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IMPLICATION OF AUGMENTED SOLOW GROWTH MODEL IN SOUTH ASIAN REGION

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Abstract

This research aims to demonstrate the implications of the augmented Solow growth model within the particular region of South Asia. The study analyzes secondary panel data from six countries, covering the period from 2010 to 2019, with a total of 60 observations. The GDP growth rate is considered the dependent variable, while investment capital formation, population growth rate, and employment rate are considered independent factors. Pearson's correlation matrix and ordinary least square regressions with fixed effect have been conducted for cross-country panel data analysis along with several econometrical tests to remove multicollinearity, autocorrelation, and homoskedasticity. All econometrics tests conducted to assess the adequacy of the OLS regression model confirm that the created regression model is suitable. The empirical findings indicate that there is a strong and positive correlation between capital formation and variations in GDP growth rate. The changes in the explained variable are not significantly affected by any of the other explanatory factors, although they do have a beneficial impact. This study may help the policymakers of South Asian region on emphasizing more on capital formation for obtaining growth. The strong positive coefficient of employment, though statistically insignificant, depicts that investment in human capital in the form of education and skill-enhancing training which makes people eligible for employment; also plays important role in attaining sustainable growth.

Keywords: augmented Solow growth model, cross-country, South Asia, GDP growth rate, capital formation, population growth rate, employment rate, panel data.

1. Introduction

1.1 Background of the Study

Diverse factors, including fluctuations in macroeconomic conditions and productivity levels, contribute to national wealth disparities. A country's ability to create productivity from different production components is a major determinant of its economic growth. While focusing on productivity makes it relatively easy to assess

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economic growth within a given nation, the unique economic characteristics of each nation make it more difficult to understand growth trends globally (Soejoto, Cahyono, & and Solikhah, 2017).

South Asia's economy has grown steadily since 2009, surpassing the 3 percent global average from 2010 to 2018. India's economic initiatives, such as the creation of infrastructure, the decrease of poverty, and the growth of exports, were crucial. Chinese investments in Pakistan and the textile sector in Bangladesh both made a contribution. Individual nations did, however, have economic crises. For example, Sri Lanka's enormous debt and balance of payments problems led to the country's collapse in 2022 as a result of poor management and hyperinflation. South Asia is one of the world's fastest-growing regions, yet it still faces challenges like low private investment and a sluggish epidemic recovery. However, according to the South Asia Economic Update prepared by the World Bank, South Asia's growth is expected to slow in 2026 amid global energy market disarticulation due to Iran war. Since 2022, about half of South Asia's industrial policies have been directed at manufacturing, particularly activities with more or better-paid employment. The introduction of AI-related activities may reduce job creation. (South Asia Economic Update, The World Bank, April 2026)

The basic Solow Growth Model explains that a country's economic growth is determined by saving rates and population growth (Solow, 1956). The Augmented Solow Model incorporated **human capital** (education and skills) with this basic model. (Mankiw, Romer, & Weil, 1992) The original Solow model predicted that poor countries reach to the steady-state growth rate quickly. However, in reality, some poor countries remain poor. And often, countries with similar physical capital often have very different productivity. The augmented model explains this by recognizing that countries with more educated and skilled workers are more productive which helps to achieve sustainable growth in the long run. Technology is considered as an exogenous variable in both cases. (Mankiw, Romer, & Weil, 1992) South Asia has gone through major technological progress by the inauguration of internet throughout the region. This study aims to analyze the influence of augmented Solow model on economic growth of six South Asian countries (namely Bhutan, Bangladesh, India, Pakistan, Nepal, Sri Lanka) using cross-country panel data from year 2010 to 2019. The reason of selecting these ten years is to avoid the extreme values during the period of Covid 19 pandemic in 2020 and 2021 and later the recovery period during 2022 and 2023. Afghanistan has not been included due to its structural difference and Maldives has not been included due to unavailability of data. This study will help the policymakers to decide whether to invest only in physical capital or to invest only in human capital or both to achieve sustainable growth.

In analyzing the model, fixed effect OLS have been used to overcome endogeneity problem of cross-country panel data. The variables that have been used are GDP growth rate, Gross capital formation rate, population growth rate, employment rate. Here, Educational attainment data cannot be included as representative of human capital due to unavailability of data. However, employment ratio has been included as a proxy variable for human capital as it is assumed that ensuring employment requires minimum educational qualification along with training to increase skills. The limitation of this study is that it does not include structural differences of the countries into consideration.

