local and non-public bank loans meaningfully add to economic growth in Economic Community of the West African States (ECOWAS), together straight and through augmenting human capital accumulation. The study suggested that betterment to credit access for consumers and businesses can efficiently contribute in regional development. Adam & Guettler (2015) found that team managed funds outperform solo-managed ones when using multifaceted tools like CDS due to wider knowledge. Conversely, at the time of financial disasters, team decision becomes slower and less effective. The article also explains that funds primarily used CDS for market timing rather than evading credit risk. The investigated study by Bara & Mudzingiri (2016) calculated a bidirectional pivotal connection among financial innovation and economic growth in Zimbabwe. It showed that growth-driven financial innovation plays a vital long-term role in promoting sustainable economic development, highlighting the need for policies that contribute financial innovation in rising economies.

Adeyemi & Ogunsola (2016) investigated that in Nigeria, there is a long term correlation among human capital determinants such as life expectancy, public education spending, and secondary school enrollment and economic growth. But, they also pointed out those negative long term impacts of public health expenditures and registration in primary and tertiary schooling, advising wastefulness in resource allocation. The authors suggested focused policies in health and education to enrich human capital and funding sustainable growth. Similarly, Ali (2016) surveyed Bangladesh from 1981 to 2014 and presented that government expenditure on health and schooling, connected with school enrollment at all intervals, plays a significant role in promoting GDP growth. The study pointed that Bangladesh's tenacious encounters, such as a 29% illiteracy rate and a great part of unskilled

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workforces, which weaken growth and slow economic development. These findings emphasize that strengthening education and healthcare systems is essential for long term growth and development. In distinction, Adusei (2013) studied Ghana's financial development between 1971 and 2010 by using different econometric techniques, including FMOLS and GMM. The study measured financial development through regional credit and broad money supply as a percentage of GDP and found a negative relationship between financial development and economic growth.

Ahsan & Haque (2017) found that schooling does not unanimously connect with economic improvement; its positive impact emerges only after economies reach a certain growth threshold. Using data from 126 countries (1970–2012) and a vibrant panel threshold model, the study underlined that schooling develops an active growth driver at progressive development phases. Likewise, Qadri & Waheed (2013), evaluating 106 countries (2002–2008), detected that returns to human capital differ by income level, with less income nations promoting more from investments in schooling subsidiary the idea of human capital's conditional impression on growth.

In Pakistan, Jawaid et al. (2011) found that fiscal and monetary plans have solid long- and short-term positive special effects on growth (1981–2009), while trade policy had nominal influence. The study advised listing monetary policy to ensure stable development. Covering this viewpoint, Jawaid & Waheed (2017) explored the relation between trade and human development in Pakistan (1980–2013), illuminating a long-term connection where international trade especially in manufactured exports and capital goods supports human development, reinforcing the feedback between economic openness and social progress.

Pradhan et al. (2013), using data from 15 Asian countries (1961–2011), found mutual Granger causalities between financial, social, and economic development, indicating that improvements in one domain reinforce others, though effects vary across regions. Similarly, Hasan & Barua (2015), examining five South Asian countries (1974–2012), found that domestic savings and total debt servicing significantly promote growth, whereas variables like broad money and trade balance have little or no effect.

The seminal papers of Schultz (1961) and Nelson & Phelps (1966) set the foundation of importance of human capital as driver of economic growth. Education, vocational training and on job training are the major components of the human capital accumulation. Pace of innovation gets triggered with the inclusion of educated people in the stream of inventions Nelson & Phelps (1966). Schultz (1961) and Nelson & Phelps (1966) contributed by putting emphasize on the significance of human capital, the factors that accumulate it and differentiate it from other type of capital. Human capital has been first modeled by Lucas Jr (1988) and Romer (1986). Lucas Jr (1988) treats human capital as an additional input in production like physical capital. On the other hand, Romer (1986) presents the idea of human capital as of Nelson & Phelps (1966) that human capital is a starting point for the creation of new knowledge, innovations and ideas. But Romer moves a step forward from Nelson & Phelps (1966) in the sense that Romer (1986) models the research and development of the human capital. Inclusion of human capital accumulation to production function led to new growth regression with human capital accumulation being a vital component but the problem arose in the proper proxy for the human capital. Barro (1991) performs growth regression for a panel of countries taking primary and secondary enrollment rates as proxy of human capital confirm that human capital positively influences the economic growth.

Mankiw et al. (1992) augment the Solow model and take human capital accumulation as another factor input, using human capital accumulation; authors show significant impact of human capital on the growth. These studies showcased a positive effect of human capital accumulation for the growth however, the results became contradictory when different proxies, estimation techniques and data sets were employed. Studies advocate a positive influence of human capital in the growth empirics where a panel of countries is assembled Barro (1991) Middendorf (2006); Cohen & Soto (2007); de la Fuente & Doménech (2006); Workie Tiruneh & Radvansky (2011); Bassanini & Scarpetta (2002). At the same time, negative impact of human capital on the GDP is also significant Pritchett (2001); Benhabib & Spiegel (1994) Data quality of the human capital accumulation remains an issue from the very beginning. At first the enrollment rates had been utilized for human capital. Most frequent of these is primary and secondary enrollment rate Barro (1991); Abbas & Mujahid-Mukhtar, 2000; Abbas & Nasir (2001). Psacharopoulos & Arriagada, (1986) made first attempt to make a proxy for human capital by compiling the educational attainment data using census data for 99 countries. Data is constructed for five categories: incomplete primary, complete primary, incomplete secondary, complete secondary and higher education. The data set coverage is too small and data is for the male educational attainment instead of total labor force educational attainment.

de la Fuente & Doménech (2006) revise Barro & Lee (1996) data set by eliminating fragments from the data. Authors use their data for the growth regression and find that superior outcome is obtained when pooled data calculations are analyzed, and yield inferior results with the use of time-series variation. Krueger & Lindahl (2001) state that measurement error and poor informational content is the source of disturbance in the results. Barro and lee's reliability tests are not significant for OECD countries, suggesting a large measurement error for these countries.

Cohen & Soto (2007) present a new data set for years of schooling across countries for the period 1960-2000 and an extrapolation till the year 2010. The series are based on OECD database of educational attainment and UNESCO surveys. The quality of their data is better as compared to other data sets due to the use of high degree information on age groups and uniform classification of education across time. Extrapolation is used to obtain the years of schooling for previous time. Information is available for the population aged 15 and over, which is split in different sub groups. Methodology is same as Barro and lee except that they use data of OECD educational statistic and national statistical agency along with the census information. Accuracy was checked by matching the extrapolated values with the original Census values and no significant differences were found. Death rate heterogeneity is properly accounted for. Author's data set correlate highly with the de la Fuente & Doménech (2006) which shows high quality.

Cohen & Soto (2007) suggest that data quality does not determine the significance of the human capital accumulation rather the type of formulation of human capital accumulation used for regression determines the significance. The main problem with the Mankiw et al. (1992) is the use of secondary school as a proxy because it is higher education that mainly indulges itself in the innovative part. Benhabib & Spiegel (1994) and Pritchett (2001) could not obtain a positive and significant coefficient for human capital accumulation as their data contained measurement error and the human capital was not modeled appropriately Cohen & Soto (2007).

