Article History:
Received: March 03, 2024
Revised: June 21, 2024
Accepted: July 12, 2024

DOI: https://doi.org/10.3126/pycnjm.v17i1.76833
PYC Nepal Journal of Management
Vol. XVII, No. 1, Page: 126-145
ISSN 2091-0258, 2738-9847 (Online)

Impact of Human Capital and Trade Openness on Economic Growth in Nepal

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Abstract: *This study investigates the impact of human capital and trade openness on Nepal's economic growth, addressing a gap in research on their dynamic relationship. Using time series data from 1991 to 2023, the study applies the dynamic ordinary least squares (DOLS) co-integration method, which is well-suited for addressing endogeneity and small sample bias. The key variables analyzed include GDP per capita, trade openness, tertiary education, labour force participation, urban population, and total population. The findings reveal that both trade openness and human capital significantly contribute to long-term economic growth in Nepal. Trade openness facilitates technological transfer and market expansion, positively impacting GDP. Human capital, represented by education and labour force participation, enhances productivity and income. However, the effects of labour force participation are complex and context dependent. These results emphasize the critical role of human capital and trade openness in driving Nepal's economic progress. Policymakers should prioritize trade liberalization and invest in targeted educational and vocational programs to strengthen human capital. Future research could explore the role of technology, infrastructure, and sector-specific policies in optimizing the benefits of human capital and trade openness in developing economies like Nepal.*

Keywords: economic growth, human capital, trade openness, labour force participation

I. INTRODUCTION

Human capital and trade openness are widely recognized as critical determinants of economic growth, as emphasized by Cohen and Soto (2007). Trade openness facilitates not only the exchange of goods and services but also the transfer of new technologies and ideas, enabling industrial innovation, market expansion, and job creation (Miller & Upadhyay, 2000; Sulaiman et al., 2015). Defined as the degree to which a nation engages in international trade, it enhances productivity and growth through mechanisms such as technological diffusion, broader markets, and increased investment opportunities (Pernia & Quising, 2005; Talberth & Bohara, 2006). Various metrics, including the ratio of total trade to GDP, are commonly used to measure trade openness (Nasreen & Anwar, 2014).

Similarly, human capital plays a vital role in economic development by improving productivity and income levels (Agbettor, 2016; Robeyns, 2006). It encompasses the skills, education, and innovative capabilities of the workforce, which are crucial for sustainable growth (De Oliveira et al., 2000). Strategies to enhance human capital include promoting specialization, expanding education and vocational training, and fostering self-employment opportunities (Shutt & Sutherland, 2003). Moreover, endogenous growth theory underscores the importance of human capital in driving long-term economic growth through knowledge and innovation (Köhler et al., 2006).

Despite these well-established benefits, Nepal's economy continues to face significant challenges in leveraging human capital and trade openness effectively. Although the country has made efforts to integrate into global markets, it struggles to fully exploit the potential of these drivers for sustained economic growth. While studies such as those by Ahsan and Haque (2017) and Ogundari and Awokuse (2018) have explored these dynamics in other contexts, the specific interplay between trade openness, human capital, and economic growth in Nepal remains underexplored. Existing research often focuses on larger or more developed economies, leaving a gap in understanding the nuances of smaller, developing nations like Nepal.

This study aims to fill this gap by examining the dynamic relationship between human capital, trade openness, and economic growth in Nepal. Employing the dynamic ordinary least squares (DOLS) approach and analyzing time series data from 1991 to 2023, this research provides robust empirical evidence. The findings will offer actionable insights for policymakers, enabling them to design targeted interventions that enhance trade openness and human capital to foster sustainable economic growth in Nepal.

II. LITERATURE REVIEW

The relationship between human capital, trade openness, and economic growth has been extensively studied, with its foundations rooted in endogenous growth theory. This theory posits that internal factors, such as knowledge, human capital, and innovation, are key drivers of sustainable economic development (Köhler et al., 2006). Human capital, defined as the education, skills, and productivity of a population, is central to increasing output and fostering long-term growth. Concurrently, trade openness facilitates the diffusion of new technologies, expands markets, and enhances resource allocation, creating conditions for economic prosperity (Cohen & Soto, 2007; Miller & Upadhyay, 2000).

Empirical studies provide a nuanced understanding of these dynamics. Ogundari and Awokuse (2018) investigated 35 sub-Saharan African nations and found that human capital positively influenced economic growth. Similarly, Ahsan and Haque (2017) identified a threshold effect, demonstrating that human capital significantly drives growth in both developed and underdeveloped countries. However, the findings are not universal. Abdullah (2013), examining Malaysia, noted a negative association between education and growth, attributing this to inefficiencies in resource utilization and the involvement of skilled individuals in non-productive activities. Adding complexity, Awan and Naseem (2018) observed that while health expenditures positively influence growth, education expenditures may have adverse effects in certain contexts.