The initial section of this paper presents a comprehensive analysis of the existing literature about the relationship between the variables of the augmented Solow growth model and their impact on economic growth. Next, we provide an overview of the augmented Solow growth model and describe the research methodologies employed in this study. The final section analyzes the findings of the study before formulating conclusions.

1.2 Objectives of the Research

- Examining the impact of the augmented Solow model on the economic growth of selected South Asian countries
- Determine the factors which influence growth variables significantly

2. Literature Review

2.1 Classical Solow Growth Model

In 1956, Robert Solow and Trevor Swan established the Solow-Swan model, sometimes known as the exogenous growth model. By concentrating on human and physical capital to boost productivity with technical advancements, this model attempts to explain long-run economic growth in the classic 1956 paper (Hagemann, 2009). In the past, the Harrod–Domar model, which is a Keynesian framework for economic development, was employed to provide an explanation for economic expansion. The foundation of this paradigm rested upon the capital and savings levels of the economy. The equation based on ($\Delta Y/Y$) rate of growth of GDP, c is capital output ratio, s^G is gross savings, δ is rate of capital depreciation.

$$\frac{\Delta Y}{\mathrm{Y}} = \frac{s^G}{c} - \delta$$

(Solow, 1956) said that the critics of this model are concerned with the narrow focus of the Harrod-Domar model on capital stock and its inability to adequately explain economic growth instability. Robert Solow addressed the criticisms of the Harrod-Domar model by incorporating human capital (labor) as a factor of production and capital output ratio into the model. (Solow, 1956) delves into the concept of secular instability, referring to the incompatibility of natural and justified rates of growth. In an effort to address this problem, he tried to enhance the Harrod-Domar model.

The main focus of Solow's study is a long-run growth model that maintains the majority of Harrod-Domar assumptions. However, it also introduces the concept of substituting labor for capital within standard neoclassical conditions. Examining the relationship between price, wage, and interest rate reactions is a crucial element of the neoclassical adjustment process, as explored by Solow in his analysis.

2.2 Augmented Solow Growth Model

In their study, (Mankiw, Romer, & Weil, 1990) analyze the extent to which the Solow growth model corresponds to the differences in living standards across countries. It emphasizes the significance of taking into account human capital in addition to physical capital when analyzing economic growth in their study, (Mankiw, Romer, & Weil, 1990) present an enhanced Solow model that incorporates the accumulation of human capital alongside physical capital. This expanded model offers a more comprehensive framework for grasping the dynamics of economic growth. When human capital is taken into account, they (Mankiw, Romer, & Weil, 1990) discovered that it greatly enhances the model's accuracy in predicting income per capita based on the available data. Human capital accumulation has been found to have a strong correlation with saving and population growth rates, which in turn have a significant impact on income levels across various countries.

The original Solow model predicted that poor countries reach to the steady-state growth rate quickly. However, in reality, some poor countries remain poor. And often, countries with similar physical capital often have very different productivity. The augmented model explains this by recognizing that countries with more educated and skilled workers are more productive which helps to achieve sustainable growth in the long run. The augmented Solow model provides a solid explanation for around 80% of the differences in income per capita across countries. It provides valuable insights into the factors that contribute to the varying levels of wealth among different countries and offers a comprehensive explanation for the disparities in income across nations.

Basic Solow Model: Output depends strictly on physical capital (K) and labor (L), scaled by total factor productivity (A)

$$Y = AK^{\alpha}L^{1-\alpha}$$

Augmented Solow Model: This version adds human capital (H) as a third independent input.

$$Y = K^{\alpha}H^{\beta}(AL)^{1-\alpha-\beta}$$

2.3 Solow Growth Model- Recent Studies

A study conducted by (Mankiw, Romer, & Weil, 1990) focused on the Solow growth model and its contribution to the empirical analysis of economic growth. The study emphasized that the model incorporates the accumulation of both human capital and physical capital, which provides a meaningful description for cross-country analysis. This report examined the physical and human capital's impact on economic growth by analyzing time series data. The dataset contains real income, government and private consumption, investment, and population data for almost all countries except for centrally planned economies. The data provided are annual and span from 1960 to 1985. For the cross-country panel data analysis, the validity of Solow growth was ensured by using the ordinary least squares (OLS) method, as employed by (Mankiw, Romer, & Weil, 1990) and (Hoeffler, 2000). (Hoeffler, 2000) also suggests that OLS is a biased estimator since it cannot account for the unobserved country-specific factors in cross-country analysis. Using the generalized method of moments (GMM), the study successfully addressed the issue and found a good fit with the results.