3. Theoretical Background and Model Specification

Young (1928) and Ramsey (1928) were conventionally designed growth model after great depression. Schumpeter (1939) confronted Marshall (1890) idea "economy is always tending towards balance" Schumpeter changed perfect competition to monopolistic competition. Harrod (1939) and *Dommer V. Pennsylvania Railroad Company* (1946) integrated Keynesian's ideas. The design of this model demonstrates how capital stock growth, labor force growth, and technological advancement interact with our economy and total output of goods and services. Arrow (1962) presents a model of (learning by doing knowledge).

According to Romer (1986), based on the Arrow model (Learning by Doing), human capital is a by-product of physical capital. Nelson & Phelps (1966) inspired Lucas Jr (1988). Lucas had two models in mind. Romer (1990) defined three sectors and indigenized technological change firstly, the intermediate goods sector second, the final goods sector and third Sector is research and development.

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To rigorously analyze the impact of financial innovation and human capital development on the economic growth of selected South Asian countries, this study employs both fixed effects and random effects models within its empirical framework. This approach allows for a comprehensive examination of the dynamic interactions between key variables across different countries and time periods. The variables under consideration include human capital development (HCD), financial innovation (FI), labor force (LF), gross capital formation (GCF), trade openness (TO), and technological innovation (TI).

3.1. Model Specification

The empirical estimation is captured through the following econometric models:

$GDP = \beta_0 + \beta_1 HCD_{it} + \beta_2 LF_{it} + \beta_3 GCF_{it} + \beta_4 TO_{it} + \beta_5 TI_{it} + \varepsilon_{it}$.......... (1)

$GDP = \beta_0 + \beta_1 FI_{it} + \beta_2 LF_{it} + \beta_3 GCF_{it} + \beta_4 TO_{it} + \beta_5 TI_{it} + \varepsilon_{it}$............ (2)

Where:-

GDP = Gross Domestics Product
HCD= Human Capital development
FI= Financial Innovation
LF= Labor force
GCF= Gross Capital Formation
TO=Trade Openness
TI= Technological Innovation
β_0= Intercept
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ *are the coefficients*
$\varepsilon =$ *Error term*
i = representing to cross sections (selected countries of Asia)
t = representing to time (Yearly)

3.2. Variables Description and Measurement

The variables in the empirical models are as follows.

Table 3. 1: Variables Description and Measurement

Variable	Measurement	Expected Sign
GDP	GDP at purchaser's prices (current US$)	Not Applicable
HCD	School enrollment (proxy for human capital)	Positive
FI	Broad money (IFS line 35L.ZK)	Positive
TO	Trade as a percentage of GDP	Positive
GCF	Gross capital formation (current US$)	Positive
TI	Patent applications (PCT or national)	Positive
LF	Total labor force (ages 15 and above)	Positive

Sources: Author's calculations

3.3. Data Sources

This study's research data is based on the secondary data collected over time from WDI (1991-2022). Bangladesh, India, Pakistan, Sri Lanka, Bhutan and Nepal are among the Selected Asian countries. The purpose of this study to verify the impact of independent variable on dependent variable. Data from many domestic and international sources is published on a consistent basis. However, for cross-country data on socioeconomic indicators, the World Bank is the most reliable source. The empirical research was conducted using panel data from the Selected Asian countries. The majority of the data for this variable comes from WDI. The moving average method was used to generate some missing data.

3.4. Estimation Techniques

This research employs the fixed effects model to analyze panel data, controlling for unobserved individual characteristics that remain constant over time. The fixed effects technique captures within-entity variations, allowing the estimation to focus on how changes in independent variables influence economic growth within each country. By accounting for time-invariant factors, this method minimizes bias caused by omitted variables and ensures that the estimated relationships reflect true temporal changes rather than cross-sectional differences.

To determine the suitability of the fixed effects model over the random effects alternative, the Hausman test is applied. This test examines whether individual-specific effects are correlated with explanatory variables. If the correlation exists, the fixed effects model is preferred; otherwise, the random effects model is considered appropriate. Through this approach, the study ensures the selection of an efficient and consistent model for analyzing the relationship between financial innovation, human capital development, and economic growth in South Asian countries.

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4. Result and Discussion

In this chapter descriptive analysis and empirical analysis has been discussed. Now we discuss these points in detail.

4.1. Descriptive Analysis

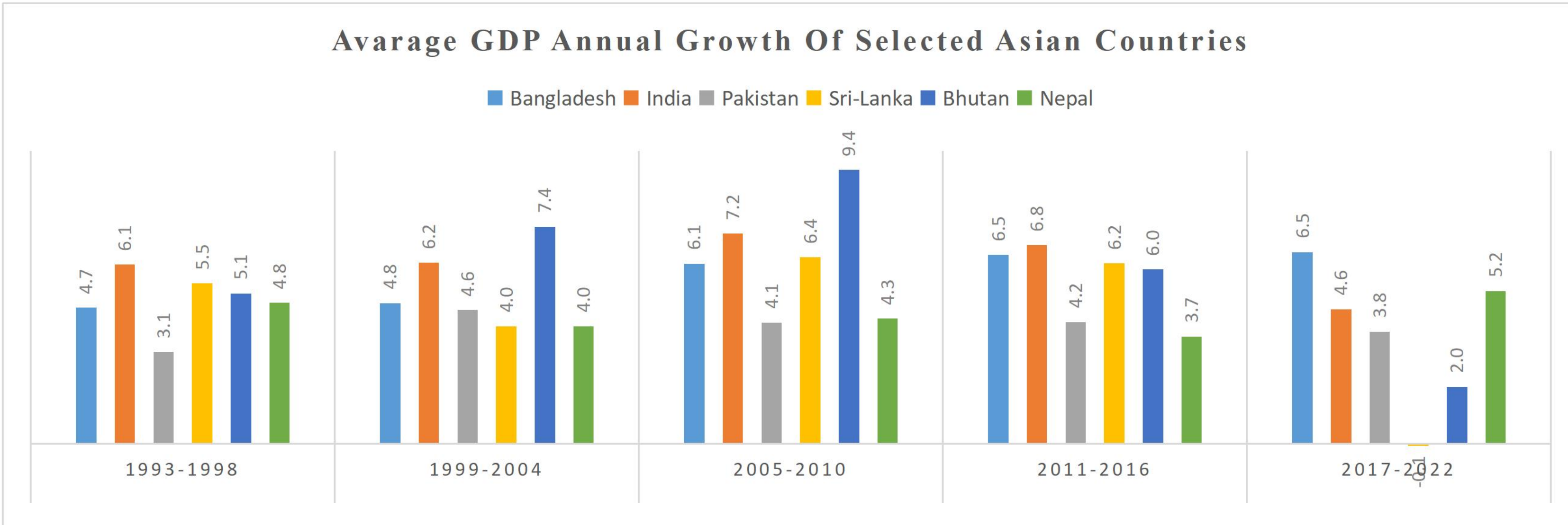

Figure 4. 1: Average GDP Annual Growth of Selected Asian Countries

The study presents the descriptive analysis for the overall economic condition in selected countries with comparative analysis.