Trade openness, often measured by the ratio of total trade to GDP (Nasreen & Anwar, 2014), has been widely linked to economic growth. Sakyi et al. (2015) analyzed developing nations and found that trade openness facilitates technological diffusion and competitiveness, yielding positive outcomes for growth. Alam and Sumon (2020), using a vector error correction model (VECM), confirmed a positive causal relationship between trade openness and growth in Asian countries. However, results vary across regions. For example, Hye and Lau (2015) observed a negative long-term relationship in India, while Yanikkaya (2003) and Nguyen (2019) highlighted significant positive impacts in developing nations, including those in Northeast Asia. Bajwa and Siddiqi (2011) noted mixed results in South Asia, where trade openness boosted growth in Pakistan but showed negative effects in other nations during specific periods.

The existing body of work provides valuable insights but also highlights gaps in understanding, particularly in the context of Nepal. While studies like those by Sakyi et al. (2015) and Alam and Sumon (2020) emphasize the importance of trade openness and human capital globally, their findings often generalize outcomes from larger economies. Nepal, with its unique economic structure, remains underexplored. Challenges such as low levels of human capital development and limited trade openness require a localized investigation to understand how these factors interact in driving growth.

Endogenous growth theory offers a robust theoretical framework for examining this relationship. It emphasizes the role of internal drivers, including knowledge accumulation and human capital, in fostering sustainable growth (Köhler et al., 2006). Trade openness, as a conduit for technology transfer and resource efficiency, aligns seamlessly with this framework. Together, these perspectives underpin the research questions of this study.

This paper builds upon the reviewed literature to analyze the dynamic relationship between human capital, trade openness, and economic growth in Nepal. Employing a dynamic ordinary least squares (DOLS) approach and time series data from 1991 to 2023, the study seeks to fill the research gap by providing localized insights. The findings aim to inform policymakers and contribute to the broader discourse on economic strategies for developing nations.

III. RESEARCH METHODOLOGY

This study conducted an empirical analysis of the dynamic impacts of Trade Openness and Human Capital on Economic Growth in Nepal, utilizing the dynamic ordinary least squares (DOLS) co-integration approach. The DOLS method is particularly advantageous for analyzing time series data as it captures short-term dynamics and long-term equilibrium, offering robust estimates and insights into economic phenomena over time (Adem, 2023). Kao and Chiang (2001) demonstrated the efficacy of the DOLS estimator in panel datasets, noting its superior performance compared to ordinary least squares (OLS) and fully modified ordinary least squares (FMOLS) estimators, regardless of the panel's homogeneity. They found that the FMOLS estimator does not significantly improve predictions relative to OLS, while Lau et al. (2019) highlighted the potential negative consequences of nonparametric corrections for FMOLS.

In this analysis, variables were measured in constant 2015 US dollars for GDP per capita (GDPPC), as well as in percentages for Tertiary Education (as a proxy for Human Capital), Urban Population, and Labour Force Participation (covering ages 15 to 64). Additionally, Trade Openness was assessed as a ratio to GDP, while Total Population was represented by the total number of legal residents. The study employed data spanning from 1991 to 2023, sourced from the World Development Indicator (WDI) dataset.

Table 1

Variables and units of measurement used in the study

Variable names	Symbol	Units
GDP per capita	GDP	constant 2015 US$
Tertiary education	TE	% of gross secondary school enrollment
Urban population	UP	% of the total population
Total population	TP	Total number of legal residents
Labour force participation rate	LFPR	Rate of the total labour force, ages 15 to 64
Trade openness	TO	Ratio with GDP

Note. World Bank, 2024

This study employs econometric analysis to try to establish a causal link between trade openness and human capital on economic growth in Nepal. The normal asymptotic distribution of the DOLS estimators and their standard deviations offer a reliable test for the variables' statistical significance (Wang, 2012). By estimating the dependent variable on explanatory variables at levels, with leads and lags, the DOLS approach proves effective in handling mixed orders of integration, allowing the incorporation of individual variables within a co-integrated framework. As noted by Amna Intisar et al. (2020), this method is particularly suited for capturing the non-linear relationship between trade openness, human capital, and economic growth. To examine the influence of trade openness and human capital on economic growth, two models were developed, each pairing different variables, as illustrated in Equations (1) and (2).

$$LNGDP_t = \beta_0 + \beta_1 LNTE_t + \beta_2 LNLFPR_t + \beta_3 LNUP_t + \varepsilon_1 \quad \text{.....................................(1)}$$

$$LNGDP_t = \beta_0 + \beta_1 LNTE_t + \beta_2 LNTP_t + \beta_3 LNTO_t + \varepsilon_2 \quad \text{.....................................(2)}$$

LNGDP is the natural log of GDP per capita used as a dependent variable in both models, while ε_1 and ε_2 denote the error terms for each model. *Table 1* provides the details of the other independent variables. Additionally, trade openness is influenced by these factors, as indicated in Equation (3):

$$LNTO_t = \beta_0 + \beta_1 LNTE_t + \beta_2 LNTP_t + \beta_3 LNLFPR_t + \varepsilon_3 \quad \text{.....................................(3)}$$

In Equation (3), trade openness, expressed as the natural logarithm and adjusted by GDP, is used as the dependent variable, with ε_3 representing the error term for model III. *Table 1* provides a detailed description of the other independent variables.