In the Local Solow Growth Model, (Durlauf, Andros, & Minkin, 2000) analyze economic growth from 1960 to 1985 across 90 countries. They consider various factors such as changes in income per capita, the growth rate of the working-age population, the proportion of real investments to real GDP, the percentage of the working-age population in secondary school, and initial per capita income. They utilized the Cobb-Douglas production technology to conduct testing on the Solow growth model, employing the general growth function. The paper emphasizes the importance of incorporating cross-country parameter diversity in empirical Solow growth models. A local Solow model, which recognizes this diversity, is found to be a more suitable fit for countries when compared to the conventional global model. Disregarding such differences may result in incorrect conclusions in empirical studies. Grasping the factors behind parameter heterogeneity is crucial for understanding the variations in economic growth between countries.

When examining economic growth across OECD countries, (Murthy & Chien, 1997) took a closer look at the Solow model and made improvements by considering factors such as human capital, physical capital, and technological advancements. Their research uncovered a noteworthy convergence rate among OECD nations, especially when effective policies promoting human capital development and trade were implemented alongside higher savings.

In a study conducted by (Lee & Smith, 1997), they utilized panel data econometric techniques to examine the empirical aspects of the stochastic Solow model. Their research specifically looked at growth and convergence in different economies, similar to the study conducted by (Murthy & Chien, 1997). Their research emphasized the effectiveness of panel analysis in tackling technical obstacles encountered in cross-sectional approaches. In addition, they discovered evidence that indicates varying rates of convergence and inconsistent parameters when using dynamic panel methods to analyze growth effects.

In their study, (Ding & Knight, 2009) examined the accuracy of the augmented Solow model within the framework of China's economic growth. They conducted an analysis using cross-country panel data from 146 nations. By utilizing the GMM estimation method, it was discovered that the incorporation of structural change and human capital development into the augmented Solow growth model had a substantial impact on economic growth. Their study highlighted the significance of making significant investments in physical capital, changes in employment and structural output, and implementing policies to manage population growth as crucial factors in China's rapid economic growth.

In a study conducted by (Sumer, 2012), an investigation was carried out to assess the combined effectiveness of growth models proposed by Solow, Harrod-Domar, Barro, and Romer in Turkey. Through the use of a sophisticated SUR model and an extensive dataset covering the years 1980 to 2010, this research has successfully pinpointed public expenditure as a crucial factor in driving economic growth in Turkey. It is worth mentioning that the study confirmed the relevance of the Barro model in the Turkish context. It indicates that factors such as government intervention, public demand, and efficient economic structures are crucial in promoting economic growth and achieving stability.

In a study conducted by (Soejoto, Cahyono, & and Solikhah, 2017), the authors investigate into the complex factors that contribute to economic growth in Southeast Asia. Experts utilize regression analysis to analyze the impact of various factors, such as workforce, capital, personnel, resources from the environment, and technology, on the Solow variables. These variables act as a measure of economic growth. The findings shed light on the intricate connections between these factors and economic growth throughout the countries in the region. Investment, workforce, and labor play vital roles in driving economic growth in Indonesia and Brunei. Thailand and the Philippines are greatly impacted by investment, natural resources, and labor. Malaysia's economic growth is heavily impacted by capital, technological advances, and human capital, while Vietnam's growth is fueled by technological advances, natural and human resources, and workforce.

The study conducted by (Nkalu, Chigozie Nelson, & Richardson Kojo, 2018) intends to evaluate the validity of the Solow growth model by analyzing cross-country panel data. The analysis employs a panel Ordinary Least Squares (OLS) approach, specifically considering recent scholarly works. The dependent variable is real Gross Domestic Product (GDP), whereas the independent variables consist of population, capital stock, and employment. The analysis demonstrates that both population and capital stock have a considerable positive effect on output, whereas employment, despite its negative influence, is not considered statistically significant. In general, the results confirm the fundamental and enhanced Solow growth models, validating the applicability of the Solow model across different countries.