The bar chart illustrates average annual GDP growth rates for selected South Asian countries from 1993 to 2022, divided into five periods. India consistently maintained strong growth, leading in several intervals, while Pakistan generally recorded the lowest rates. Bhutan showed exceptional growth between 2005 and 2016 but faced a decline in the final period. Overall, the data highlight India's steady performance and Bhutan's volatility in economic growth across the observed years.

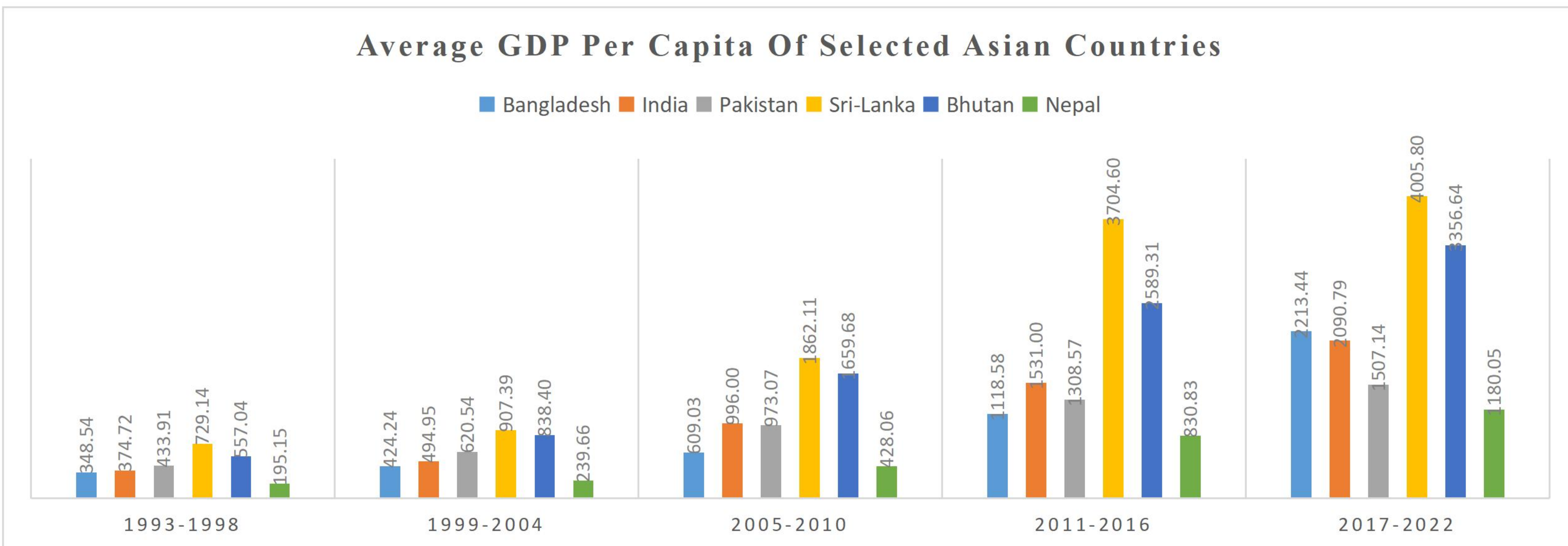

Figure 4. 2: Average GDP per Capita of Selected Asian Countries

The bar chart shows the average GDP per capita (in US dollars) for six Asian countries from 1993 to 2022 across five time periods. Overall, all countries experienced steady growth, with Bhutan and Sri Lanka showing the most significant increases. Bhutan led from 2005 to 2016, but Sri Lanka surpassed it in the final period. Nepal consistently had the lowest GDP per capita, though it also showed a gradual upward trend.

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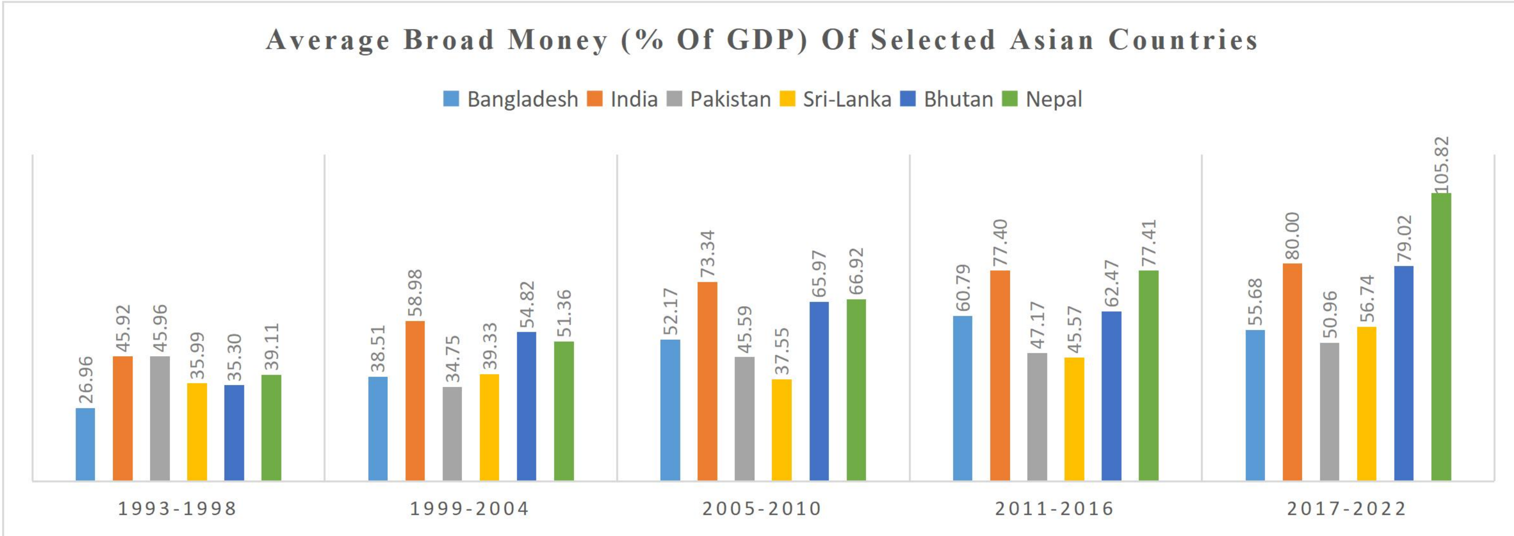

Figure 4. 3: Average Broad money (% of GDP) of Selected Asian Countries

The bar chart illustrates the average broad money as a percentage of GDP for selected Asian countries over five periods from 1993 to 2022. Broad money includes currency in circulation and various deposits. Overall, the data reveal a consistent upward trend across all countries, reflecting financial deepening over time.