Due to the accumulation of leads and lags among the explanatory variables, this estimator consequently gives solutions to the problems of small sample bias, endogeneity, and autocorrelation (Stock & Watson, 1993). The DOLS method was used to find the different levels of integrations of dependent and independent variables, as it is also used when endogeneity in independent variables (Poudel et al., 2024).

IV. RESULTS AND DISCUSSION

This section mainly covers descriptive statistics and results of the DOLS model to find the relationship between short-run and long-run nature of GDP and TO, including other concerned variables. It also checks the robustness of the model.

Table 2

Descriptive statistics

	LNGDP	LNTO	LNTE	LNTP	LNUP	LNLFPR
Mean	23.58	-0.76	3.94	17.07	2.72	3.74
Median	23.55	-0.78	3.81	17.10	2.76	3.75
Maximum	24.24	-0.45	4.49	17.25	3.09	3.75
Minimum	22.90	-1.06	3.49	16.82	2.22	3.70
Std. Dev.	0.41	0.14	0.33	0.11	0.25	0.01
Skewness	0.01	0.24	0.30	-0.60	-0.45	-2.11
Kurtosis	1.86	2.98	1.59	2.56	2.15	9.08
Observations	33	33	33	33	33	33

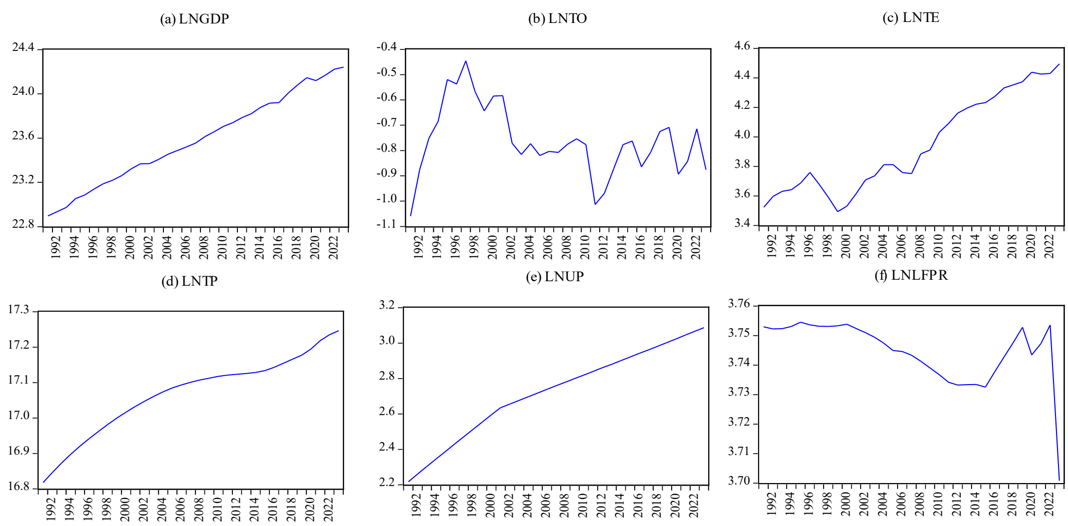
Table 2 presents the descriptive statistics for six variables: LNGDP, LNTO, LNTE, LNTP, LNUP, and LNLFPR. The mean values indicate the average logarithmic transformations of each variable, with LNGDP showing a mean of 23.58. The standard deviation reveals variability, with LNGDP having a standard deviation of 0.41, indicating moderate dispersion. Skewness suggests that LNGDP and LNTO are relatively symmetrical, while LNTP is

negatively skewed. Kurtosis values indicate that LNLFPR has a significant peak (leptokurtic distribution) compared to the other variables, suggesting more frequent extreme values.

Trend lines of concerned variables. *Figure 1* displays time series plots for the LNGDP, LNTO, LNTE, LNTP, LNUP and LNLFPR over the 1991-2023 period. Each plot visualizes the trends and fluctuations in the variables, allowing for a comparison of their behaviours over time. Observing the patterns can reveal whether the variables exhibit increasing, decreasing, or stable trends, as well as potential seasonal effects or anomalies. The plots may highlight correlations between variables, showing how changes in one might influence others over time. This visual representation aids in understanding the dynamics and relationships among the variables in the context of the study.

Figure 1

Time series plots



Unit root tests. To apply the bounds testing approach, time series data must be integrated of order zero (I(0)) or one (I(1)). Therefore, unit root tests are employed to determine the order of integration. The Phillips-Perron (PP) and Augmented Dickey-Fuller (ADF) tests were conducted to assess the stationarity of GDP, Gross Capital Formation, Exports, Consumer Price Index, Employment, and the Human Development Index. (Poudel et al., 2024; Poudel et al., 2024a).