2.4 Research Gap

Both Solow Growth Model and augmented Solow Growth Model have been used extensively all over the world. These models have been applied on developed countries, Southeast Asia, OECD countries, China, Turkey, African countries. However, the application of Solow Growth model and augmented Solow Growth Model have not been applied in explaining the growth of South Asian countries for the period of 2010 to 2019. The reason of selecting these ten years is to avoid the extreme values during the period of Covid 19 pandemic in 2020 and 2021 and later the recovery period during 2022 and 2023. This study has been conducted to identify the impact of augmented Solow growth model in South Asian region for the period of 2010 to 2019.

3. Data Collection and Research Methodology

3.1 Data and Its Sources

This study is compiled using secondary data in the form of panel data. The panel data consists of a decade's worth of data, spanning from 2010 to 2019, for specific countries. The reason of selecting these ten years is to avoid the extreme values during the period of Covid 19 pandemic in 2020 and 2021 and later the recovery period during 2022 and 2023. It has been tried to avoid the outliers. The data have been collected from The World Bank Database.

3.2 Sample Selection and Size

Currently, there are eight countries in the South Asian region namely Afghanistan, Bangladesh, India, Sri Lanka, Bhutan, Nepal, Pakistan, and Maldives. Among these countries, six countries have been selected excluding Afghanistan and Maldives. Afghanistan has not been included due to its structural difference and Maldives has not been included due to unavailability of data. Consequently, cross-country panel data from six countries have been analyzed.

3.3 Variables Definition

The Augmented Solow growth model explains that the growth rate of gross domestic product (GDP) is determined by investment and physical and human capital. Therefore, the equation can be expressed as follows.

$$Y = A\, f\,(H, K, N)$$

Above function f (), which shows that how the inputs are create influence to produce output, may be found here. 'A' variable denotes the presence or absence of industrial technology. Technological advancements stimulate economic growth by increasing the production of output relative to input combinations through form diversity. 'K' denotes physical capital. 'H' symbolizes the human capital, whereas 'N' signifies the magnitude of the population.

The study conducted by (Nkalu, Chigozie Nelson, & Richardson Kojo, 2018) intends to evaluate the validity of the Solow growth model by analyzing cross-country panel data. The analysis employs a panel Ordinary Least Squares (OLS) approach to determine growth using population growth, capital stock, and employment as independent variables. Following this research, we have taken Gross Domestic Product Growth Rate (GDPG) as the dependent variable, while other factors such as population growth rate, capital formation rate, and employment rate as the independent variables.

	Variable's Name	***Symbol***
Dependent Variable	Gross Domestic Product Growth Rate	GDPG
Independent Variables	Capital Formation Rate	CAPF
	Employment Rate	EMP
	Population Growth Rate	POPG

- **Gross Domestic Product Growth Rate**

  GDP growth rate has been widely used as a growth parameter in many studies. (Mankiw, Romer, & Weil, 1990) and (Hoeffler, 2000) The GDP represents the total value added by all producers in the economy, including taxes on products and excluding subsidies. This calculation doesn't look at how quickly manufactured goods lose value or how natural materials are used up and broken down.

  $$GDP = C + I + G + NX$$

  where:

  C=Consumption, G=Government spending, I=Investment, NX=Net exports

  On the other hand, GDP growth rate calculated as,

  $$\text{GDP Growth} = \frac{\text{GDP 2} - \text{GDP 1}}{\text{GDP 1}}$$

- **Capital Formation Rate**

  Gross capital formation, previously known as gross domestic investment, refers to the total amount of money spent on increasing the fixed assets of the economy, as well as any net changes in inventory levels. (Nkalu, Chigozie Nelson, & Richardson Kojo, 2018) used it as dependent variable for their study. Fixed assets encompass many types of physical assets such as land improvements (such as fences, ditches, and drains), purchases of plant, machinery, and equipment, as well as the construction of infrastructure including roads, trains, schools, offices, hospitals, residential homes, and commercial and industrial structures. As per the 1993 System of National Accounts (SNA), the act of acquiring valuables without any corresponding liabilities is likewise classified as capital formation. (The World Bank, Gross capital formation (% of GDP), 2024)