Initially, Pakistan held the highest ratio, while Bangladesh had the lowest. From 1999 to 2016, India consistently led, showing strong monetary expansion relative to GDP. However, in the final period (2017–2022), Nepal experienced a sharp rise, reaching 105.82%, surpassing all others. This indicates notable financial sector growth and increased liquidity in Nepal’s economy.

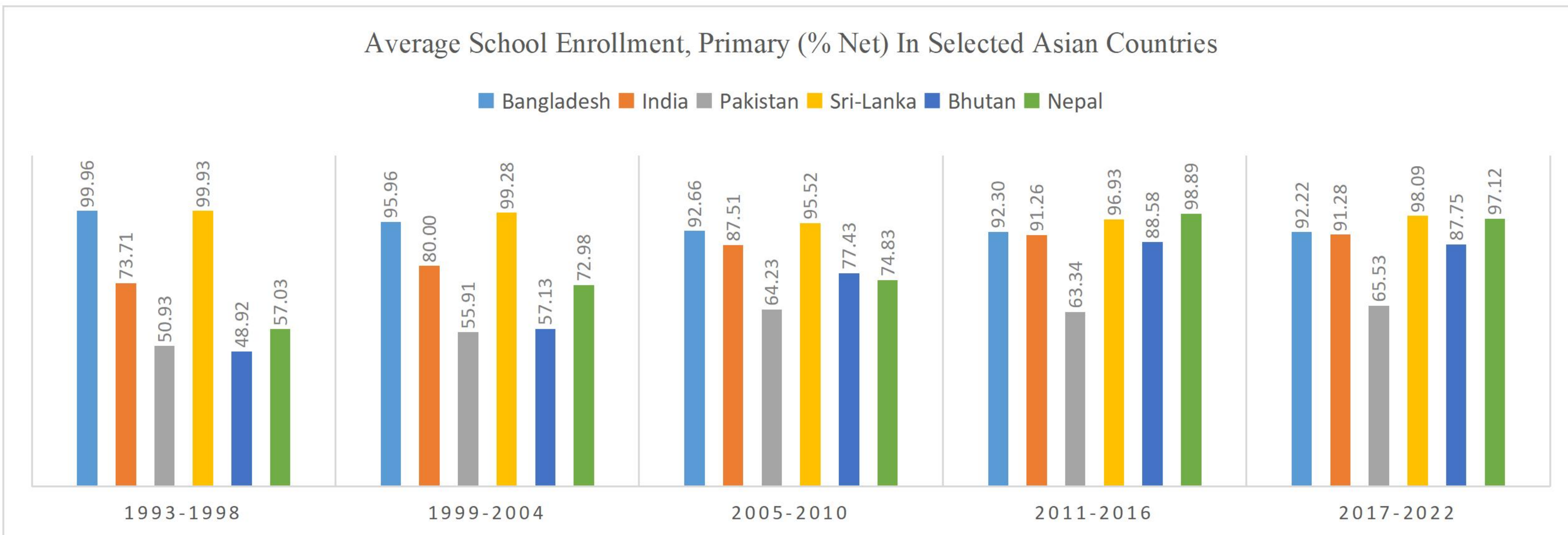

Figure 4. 4: Average School Enrollment, Primary (% Net) In Selected Asian Countries

The bar chart illustrates the average primary school enrollment rates (net %) for selected Asian countries across five periods from 1993 to 2022. Overall, the data reveal a steady improvement in enrollment over time, reflecting expanded access to basic education in the region.

In the early years, Bangladesh and Sri Lanka achieved near-universal enrollment, while Bhutan and Pakistan lagged behind. Over successive periods, Bhutan and Nepal made remarkable progress, with Nepal nearing full enrollment by 2016. Sri Lanka consistently maintained high rates throughout, while Pakistan remained the lowest performer despite gradual gains. The overall trend highlights significant regional progress toward universal primary education, particularly in Bhutan and Nepal.

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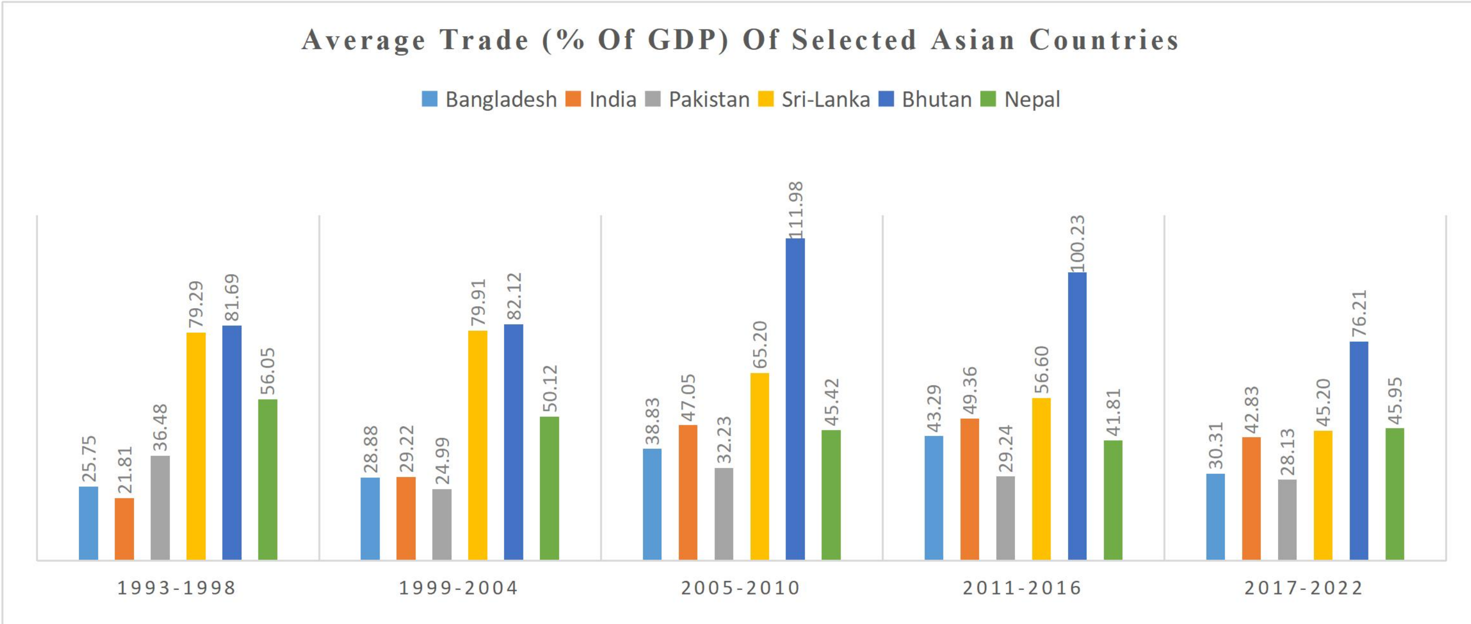

Figure 4. 5: Average Trade (% of GDP) of Selected Asian Countries

The bar chart illustrates the average trade (exports plus imports) as a percentage of GDP for six South Asian countries from 1993 to 2022. Overall, the data reveal considerable variation in trade openness across countries and time periods.