Table 3 summarizes the results of the ADF and P- tests, which assess the stationarity of six variables: LNGDP, LNLFPR, LNTE, LNTO, LNTP, and LNUP. At the level form, the PP test indicates that LNGDP, LNTO, and LNTP are potentially stationary since they show significant t-statistics and low p-values when including a constant and/or trend. However, the other variables fail to reject the null hypothesis of non-stationarity. When tested at the first difference, all variables (except LNLFPR and LNUP) exhibit strong evidence of stationarity with highly significant t-statistics and p-values below 0.01. The ADF results support these findings, revealing similar patterns of stationarity across the variables. Overall, the tests suggest that differencing may be necessary to achieve stationarity for most variables in the analysis.

Table 3

Unit root testing

Unit root test table (PP)							
At Level		LNGDP	LNLFPR	LNTE	LNTO	LNTP	LNUP
With Const.	t-Stat.	-1.4980	-0.9989	0.0237	-2.9547*	-2.7427*	-5.1998***
With Const. & T.	t-Stat.	-3.2205*	-2.5459	-1.8546	-3.7787**	-2.8458	-3.1165
First Difference		d(LNGDP)	d(LNLFPR)	d(LNTE)	d(LNTO)	d(LNTP)	d(LNUP)
With Const.	t-Stat.	-11.1491***	-4.0163***	-3.6884***	-5.3182***	-2.0132	-1.5256
With Const. & T.	t-Stat.	-11.8764***	-3.8214**	-3.7648**	-5.2450***	-1.3838	-1.3683
Unit root test table (ADF)							
At Level		LNGDP	LNLFPR	LNTE	LNTO	LNTP	LNUP
With Const.	t-Stat.	-0.5686	1.1343	0.1881	-1.7305	-3.8398***	-1.3454
With Const.& T.	t-Stat.	-3.3309*	-3.6873**	-2.4962	-3.7774**	-3.6613**	-3.1248
First Difference	t-Stat.	d(LNGDP)	d(LNLFPR)	d(LNTE)	d(LNTO)	d(LNTP)	d(LNUP)
With Const.	t-Stat.	-5.7296***	-3.9875***	-3.9090***	-4.8864***	-2.2365	-1.5221
With Const.& T.	t-Stat.	-5.7081***	-4.0299**	-3.9640**	-4.8917***	-1.0173	-1.3683

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

DOLS is suitable for this analysis because it effectively addresses potential endogeneity and autocorrelation in the time series data by incorporating leads and lags of the regressors. Additionally, DOLS provides consistent estimators even when the variables are non-stationary, making it appropriate for use after confirming that the series are integrated in the same order. Its robustness in handling long-run relationships further strengthens its applicability to the study's objectives (Poudel et al., 2024). Therefore, the application of the DOLS analysis is also validated by the presence of mixed-order integration for variables estimated by the ADF and PP tests.

Co-integration. Co-integration is a statistical property of a collection of time series variables that indicates a long-term equilibrium relationship among them, even if the individual series themselves are non-stationary. When variables are co-integrated, they tend to move together over time, suggesting that deviations from this equilibrium are temporary. This concept is crucial for economic modelling, as it allows researchers to identify and model relationships that persist despite short-term fluctuations.

Table 4

The Johansen co-integration test

Model	No. of CE(s)	Trace Statistic	p-Value	Max-Eigen Statistic	p-Value
I	None	63.33514***	0.0009	36.01991***	0.0033
	At most 1	27.31524*	0.0941	19.82549*	0.0753
	At most 2	7.489747	0.5214	6.077520	0.6033
	At most 3	1.412227	0.2347	1.412227	0.2347
II	None	49.58659**	0.0341	21.05559	0.2729
	At most 1	28.53101*	0.0694	18.55176	0.1106
	At most 2	9.979246	0.2823	9.723168	0.2308
	At most 3	0.256078	0.6128	0.256078	0.6128
III	None	111.5215***	0.0000	69.40127***	0.0000
	At most 1	42.12023***	0.0012	21.97828**	0.0380
	At most 2	20.14194***	0.0093	18.20832**	0.0113
	At most 3	1.933628	0.1644	1.933628	0.1644

The Johansen co-integration test identifies long-run relationships between variables by examining both the trace and max-eigen statistics. In Model I, the test reveals strong evidence of co-integration with the null hypothesis of no co-integration rejected at the 1% level, indicated by significant trace and max-eigen statistics (p-values of 0.0009 and 0.0033). This suggests a long-run equilibrium exists among the variables in the system. In contrast, for Model II, while there is moderate evidence of co-integration (p-value of 0.0341 for the trace statistic), the max-eigen statistic shows no significant result ($p = 0.2729$), indicating weaker long-run relationships. Model III provides the strongest evidence for co-integration, with multiple levels showing statistical significance at the 1% level. The existence of co-integrating equations suggests that despite short-term fluctuations, the variables in these models tend to move together in the long run, which is crucial for economic forecasting, policymaking, and understanding stable relationships between macroeconomic variables such as GDP, human capital, urban population, or trade openness in economic applications.