- **Employment**

  The employment to population ratio refers to the percentage of a nation's population that is now employed. (Nkalu, Chigozie Nelson, & Richardson Kojo, 2018) used it as dependent variable for their study. Employment refers to individuals who, within a specific timeframe, were involved in any activity that generated goods or services for monetary gain, regardless of whether they were physically present at work for at least one hour or temporarily absent from their job due to various reasons or working-time arrangements. The working-age population is typically defined as individuals aged 15 and above. (The World Bank, Employment to population ratio, 15+, total (%) (modeled ILO estimate), 2024)

- **Population Growth Rate**

  The annual population growth rate for a given year, denoted as t, is the exponential rate at which the midyear population grows from the previous year (t-1) to the current year (t), expressed as a percentage. (Nkalu, Chigozie Nelson, & Richardson Kojo, 2018), (Mankiw, Romer, & Weil, 1990) and (Hoeffler, 2000) used it as dependent variable for their study. Population is determined using the de facto definition, which includes all individuals residing in a given area, regardless of their legal status or citizenship. (The World Bank, Population growth (annual %), 2022)

3.4 Regression Analysis

Regression is employed to illustrate the relationship between a dependent variable and one or more independent variables.

The following regression model has been developed for this study.

$$GDPG = c + \beta 1 EMP + \beta 2\ CAPF + \beta 3\ POPG + e$$

Where,

c = constant
β1 = beta coefficient of EMP
β2 = beta coefficient of CAPF
β3 = beta coefficient of POPG
e = error

In this work, additional tests have been conducted to verify the assumptions of regression analysis. These tests include the assessment of heteroskedasticity, multicollinearity, and normality.

4 Empirical Results and Discussion

4.1 Descriptive Statistics

Descriptive analysis summarizes or explains data through the application of statistical methods. A prominent type of data analysis, descriptive analysis produces insights from uninterpreted data. Unlike alternative forms, descriptive analysis does not generate future predictions. Instead, conclusions are drawn from historical data that has been manipulated.

Table 4-1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPG	60	.056	.022	-.002	.119
EMP	60	.504	.082	.354	.659
CAPF	60	.341	.13	.146	.695
POPG	60	.01	.004	.002	.023

Note: *The authors' calculation*

Table 4-1 provides descriptive statistics regarding gross domestic product growth (GDPG), employment rate (EMP),the capital formation rate (CAPF), and population growth rate (POPG). A total of sixty observations comprises each of the variables, covering the period from 2010 to 2019. The central values of GDP, EMP, CAPF, and POPG are corresponding to their respective means, which are 5.6%, 50.4%, 34.1%, and 1%. All of the variable observations are highly concentrated around the mean.

4.2 Pearson Correlation Analysis

A statistical method, Pearson's correlation coefficient quantifies the strength of the association between two continuous variables, as well as the direction in which that association occurs. Pearson's correlation coefficient of significance is the determinant of the strength of the relationship between two variables. (Cohen, 1988) outlines some general criteria that can be utilized to attribute specific values with the intensity of a connection. Although there are no absolute laws, the following recommendations are reasonable:(1) A correlation is considered minor if its value falls within the range of.1 to.3; (2) It is considered medium if its value falls between.3 and.5; and (3) It is considered large if its value exceeds 0.5.

Table 4-2: Pairwise correlations

Variables	GDPG	EMP	CAPF	POPG
GDPG	1.000			
EMP	0.201	1.000		
CAPF	0.364*	0.285*	1.000	
POPG	0.121	0.399*	-0.305*	1.000

Note: *The authors' calculation * p<.05*

The results of the Pearson correlation matrix are presented in Table 4-2. The matrix indicates that there is significant correlation presence between the different variables. Among the variables, there is a significant correlation between CAPF and both GDPG and EMP and also a significant correlation between POPG and both EMP and

CAPF where the CAPF is negatively correlated. None of the other associations are statistically significant.

4.3 Regression Analysis

The goal of regression analysis is to determine an estimate of the connection between the dependent variable and the independent variables. This methodology can be used to predict future interactions between two or more variables and evaluate the strength of existing relationships.