Bhutan consistently recorded the highest trade-to-GDP ratios, often exceeding 100%, indicating a strong reliance on trade relative to its economy. Sri Lanka and Nepal also maintained relatively high ratios in earlier decades but experienced declines in recent years. In contrast, India and Bangladesh showed gradual increases, reflecting growing integration into global markets, while Pakistan's trade share declined over time. Overall, the results suggest divergent trends in trade performance, with Bhutan remaining the most trade-dependent economy in the region.

4.2. Empirical Findings Estimation for Model 1

In this section panel regression and different diagnostics tests has been applied. The details of these points have been given below.

4.3. Test for Multicollinearity

A VIF value above 10 typically indicates a serious multicollinearity issue. However, in this study, all VIF values reported in Table 4.1 are below 2.4, well under the threshold, suggesting that multicollinearity is not a concern in the model estimation.

Table 4. 1: Test for Multicollinearity for Model-1

Variable	VIF	1/VIF
TO	2.39	0.418012
HCD	1.96	0.509961
GCF	1.89	0.528996
TI	1.84	0.54385
LF	1.63	0.615103
Mean VIF	1.94	

The Variance Inflation Factor (VIF) analysis is used to check for the presence of multicollinearity among explanatory variables in the regression model. The VIF values of Trade Openness, Human Capital Development, Gross Capital Formation, Technology Innovation and Labor Force are below the critical price of 5 halve, showing that the multicollinearity problem is not serious. This is further corroborated higher (mean VIF 1.94) confirming the valid evidence that the predictors are sufficiently independent and the derived coefficient estimates do not change much. Not only that, because there may be variations of countries due to social, economic or cultural, the OLS estimation may not be complete. Therefore, to solve the above problem, the Breusch-Pagan Lagrange Multiplier and Hausman Tests are imposed in order to identify the best suited model after random or fixed effects for panel data analysis problem.

4.4. Breusch pagan LaGrange multiplier test for random effect or OLS

The Breusch-Pagan Lagrange Multiplier (LM) test serves as an essential diagnostic tool in econometric analysis, particularly for deciding between the random effects and ordinary least squares (OLS) models in panel data. It tests the null hypothesis that error variances are constant across entities, implying that OLS is sufficient. Rejection of this hypothesis suggests significant random effects, justifying the use of a random effects model to account for unobserved heterogeneity among entities. In this study, the LM test results indicate

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that the random effects model is more appropriate than OLS, confirming the presence of entity-specific variation. This choice enhances the model's statistical efficiency, ensures more reliable coefficient estimation, and strengthens the validity of the regression analysis.

4.5. Hausman Test

Null Hypothesis: Difference in coefficients not systematic (Random effect is appropriate) Alternative Hypothesis: Difference in coefficients systematic (Fixed effect is appropriate)

Table 4. 2: Results of Hausman Specifications test for Model-1

chi2(5)	17576.58
Prob > chi2	0.0000

The Hausman test is used to compare the fixed effects (FE) and random effect models in order to identify suitable model specification for the effects of human capital development (HCD), openness to trade (TO), gross capital formation (GCF), technology innovation (TI) and labor force (LF) on GDP. The results show significant differences between the model estimates on the coefficient estimates, they are significant especially when it comes to trade openness and human capital development, i.e., the choice of model is a significant factor that changes the interpretation of model effects. The test produces a chi-square statistic of 17,576.58 with 5 degrees of freedom and p-value = 0.0000 indicating an extremely significant difference between FE and RE estimators. Consequently, the null hypothesis is rejected and we show that the fixed effects model is more suitable since it is capable of controlling for the unobserved heterogeneity, which is ego-correlated with enrolled into the model explanatory variables.

4.6. Fixed Effect Estimation

Fixed effect estimation has become one of the most important methodologies in panel data analysis, where cases are observed over time for the same entities (that is individuals, firms or countries). This type of instrumental variable approach is well suited to controlling for unobserved heterogeneity when that heterogeneity is time-invariant but differentially distributed across the entities. By restricting the relationship to within-entity changes, the fixed effect model reveals the fully causal effect of independent variables on the dependent variable and carefully isolates it from all potentially causal characteristics, including time-invariant ones, which are themselves not measurable by themselves. The advantage of one fixed effects estimation is that it allows us to avoid the bias in the estimate of the parameter that can be caused by omitted variables as long as these omitted variables are not time-varying. Therefore some unconformity being allows every entity to have its own peculiar influence on the dependent parameter that is affected by it and that cannot be reflected in the arguments captured by the observed variables. These would be entity specific effects which would be estimated as fixed parameters, thus, the name was fixed effects model.
By contrast, in the random effects models the entity-specific effects are said to be randomly distributed and uncorrelated with the independent variables. In empirical applications the decision to use a fixed effects model can be justified using statistical tests like the Hausman test, which tests the suitability of either a fixed or random effect model through the combination of the correlation between the effects for a particular entity once it has been extracted and the independent variables. When there is correlation of the unique entity effects and the predictors, the estimation of fixed effect is becoming dominant, in order to have unbiased and consistent parameter estimation. By taking a fixed effect estimation approach, researchers are able to explore the dynamic complexity of the data, and to capture more nuance of the effect over time on variables while robustly allowing for the exclusion of observable individual traits. His methodology is especially useful in areas like economics, finance, and social sciences, where it is essential to determine the exact effect that policy changes, economic conditions, or social interventions have on various variables. The forthcoming results, based on fixed effect estimation, will provide profound knowledge on the subject matter with solid grounding to sound analytical model that gives high-level attention to the accuracy and reliability of causal inferences.

Table 4. 3: Results of Fixed Effect for Model-1

GDP	Coefficient	Std. errs.	TStat	P-Value
HCD	0.6674914	0.0846505	7.89	0.000
TO	0.7689211	0.1155407	6.65	0.000
GCF	0.0232487	0.0044855	5.18	0.000
TI	0.6074954	0.050776	11.96	0.000
LF	1.11986	0.1060113	10.56	0.000
_cons	16.59002	0.9591188	17.3	0.000
R Square	0.8212			
F (5,179)	173.83			

The fixed-effects regression model investigates the impact of Human Capital Development (HCD), Trade Openness (TO), Gross Capital Formation (GCF), Technology Innovation (TI), and Labor Force (LF) on the logarithm of GDP across six groups and 190 observations. The results reveal that all explanatory variables exert a positive and statistically significant influence on GDP, with the labor force (LF) showing the strongest effect, followed by trade openness (TO) and human capital development (HCD). The model demonstrates strong explanatory power, as reflected by a high within R-squared value of 0.8212, indicating that approximately 83% of the within-entity variation in GDP is explained by the independent variables. The F-statistic (173.83, p = 0.000) further confirms the joint significance of the predictors. Additionally, the rho value (0.89) suggests that

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most of the GDP variation arises from individual-specific effects. The significance of the fixed-effects test validates the model's appropriateness in capturing heterogeneity across entities and explaining key drivers of economic growth.