Table 5

Results of DOLS Model I

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTE	0.382334	0.047657	8.022655	0.0000
LNLFPR	2.220349	0.784663	2.829685	0.0116
LNUP	1.307528	0.087485	14.94565	0.0000
C	10.12189	2.942670	3.439695	0.0031
R-squared	0.998359	Mean dependent var		23.60578
Adjusted R-squared	0.997201	S.D. dependent var		0.368170
S.E. of regression	0.019480	Sum squared resid		0.006451
Long-run variance	0.000324			

Dependent variable: LNGDP

Table 5 presents the results of the Dynamic Ordinary Least Squares (DOLS) model, with GDP as the dependent variable. The coefficients indicate significant positive relationships between GDP and the independent variables: LNTE (0.382), LNLFPR (2.220), and LNUP (1.308), suggesting that increases in these factors—total employment, labour force participation rate, and unemployment rate—correlate with GDP growth. The high R-squared (0.998) and adjusted R-squared (0.997) values imply that the model explains a substantial portion of the variance in GDP, reinforcing its robustness. Economically, these results highlight the importance of labour market dynamics in influencing GDP, emphasizing policies that promote employment and higher labour force participation as vital for economic growth. However, the small standard error and low sum of squared residuals indicate that while the model fits well, it may also suggest potential overfitting, warranting cautious interpretation of the results.

Table 6

Results of DOLS Model II

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTE	0.562964	0.065963	8.534480	0.0000
LNTP	2.301517	0.235377	9.778005	0.0000
LNTO	0.111221	0.107092	1.038553	0.3136
C	-17.84920	3.803628	-4.692676	0.0002
R-squared	0.995853	Mean dependent var		23.60578
Adjusted R-squared	0.992926	S.D. dependent var		0.368170
S.E. of regression	0.030967	Sum squared resid		0.016302
Long-run variance	0.001099			

Dependent variable: LNGDP

Table 6 displays the results of the Dynamic Ordinary Least Squares (DOLS) model for GDP, with significant findings for the independent variables. The coefficients reveal strong positive relationships between GDP and total employment (LNTE, 0.563) and total productivity (LNTP, 2.302), indicating that increases in employment and productivity are crucial for economic growth. However, the coefficient for total output (LNTO, 0.111) is not statistically significant ($p = 0.3136$), suggesting it may not be a critical driver of GDP in this model. The high R-squared (0.996) and adjusted R-squared (0.993) indicate a good fit, but the relatively higher standard error and sum of squared residuals compared to Model I raise concerns about potential omitted variable bias or the model's sensitivity to outliers. Economically, the results emphasize the importance of enhancing employment and productivity through effective labour and economic policies to foster sustainable growth while cautioning against reliance on output measures alone for GDP forecasting.

Table 7

Results of DOLS Model III

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNTE	0.461411	0.270221	1.707530	0.1059
LNTP	-3.299000	1.023404	-3.223557	0.0050
LNLFPR	39.68287	11.89103	3.337210	0.0039
C	-94.22823	29.98493	-3.142519	0.0059
R-squared	0.764661	Mean dependent var		-0.745362
Adjusted R-squared	0.598539	S.D. dependent var		0.130617
S.E. of regression	0.082760	Sum squared resid		0.116438
Long-run variance	0.004045			

Dependent variable: LNTO

Table 7 outlines the results of the Dynamic Ordinary Least Squares (DOLS) model with total output (LNTO) as the dependent variable. The coefficient for total employment (LNTE) is positive but not statistically significant (p = 0.1059), suggesting its limited influence on total output in this context. Conversely, the coefficient for total productivity (LNTP) is negative and significant (-3.299, p = 0.0050), indicating that productivity increases might not translate into higher output, which could reflect diminishing returns or inefficiencies in resource allocation. The labour force participation rate (LNLFPR) shows a significant positive relationship (39.683, p = 0.0039), emphasizing its crucial role in driving total output. The relatively low R-squared (0.765) and adjusted R-squared (0.599) suggest that the model explains a moderate amount of the variance in total output, implying the need for further variables or interactions to better capture the complexities of output dynamics. Economically, these findings highlight the importance of improving labour participation and reevaluating productivity strategies to enhance total output sustainably.

Granger causality test. In the ARDL framework, the Granger Causality Test is a common method used to assess causal relationships among the model's variables. A significant result from this test suggests that historical values of the proposed predictor variable provide useful information for forecasting the dependent variable.