Table 4-3: Regression results (Fixed Effect)

GDPG	Coef.	St.Err.	t-value	p-value	Sig
EMP	.231	.149	1.55	.127	
CAPF	.056	.027	2.09	.041	*
POPG	.003	.008	0.37	.715	
Constant	.297	.103	2.87	.006	*
Mean dependent var		0.057	SD dependent var	0.021	
R-squared		0.194	Number of obs	60	
F-test		4.085	Prob > F	**0.001***	
Akaike crit. (AIC)		-310.080	Bayesian crit. (BIC)	-301.703	

Note: *The authors' calculation * p<.05*

Here, fixed effect regression analysis has been performed to reduce the effect of endogeneity. Fixed effect regression is a statistical method used to control for unobserved, time-invariant variables in panel (longitudinal) data. Hausman specification test also supports the use of the fixed effect regression model for this investigation.

The regression results of the model can be seen in the table titled 4-3 above. This table presents the coefficients of the independent variables, together with their corresponding standard errors, t-values, p-values, and significance levels.

The model is now,

$$GDPG = 0.297 + 0.231EMP + 0.056\ CAPF^{*} + 0.003\ POPG + e$$

The equation represents a linear regression model that aims to elucidate the relationship between the Gross Domestic Product Growth Rate (GDPG) and three independent variables: Employment (EMP), Capital Formation Rate (CAPF), and Population Growth Rate (POPG). Here's a breakdown of each component:

- **GDPG (Gross Domestic Product Growth Rate):** This is the variable that we are aiming to forecast. Gross Domestic Product (GDP) is a measure of the percentage change in the value of all products and services produced within a country's borders within a specified time frame. The R-squared score of 19.4% indicates that 19.4% of the variation in gross domestic product growth can be explained by the specified independent variables.
- **CAPF (Capital Formation Rate):** Capital formation is the process of increasing a country's physical capital stock, which includes machines, buildings, infrastructure, and other such assets. It signifies the financial

resources allocated to the economy. The coefficient for CAPF in this equation is 0.056. This coefficient represents the influence of capital formation on the rate of GDP growth, assuming that all other factors remain unchanged. Each additional unit of capital creation is associated with a corresponding rise in the GDP growth rate of 0.056. This variable has been found statistically significant at 5% level of significance as p value is .041. This result is consistent with the findings of (Ding & Knight, 2009), who found that huge investment in physical capital played substantial role in China's growth.

- **EMP (Employment):** This variable denotes the extent of employment in the economy. The equation contains a coefficient of 0.231. This coefficient quantifies the influence of employment on the rate at which the Gross Domestic Product (GDP) grows, while keeping all other variables unchanged. More precisely, the data indicates that for each additional unit of employment, there is a corresponding increase in the GDP growth rate of 0.231. Though statistically insignificant, the positive relationship between EMP and GDPG recognizes that employment of human resources exerts positive impact on growth.
- **POPG (Population Growth Rate):** This variable denotes the population growth rate of a country within a specified time period, usually on an annual basis. It quantifies the extent of changes in population characteristics. The coefficient for POPG in this equation is 0.003. This coefficient quantifies the influence of the rate of population growth on the rate of GDP growth, while keeping all other factors unchanged. Each additional unit of population growth rate corresponds to a 0.003 rise in GDP growth rate. The coefficient indicates that population increase has a comparatively minor influence on the pace of GDP growth when compared to the effects of employment and capital formation. However, this variable has not been found statistically significant at 5% level of significance. (Nkalu, Chigozie Nelson, & Richardson Kojo, 2018) found similar positive impact of population growth on GDP growth rate.

4.4 Multicollinearity Test

Assessing multicollinearity among variables is often done using the VIF (variance inflation factor) and the tolerance value. These techniques offer useful insights on the degree of multicollinearity present in a specific dataset. The tolerance value is defined as the inverse of the VIF (Variance Inflation Factor), which quantifies the impact of the other parameters on the standard deviation of the regression coefficient.

Table 4-4: Variance inflation factor (VIF)

	VIF	1/VIF
EMP	1.518	.66
CAPF	1.408	.71
POPG	1.538	.65
Mean VIF	1.488	.67

Note: *The authors' calculation*

A high value of the Variance Inflation Factor (VIF) signifies a significant occurrence of collinearity between the independent variable and the other variables. Low multicollinearity is observed when both the variable of interest (VIF) and the tolerance value demonstrate high values. The study indicates a dearth of substantial correlations among the independent variables. Typically, a widely recognized standard for the Variance Inflation Factor (VIF) is a value of 10 or lower. Similarly, a widely acknowledged threshold for a tolerance level is 0.10 or above.