4.7. Regression with Driscoll-Kraay standard errors for Robustness

Table 4. 4: Regression with Driscoll-Kraay standard errors for Model-1

GDP	Coefficient	std. errs.	t-Stat	P-Value
HCD	0.6674914	0.1178988	5.66	0.000
TO	0.7689211	0.1322234	5.82	0.000
GCF	0.0232487	0.0057613	4.04	0.000
TI	0.6074954	0.0827992	7.34	0.000
LF	1.11986	0.1219401	9.18	0.000
_cons	16.59002	1.080099	15.36	0.000
R-Square	0.8292			
F (5, 31)	265.21			
Prob > F	0.0000			

The fixed-effects regression analysis with Driscoll–Kraay standard errors, based on 190 observations across six groups and using a maximum of three lags, examines how human capital development (HCD), trade openness (TO), gross capital formation (GCF), technological innovation (TI), and labor force (LF) affect the logarithm of GDP. Results show that HCD (0.667) and TO (0.769) are positively and significantly related to GDP, indicating that improvements in education, skills, and trade integration foster economic growth. GCF (0.023) also contributes positively, suggesting that investment in assets and infrastructure enhances output. TI (0.607) demonstrates that innovation and patent activity strongly support growth, while LF (1.119) exhibits the largest coefficient, underscoring the crucial role of labor size and productivity. The constant term (16.59) represents baseline GDP levels. The model's high F-statistic (265.21, $p < 0.01$) and within R-squared of 0.829 confirm strong explanatory power. Driscoll–Kraay errors ensure robustness to cross-sectional and temporal dependence, reinforcing the model's reliability.

4.8. Test for Omitted Variables and Model Specification

Ramsey RESET test for omitted variables
Omitted: Powers of fitted values of GDP
H0: Model has no omitted variables

Table 4. 5: Test for Omitted Variables and Model Specification for Model-1

F (3, 181) = 1.24
Prob > F = 0.2969

The results of a Ramsey RESET test, which is used to detect omitted variable bias in a regression model.
The hypothesis being tested is:
Null Hypothesis: The model has no omitted variables (the model is correctly specified).
Alternative hypothesis: The model has omitted variables (the model is incorrectly specified).
According to the output: The F-statistic for the test is 1.24, with 3 and 181 degrees of freedom. The p-value (Prob > F) is 0.2969.
With a p-value higher than the common significance levels (0.01, 0.05, or 0.1), we fail to reject the null hypothesis ($H0$). This means that there's no statistical evidence at the conventional significance levels to suggest that the model has omitted variables or that there are issues with the model specification based on the RESET test. In practical terms, this suggests that the model may be well-specified with respect to the included variables and their functional form, at least as far as the RESET test can detect. However, it's important to note that passing the RESET test does not prove that the model is correct; it merely fails to provide evidence of it being mis specified. It's always good practice to consider other diagnostic tests and theoretical justifications for the model as well.

4.9. Link Test for Model Specification

Table 4. 6: Link Test for Model Specification for Model-1

GDP	Coefficient	Std. errs.	t-Stat	P-Value
_hat	1.233169	0.3845717	3.21	0.002
_hatsq	-0.0048129	0.0079283	-0.61	0.545
_cons	-2.80009	4.636217	-0.6	0.547

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The link test results assess the correctness of the regression model's specification by including the predicted values (_hat) and their squares (_hatsq). The model shows a high explanatory power, with an R-squared of 0.9367 and a highly significant F-statistic of 1383.13, confirming a good overall fit. The _hat variable is significant, as expected, while the _hatsq term is insignificant (p = 0.545), indicating no evidence of model misspecification or omitted non-linear relationships. Although the results suggest the model is properly specified, further diagnostic checks and theoretical validation remain essential for confirming robustness.

4.10 Summary Statistics

Table 4. 7: Summary Statistics for model 1

Variable	Obs	Mean	Std. dev.	Min	Max
GDP	192	24.41948	2.346387	19.23593	28.85968
HCD	192	10.76447	0.4988574	9.732471	12.19121
TO	192	3.815189	0.4578673	2.832491	4.758318
GCF	192	29.85363	11.54076	14.53469	69.47258
TI	192	5.481894	2.719936	0.6931472	11.03489
LF	192	0.3747743	0.3532381	-0.0044669	1.128844

The descriptive statistics table shows the summary statistics of the most important economic indicators in the dataset. The Orros' index for military spending: log GDP measured on the basis of 192, where there are 192 countries on the planet, has a mean of 24.42 and a standard deviation of 2.35 indicating moderate homogeneity among countries with respect to economic sizes in the exchange. Human Capital Development (HCD) with a mean of 10.76 and a low standard deviation of 0.50 signifying little dispersion. Trade Openness (TO) have a mean and standard deviation of 3.82 and 0.46 respectively, which is indicative of moderate agreement among countries. In contrast, Gross Capital Formation (GCF) indicates quite a bit of dispersion with a mean of 29.85 and SD of 11.54, therefore indicating that there are large variations in investment levels. Regarding the average values, Technology Innovation (TI) also shows a large variability in the average value, 5.48, with standard deviation of 2.72, evidencing differences among the innovation capability. The output of the Labour Force (LF) calculated on 192 observations is a mean of 0.37 with a standard deviation of 0.35, which might be interpreted as suggestive of increased variability in labour participation. From the descriptive statistics, it appears that there is great economic heterogeneity in the data with regards to growth, openness, investment and innovation.

4.11. Test for Heteroskedasticity

The Breusch-Pagan/Cook-Weisberg test is a key econometric tool used to detect heteroskedasticity in regression models.

Table 4.8: Result of Breusch-Pagan/Cook-Weisberg test stands for Heteroscedasticity Mode1-1

chi2(1)	6.24
Prob > chi2	0.125

1.1.1 The Breusch–Pagan/Cook–Weisberg test results do not provide sufficient evidence of heteroskedasticity in the regression model. Although the chi-square statistic is 6.24, the associated p-value is 0.125, which is greater than the 0.05 significance level. Therefore, the null hypothesis of constant variance (homoskedasticity) cannot be rejected. This indicates that the error variance does not significantly vary with the fitted values of GDP (log form), and the OLS assumption of homoskedasticity is not violated. As a result, the standard OLS estimates and standard errors can be considered reliable, and the use of robust standard errors is not strictly required, though it may still be used as a precaution.

4.12. Test for Correlation Matrix

Table 4. 9: Results of correlation matrix for Model 1

	GDP	HCD	TO	GCF	TI	LF
GDP	1					
HCD	0.2328	1				
TO	0.656	-0.2588	1			
GCF	0.4169	-0.3616	0.6396	1		
TI	0.9316	0.257	0.524	0.3457	1	
LF	0.0256	0.5491	-0.4104	-0.3005	-0.0388	1

The correlation matrix illustrates the linear relationships among key economic indicators. GDP shows a mild positive correlation with Human Capital Development (0.2328) and a stronger link with Trade Openness (0.656), suggesting that trade-oriented and moderately skilled economies tend to have higher output. Gross Capital Formation is also positively related to GDP (0.4169), while Technological Innovation shows the strongest correlation (0.9316), emphasizing its crucial role in economic growth. Labor Force exhibits a negligible relationship (0.0256), indicating minimal influence on GDP. Overall, the results reveal generally positive associations among innovation, trade, and capital formation, though human capital and labor show weaker connections.