Table 8

Pairwise Granger causality tests for Model I

Null Hypothesis:	Obs	F-Statistic	Prob.
LNTE does not Granger Cause LNGDP	31	0.54237	0.5878
LNGDP does not Granger Cause LNTE		3.48191	0.0457
LNLFPR does not Granger Cause LNGDP	31	2.22228	0.1285
LNGDP does not Granger Cause LNLFPR		1.65652	0.2103
LNUP does not Granger Cause LNGDP	31	0.05377	0.9478
LNGDP does not Granger Cause LNUP		3.41716	0.0481
LNLFPR does not Granger Cause LNTE	31	1.45132	0.2526
LNTE does not Granger Cause LNLFPR		1.00873	0.3785
LNUP does not Granger Cause LNTE	31	2.12887	0.1392
LNTE does not Granger Cause LNUP		7.54972	0.0026
LNUP does not Granger Cause LNLFPR	31	1.99997	0.1556
LNLFPR does not Granger Cause LNUP		0.67691	0.5169

Table 8 examines the pairwise Granger causality relationships among key economic variables in Nepal, providing insights into the interplay between GDP, tertiary education (as a proxy for human capital), labour force participation, and urbanization. The results indicate that GDP (LNGDP) Granger causes tertiary education (LNTE), suggesting that economic growth enhances secondary school enrollment rates. However, TE does not Granger-cause GDP, implying that improvements in education alone do not predict higher economic output. Additionally, LNGDP significantly influences the urban population (LNUP), indicating that economic expansion drives urbanization as individuals seek better opportunities. The lack of significant causality between labour force participation (LNLFPR) and GDP further suggests that increasing participation rates alone may not lead to enhanced economic growth. These findings underscore the importance of integrated policies that leverage education to foster economic development and manage urban transitions effectively in Nepal.

Table 9

Pairwise Granger causality tests for Model II

Null Hypothesis:	Obs	F-Statistic	Prob.
LNTE does not Granger Cause LNGDP	31	0.54237	0.5878
LNGDP does not Granger Cause LNTE		3.48191	0.0457
LNTP does not Granger Cause LNGDP	31	0.10446	0.9012
LNGDP does not Granger Cause LNTP		9.77330	0.0007
LNTO does not Granger Cause LNGDP	31	0.82863	0.4479
LNGDP does not Granger Cause LNTO		3.07597	0.0632
LNTP does not Granger Cause LNTE	31	1.60181	0.2208
LNTE does not Granger Cause LNTP		2.48701	0.1027
LNTO does not Granger Cause LNTE	31	0.82657	0.4487
LNTE does not Granger Cause LNTO		1.97950	0.1584
LNTO does not Granger Cause LNTP	31	0.49341	0.6161
LNTP does not Granger Cause LNTO		5.25601	0.0121

Table 9 reveals that GDP (LNGDP) Granger causes tertiary education (LNTE), suggesting that economic growth enhances educational enrollment, while the reverse is not significant. Additionally, GDP also Granger-causes total population (LNTP), indicating that economic expansion influences demographic changes. Conversely, the relationship between total population and trade openness (LNTO) indicates that while total population Granger causes trade openness, trade openness does not significantly affect the total population, highlighting the complex interdependencies among these variables.

Table 10

Pairwise Granger causality tests for Model III

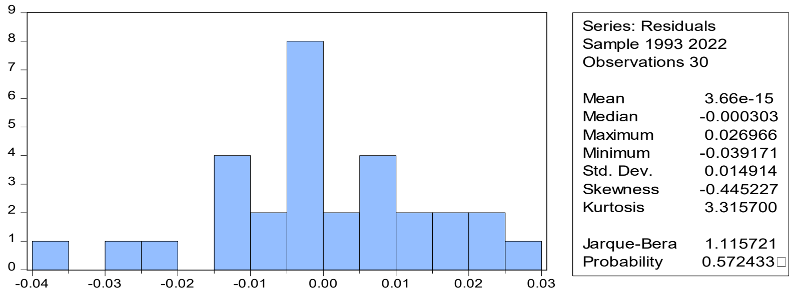
Null Hypothesis:	Obs	F-Statistic	Prob.
LNTE does not Granger Cause LNTO	31	1.97950	0.1584
LNTO does not Granger Cause LNTE		0.82657	0.4487
LNTP does not Granger Cause LNTO	31	5.25601	0.0121
LNTO does not Granger Cause LNTP		0.49341	0.6161
LNLFPR does not Granger Cause LNTO	31	0.94477	0.4017
LNTO does not Granger Cause LNLFPR		0.23658	0.7910
LNTP does not Granger Cause LNTE	31	1.60181	0.2208
LNTE does not Granger Cause LNTP		2.48701	0.1027
LNLFPR does not Granger Cause LNTE	31	1.45132	0.2526
LNTE does not Granger Cause LNLFPR		1.00873	0.3785
LNLFPR does not Granger Cause LNTP	31	0.37151	0.6933
LNTP does not Granger Cause LNLFPR		2.91355	0.0722

Table 10 indicates that there are no significant causal relationships between tertiary education (LNTE) and trade openness (LNTO), suggesting that educational improvements do not directly influence trade dynamics. However, total population (LNTP) Granger causes trade openness, highlighting that demographic factors may drive increased trade activity in Nepal. The weak causality observed between labour force participation (LNLFPR) and both trade openness and total population underscores the complexity of these interrelations, suggesting that more nuanced policies may be necessary to align education, labour, and trade in promoting economic development.