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54.13. Empirical Findings Estimation for Model 2

4.13.1 Test for Multicollinearity

Typically, a VIF above 10 indicates a problematic amount of multicollinearity, suggesting that the associated predictor variables might need to be revised or removed from the model to improve the analysis. VIF of the explanatory variables reported in table 4.1(less than 1.67) than the threshold level and thus it is less likely to have multicollinearity in over estimation.

Table 4. 10: Test for Multicollinearity for Model 2

Variable	VIF	1/VIF
TO	1.67	0.597742
TI	1.41	0.71088
LF	1.33	0.754313
FI	1.3	0.767043
GCF	1.17	0.855838
Mean VIF	1.38	

The Variance Inflation Factor (VIF) analysis assesses multicollinearity among the model's predictors. The VIF values for Trade Openness (1.67), Technological Innovation (1.41), Labor Force (1.33), Financial Innovation (1.30), and Gross Capital Formation (1.17) are all well below the critical thresholds of 5 or 10, indicating no serious multicollinearity issues. The corresponding 1/VIF values are also high, confirming that each variable contributes unique information to the model. The mean VIF of 1.38 further supports the absence of multicollinearity. Therefore, the model's coefficient estimates are stable and reliable, ensuring valid hypothesis testing and accurate inference.

4.13.2 Hausman Test

Null Hypothesis: Difference in coefficients not systematic (Random effect is appropriate) Alternative Hypothesis: Difference in coefficients systematic (Fixed effect is appropriate)

Table 4. 11: Results of Hausman Specifications test for Model 2

chi2(5)	512.83
Prob > chi2	0.0000

The Hausman specification test compares the coefficients of fixed-effects (FE) and random-effects (RE) models to determine the most appropriate estimator for the panel data. The results show that the chi-square value is 512.83 with a p-value of 0.0000, indicating a significant difference between the two models. This means that the assumption of no correlation between the individual effects and the explanatory variables in the RE model is rejected. Therefore, the fixed-effects model is preferred, as it provides consistent estimates in the presence of such correlation. Although the note "(V_b – V_B is not positive definite)" indicates a potential computational issue in the variance-covariance matrix, the strong statistical significance still supports the selection of the fixed-effects model for reliable interpretation of the results.

4.13.3. Fixed Effect Estimation

The fixed-effects estimation is a key technique in panel data analysis, used when data track the same entities such as individuals, firms, or countries over time. This method effectively controls for unobserved characteristics that remain constant within an entity but differ across entities. By concentrating on variations within each entity, the fixed-effects model helps identify the true relationship between the dependent and independent variables while removing bias from unchanging factors. Unlike the random-effects model, which assumes that unobserved effects are uncorrelated with the repressors, the fixed-effects approach allows each entity to have its own intercept, capturing its unique influence. The choice between fixed and random effects is often guided by the Hausman test, which determines whether the unobserved effects are correlated with the explanatory variables. If such correlation exists, the fixed-effects model provides more reliable and consistent estimates. This approach is widely used in economics and social sciences for its ability to produce accurate insights into how variables evolve over time, making it especially valuable for analyzing the effects of policies, economic trends, or social changes.

Table 4. 12: Fixed Effect Estimation for model-2

GDP	Coefficient	Std. errs.	t-Stat	P-Value
FI	1.317318	0.1800944	7.31	0.000
TO	0.7600365	0.1439225	5.28	0.000
GCF	0.0914879	0.0509694	1.79	0.075
TI	0.4647352	0.0695224	6.68	0.000
LF	0.8863099	0.1320666	6.71	0.000

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_cons	20.2558	0.6879081	29.45	0.000
R Square	0.9056			
F (5,142)	114.51			

The table gives results for a fixed effects regression model adapted to panel data, which respect the fact that the same entities are observed for many countries through time. The dependent variable in the logarithmic form of GDP is the natural logarithm of GDP, for which interpretation of the coefficients into percentage terms is possible. The independent variables are the variables of broad money growth, trade openness, technological innovation, and gross capital formation and population growth. Results indicate that broad money growth, trade openness, technological innovation and population growth have positive and significant impact on GDP, showing its importance to contribute in economic growth. There is a positive though not good statistical relationship and hence less certain when it comes to the influence of gross capital formation on GDP.
The model results have a high extent of fit measured with high within (.8013), between (.9469), and overall (.9056) R-squared, meaning that most of the variation for GDP across time and between entities are explained by the model that I developed. The F-statistic (22.10; p = 0.0000) supports the evidence of the significant explanatory power of the independent variables when taken at the same time. The intra-class correlation (r = 0.8687) shows that much of the GDP variance arises across the country as opposed to within the country over the years. Finally, the fixed-effect estimation can well handle unobserved country-specific assimilations, illustrating the price-level inflation, trade openness, innovation, and population growth as more important determinants of the economic performance in this sample.

4.13.4. Regression with Driscoll-Kraay standard errors for Robustness

Table 4. 13: Regression with Driscoll-Kraay standard errors for Model-2

GDP	Coefficient	std. errs.	t-Stat	P-Value
FI	1.317318	0.2209991	5.96	0.000
TO	0.7600365	0.1219943	6.23	0.000
GCF	0.0914879	0.0523214	1.75	0.090
TI	0.4647352	0.0870884	5.34	0.000
LF	0.8863099	0.1776604	4.99	0.000
_cons	20.2558	0.6302623	32.14	0.000
R-Square	0.8013			
F (5, 31)	82.83			
Prob > F	0.0000			

The regression analysis, via fixed-effects for panel data, considers in its estimate and, thus, control, several consideration of the determinants of GDP using standard errors of the type Driscoll-Kraay considered their presence, in order to consider them as a corrective factor to certain cancellation or other types of problems such as the existence of autocorrelation or heteroskedasticity. The dependent variable is log of GDP, so results can be interpreted in terms of percentage change in economic growth. The explanatory variables are Broad money growth (FI), Trade openness (TO), technological innovation (TI), Labor force growth (LF) and Gross capital formation (GCF).
The results suggest that all four variables (FI, TO, TI, and LF) have a positive and significant relationship with GDP at 1% significant level of confidence and suggest a key role of monetary expansion, greater integration of trade, improvement in the level of technology, and improvement in labor force in promoting economic development. Gross capital formation also exhibits a positive and stronger association being significant only at 10% level. The value of sometime RS2, which is 0.8013 shows that the model accounts for and explains approximately 80% of the GDP within entities variation with time and is a premium model fit. Overall, the results indicate financial, trade, technological and demographic factors are very important drivers of economic growth, while the impact of investments seems less clear. The application of Driscoll-Kraay standard errors helps make these conclusions more robust and robust by errant possible cross section and time dependence in the data. In summary, Human Capital Development and Financial Innovation being the variable of interests in this research work. In both models, Human Capital Development (HCD) is statistically significant and positive connected to GDP.
These findings align with the literature Nelson & Phelps (1966); Benhabib & Spiegel (1994); Engelbrecht (2003); Cohen & Soto (2007); Engelbrecht (2002). Similarly in both models, Financial Innovation is also positive and statistically significant with economic growth of selected countries. This empirical finding is found in the line of previous studies like Arestis & Demetriades (1997); Demetriades & Hussein (1996); Biswas (2008); Liu & Shu (2002); Masoud & Hardaker (2012); Sunde (2013); Munepapa (2022).

4.13.6. Link Test for Model Specification

Table 4. 14: Link Test for Model Specification for Model-2

GDP	Coefficient	Std. errs.	t-Stat	P-Value
_hat	1.639128	0.3533861	4.64	0.000
_hatsq	-0.0130686	0.0072164	-1.81	0.072
_cons	-7.756337	4.306264	-1.8	0.074

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The link test was applied to assess potential specification errors in the regression model based on 153 observations. The model demonstrates a strong overall fit, with an F-statistic of 1527.61 ($p < 0.01$) and an R-squared value of 0.9532, indicating that approximately 95% of the variation in the dependent variable is explained by the independent variables. In the link test, the predicted values (_hat) show a positive and highly significant coefficient (1.6391), confirming that the model's predictions are closely aligned with the observed data. The squared predicted term (_hatsq) is not statistically significant ($p = 0.072$), suggesting that no major nonlinear relationships have been omitted. The constant term is also insignificant, which is expected and does not affect the interpretation. Overall, the test results suggest that the model is well specified, with no strong evidence of misspecification or omitted variable bias, though additional diagnostic checks are recommended for confirmation.

4.13.7. Summary Statistics

Table 4.15: Summary Statistics for Model-2

Variable	Obs	Mean	Std. dev.	Min	Max
GDP	192	24.41948	2.346387	19.23593	28.85968
FI	192	3.923995	0.3370048	3.178417	4.79295
TO	192	3.815189	0.4578673	2.832491	4.758318
GCF	155	2.095717	0.666367	0.8998371	3.393601
TI	192	5.481894	2.719936	0.6931472	11.03489
LF	192	0.3747743	0.3532381	-0.0044669	1.128844

The descriptive statistics show substantial variation across 192 observations. GDP averages 24.42 with a wide range (19.24–28.86), reflecting diverse economic sizes. Financial innovation (FI) and trade openness (TO) display moderate variation, with means of 3.29 and 3.82, respectively. Gross capital formation (GCF) and technological innovation (TI) show greater dispersion, especially TI (mean 5.48), indicating uneven levels of investment and innovation. Labor force (LF) averages 0.37, ranging from slight declines to strong growth. Overall, the data highlight considerable differences in economic performance, investment, trade, and innovation across entities.

4.13.8 Test for Heteroskedasticity

The Breusch–Pagan/Cook–Weisberg test is used to detect heteroskedasticity in regression models, where the variance of the error terms changes across observations. This violates the OLS assumption of constant error variance and can distort statistical inferences. The test checks whether the residuals from a regression show systematic patterns related to the independent variables. A significant result indicates the presence of heteroskedasticity, suggesting that standard errors need adjustment to maintain reliable and valid regression results.

Table 4.16: Result of Breusch-Pagan/Cook-Weisberg test stands for Heteroscedasticity Model-2

chi2(1)	3.64
Prob > chi2	0.0564

The Breusch–Pagan/Cook–Weisberg test was applied to check for heteroskedasticity in the model with the natural logarithm of GDP as the dependent variable. The test produced a chi-square value of 3.64 and a p-value of 0.0564. Since the p-value is slightly above 0.05, the null hypothesis of constant variance cannot be rejected, indicating no strong evidence of heteroskedasticity. However, the result is close to the significance threshold, suggesting a mild indication of unequal error variance. To ensure reliable inference, the use of heteroskedasticity-robust standard errors may still be advisable.

4.13.9. Test for Correlation Matrix

Table 4.17: Results of correlation matrix for Model-2

	GDP	FI	TO	GCF	TI	LF
GDP	1					
FI	0.2041	1				
TO	0.6099	-0.2194	1			
GCF	0.1015	-0.3479	0.2142	1		
TI	0.9254	0.1113	0.4658	0.0756	1	
LF	0.0743	0.3322	-0.3989	-0.1762	-0.0005	1

The correlation matrix highlights the relationships among key economic variables. GDP has a very strong positive correlation with Technological Innovation (TI) (0.9254), showing that more innovative economies tend to have higher GDP levels. A moderate positive correlation with Trade Openness (TO) (0.6099) also indicates that greater trade integration is

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associated with stronger economic performance. Financial Investment (FI) shows a weak positive link with GDP (0.2041) and Labor Force (LF) (0.3322), suggesting modest connections between financial activity, employment, and growth.

A moderate negative correlation between FI and Gross Capital Formation (GCF) (-0.3479) suggests that increases in financial investment do not necessarily align with rises in physical capital investment. Trade Openness (TO) shows weak negative correlations with FI and LF but a moderate positive link with TI, implying that openness may promote innovation. Correlations involving LF are generally weak, indicating limited direct association with investment or innovation. Overall, the matrix reveals meaningful patterns among the variables, though these represent associations rather than causal relationships.

5. Conclusion and Policy Recommendation

This paper examined the role of financial innovation and human capital in economic growth of six South Asian countries namely India, Pakistan, Bangladesh, Sri Lanka, Nepal, and Bhutan for their twist during the period 1991-2022. The panel data from the World Development Indicators (WDI) were used, where the dependent variable is the GDP, and the explanatory variables are financial innovation, human capital development, the labor force participation rates, trade openness, technological innovation, and gross capital formation. The empirical findings validating the positive and statistically degradation for economic growth in both financial innovations as well as human capital development. Furthermore, it is found that trade openness; technology improvements, investment and participation of the labor force are complementary factors of growth. These findings underscore that education, technological innovation, investment, and capacity building are key foundations for building inclusive and sustainable, strong economic growth in South Asia.

In view of these empirical findings, a few policy implications are drawn out of the study. Investment in Education and Healthcare: Governments need to allocate resources continuously to education and healthcare and modernize them based on the changing economic conditions. To develop a skilled and effective workforce, there is need to strengthen efforts towards measuring quality of education, digital literacy, and increase equitable access to learning outcomes. At the same time, policymakers can boost financial innovation by providing enabling regulatory frameworks for finch and digital financial service development and financial inclusion. There is value in strengthening the financial infrastructure and increasing financial literacy to help catalyze further growth in innovation and savings mobilization as well as access to credit. Taken together, integrated policies that underpin human capital formation and financial innovation will play an important role in ensuring continued, resilient and inclusive growth in the region of South Asia.

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