Normality test. The JB Normality test assesses if a dataset adheres to a normal distribution by analyzing its skewness and kurtosis. When the p-value is significant, it indicates that the null hypothesis of normality can be rejected, which is vital for ensuring valid assumptions in econometric analyses (Khatri et al., 2024)

Figure 2

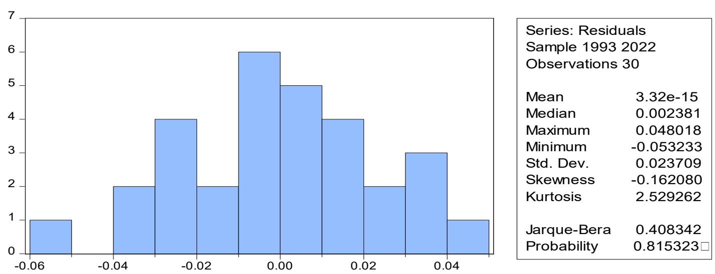
Normality test Model I



The Jarque-Bera test results suggest that the null hypothesis is accepted since the test's probability is greater than the 5% significance level. Given that the Jarque-Bera probability value is 0.572433, which exceeds 5%, it can be concluded that the model's residuals are normally distributed.

Figure 3

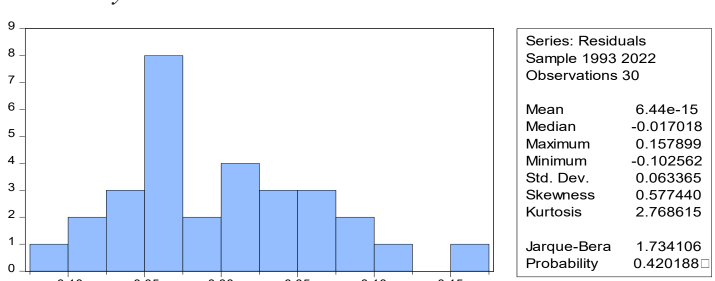
Normality test Model II



The Jarque-Bera test results suggest that the null hypothesis is accepted since the test's probability is greater than the 5% significance level. Given that the Jarque-Bera probability value is 0.815323, which exceeds 5%, it can be concluded that the model's residuals are normally distributed.

Figure 4

Normality test Model III



The Jarque-Bera test results suggest that the null hypothesis is accepted since the test's probability is greater than the 5% significance level. Given that the Jarque-Bera probability value is 0.420188, which exceeds 5%, it can be concluded that the model's residuals are normally distributed.

Wald test. The Wald test is a statistical test used to assess the significance of individual coefficients in a regression model. It evaluates whether a parameter estimate is significantly different from zero (or another specified value) by comparing the estimated value to its standard error. The test statistic is calculated as the square of the ratio of the estimated coefficient to its standard error. A large Wald statistic indicates that the coefficient is significantly different from zero, leading to the rejection of the null hypothesis (Poudel, 2022; Poudel. 2023; Poudel, 2024). This test is commonly used in econometrics and other fields to test hypotheses about model parameters.

Table 11

Wald test results

Model	F-statistic(Value)	Probability	Chi-square (Value)	Probability
I	871.1027	0.0000	2613.308	0.0000
II	594.0578	0.0000	1782.173	0.0000
III	6.690539	0.0035	20.07162	0.0002

The Wald test results for the three models reveal significant findings regarding the joint impact of explanatory variables on economic growth, as measured by the dependent variable LNGDP. For Model I, the F-statistic of 871.1027 and the Chi-square value of 2613.308 both have p-values of 0.0000, indicating that the coefficients for LNTE, LNLFPR, and LNUP are significantly different from zero, suggesting that tertiary education, labor force participation, and urban population are key drivers of GDP growth. Model II shows similar strong results, with an F-statistic of 594.0578 and a Chi-square value of 1782.173, indicating that the coefficients for LNTE, LNTP, and LNTO are statistically significant, emphasizing the role of education, total population, and trade openness in economic growth. Model III, with an F-statistic of 6.690539 and a Chi-square value of 20.07162, indicates a significant joint effect of the variables on trade openness. These results highlight the critical role of human capital and trade openness in shaping long-run economic growth.

Table 12

Multicollinearity test for Model I

Variable	Coefficient Variance	Centered VIF
LNTE	0.002271	5.405122
LNLFPR	0.615696	1.075639
LNUP	0.007654	5.236545
C	8.659308	NA

In Model I, the Centered VIF values for LNTE (5.41) and LNUP (5.24) suggest moderate but non-problematic multicollinearity, as both are well below 10. The LNLFPR (1.08) shows almost no multicollinearity, indicating its independent effect on GDP. These VIF values ensure that the model's estimates are reliable and not distorted by variable overlap. Economically, this means that education, labor force participation, and urban population independently and meaningfully contribute to GDP growth. Hence, multicollinearity does not affect the robustness of Model I's conclusions

Table 13

Multicollinearity test Model II

Variable	Coefficient Variance	Centered VIF
LNTE	0.004351	5.944703
LNTP	0.055402	5.590891
LNTO	0.011469	1.449373
C	14.46759	NA

In Model II, the Centered VIF values for LNTE (5.94) and LNTP (5.59) indicate moderate multicollinearity but remain well within acceptable limits. LNTO (1.45) has a low VIF, showing minimal overlap with other variables, ensuring its distinct role in the model. These values suggest that education, total population, and trade openness independently affect GDP. The model remains robust, and multicollinearity does not compromise the reliability of these variable estimates. This allows for clear policy implications focused on enhancing education and trade for economic growth.

Table 14

Multicollinearity test for Model III

Variable	Coefficient variance	Centered VIF
LNTE	0.073019	5.218408
LNTP	1.047355	7.784845
LNLFPR	141.3966	7.286781
C	899.0962	NA

In Model III, Centered VIF values for LNTE (5.22), LNTP (7.78), and LNLFPR (7.29) are all below 10, indicating no significant multicollinearity. Though higher than in the other models, these values are still acceptable and do not affect the model's reliability. Each variable contributes independently to explaining LNTO (trade openness). Therefore, the absence of multicollinearity concerns ensures that the model's results on how education, population, and labor force participation influence trade openness are valid.

Discussion. The findings of this study highlight the significant roles of trade openness and human capital in driving economic growth in Nepal, consistent with a broad range of international studies. For instance, the positive relationship between trade openness and GDP aligns with Sakyi et al. (2015) and Yanikkaya (2003), who demonstrated similar effects in developing countries. However, contrasting findings by Hye and Lau (2015) in India indicate that the impact of trade openness may vary depending on regional economic structures. Similarly, the study's results reinforce the importance of human capital, echoing Ahsan and Haque (2017) and Agiomirgianakis et al. (2002), who found that education and labour force participation contribute significantly to economic growth. Yet, the observed negative impact of labour force participation in some instances contrasts with Oketch (2006), emphasizing that the effects of human capital may depend on local labour market dynamics. The study also supports Nasreen and Anwar (2014) and Nguyen (2019), who found strong positive links between trade openness and economic growth in Asia, though mixed results from Bajwa and Siddiqi (2011) suggest that these effects are context-specific.

Moreover, the findings on human capital's complex effects are in line with Abdullah (2013) and Awan and Naseem (2018), who showed that education expenditure does not always yield positive growth outcomes. This study's methodological approach, using DOLS to capture long-term relationships, further supports Lau et al. (2019) and Amna Intisar et al. (2020), who endorsed the robustness of this model in dealing with endogeneity. The observed impact of urban population growth on GDP mirrors the conclusions of Pernia and Quising (2005), while the study's mixed findings on labour force participation resonate with, who noted that education does not automatically translate into growth without proper economic integration. Overall, these results align with much of the existing literature but also reveal the importance of context-specific factors, particularly in emerging economies like Nepal.

V. CONCLUSION AND IMPLICATIONS

This study empirically examines the impact of human capital and trade openness on economic growth in Nepal using a dynamic ordinary least squares (DOLS) approach. The results confirm that both trade openness and human capital significantly contribute to the country's economic growth, particularly in the long run. Trade openness fosters technological innovation, broadens market access, and enhances investment opportunities, while human capital—through education and labour force participation—plays a pivotal role in enhancing productivity and income levels. However, the study also highlights that the relationship between these factors and economic growth can be complex, with regional and structural differences influencing the outcomes. The findings suggest several important policy implications for Nepal's economic development. First, the government should continue to promote trade liberalization by reducing barriers to international trade and facilitating the diffusion of technology and innovation. Policies that encourage foreign direct investment and improve trade infrastructure could further enhance the benefits of trade openness. Second, investing in human capital development, particularly education and vocational training, should be a priority. Education policies must align with the needs of the labour market to ensure that the workforce's skills match the evolving demands of the economy. Additionally, enhancing labour force participation, particularly among women and underrepresented groups, would help maximize the potential of human capital to drive growth.

This study's novelty lies in its focus on the specific context of Nepal, a developing country with unique economic structures. While much of the existing literature on trade openness and human capital focuses on larger economies or regions, this study contributes to the understanding of how these factors influence economic growth in a smaller, emerging economy. The use of the DOLS approach also allows for a more robust analysis of both short-term dynamics and long-term equilibrium relationships, addressing endogeneity issues often encountered in time series data. Future research could explore the role of other economic factors such as infrastructure development, technological advancements, and political stability in enhancing the effectiveness of human capital and trade openness on economic growth.

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Funding

The authors received no funding or financial support in carrying out the research.

Conflict of Interest

The authors declared having no conflict of interest in the research work.