Based on the data provided in table 4-4, the mean VIF (Variance Inflation Factor) for the models is exactly the same, with a value of 1.488. The Variance Inflation Factor (VIF) for each variable is below 10, and the tolerance value for each variable is above 0.10. Therefore, the problem of multicollinearity is absent in these models.

4.5 Jarque-Bera Normality Test

The Jarque-Bera test is a statistical test employed to evaluate the normality of a distribution. This method is used to evaluate the extent to which a given dataset displays kurtosis and skewness that are consistent with the properties of a normal distribution. The Jarque-Bera test is a statistical test that evaluates the degree to which a distribution conforms to the normal distribution. The method is based on the skewness and kurtosis of the sample, as suggested by (Jarque & and Bera, 1987).

Table 4-5: Normality Test

Ho: Residuals are normally distributed
Prob > chi^2: 0.6146

Note: *The authors' own calculation*

Table 4-5 displays the outcomes of the Jarque-Bera Normality Test, which indicate that the test findings do not provide sufficient evidence to reject the null hypothesis that the residuals follow a normal distribution.

4.6 Test of Heteroskedasticity

To detect heteroscedasticity, the statistical procedure known as the White test (White, 1980) is widely applied. The principal aim of this analysis is to identify the existence of heteroscedasticity by examining the residuals that are produced by the regression models. The evaluation of the test hypothesis is conducted by utilizing the chi-square distribution.

Table 4-6 Test of Heteroskedasticity

Ho: Heteroskedasticity	
chi^2 = 10.82	Prob > chi^2: 0.2879

Note: *The authors' own calculation*

The results of the white test for heteroskedasticity are presented in Table 4-6. Consistent with the results, the error terms appear to be homoscedastic.

5. Conclusion

This research aims to investigate the impact of the augmented Solow growth model in the South Asian region, specifically in Bangladesh, India, Sri Lanka, Bhutan, Nepal, and Pakistan The study utilized quantitative research methodologies to assess secondary panel data from 2010 to 2019. The reason of selecting these ten years is to avoid the extreme values during the period of Covid 19 pandemic in 2020 and 2021 and later the recovery period during 2022 and 2023. The empirical data demonstrated a robust and positive link between capital formation and fluctuations in GDP growth rate, suggesting that changes in GDP growth rate were considerably impacted by capital formation. This result is consistent with the findings of (Ding & Knight, 2009), who found that huge investment in physical capital played substantial role in China’s growth. In this study, the population growth rate and employment rate were observed to have a positive effect, while their influences on the explained variable were not statistically significant. In analyzing the model, fixed effect OLS have been used to overcome endogeneity problem of cross-country panel data.

Based on the study, there is a positive correlation between the growth rate of gross domestic products and the growth rate of population, the rate of capital formation, and the rate of employment. The Augmented Solow growth model also highlights the importance of both the physical capital and human capital in driving economic growth. Based on an analysis of panel data from 6 South Asian countries over a span of 10 years, the study found that both human capital and physical capital have a positive impact on economic growth. Various econometric tests have been used to evaluate the accuracy of the developed regression model. The regression model is supported by the results of the White test of heteroskedasticity, VIF test of multicollinearity, and Jarque-Bera test of normality.

The overall regression is statistically significant at a 5% level, as indicated by the p-value of the F-test being 0.001. The overall R-squared indicates that the GDP growth rate is influenced by changes in the population growth rate, employment rate, and capital formation rate.

In this study, we want to examine the implications of the augmented Solow growth model within the South Asian region. However, it’s crucial to acknowledge that there are certain limitations. Initially, we did the study with certain predetermined variables while disregarding other contributing variables like trade, foreign direct investment etc. We can employ additional variables to ascertain more precise results. We have utilized data for a span of 10 years, specifically from 2010 to 2019. Given the time frame, it is possible to do additional research during and post Covid 19 era. Moreover, structural differences between the countries have not been included. Country specific discussion of growth has not been mentioned in this study. Further study can be conducted to overcome all these limitations.

This study may help the policymakers of South Asian region on emphasizing more on capital formation for obtaining growth. The strong positive coefficient of employment, though statistically insignificant, depicts that investment in human capital in the form of education and skill-enhancing training which makes people eligible for employment; also plays important role in attaining sustainable growth; proving the implication of augmented Solow growth model.

References

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). New York.

Dalgaard, C.-J., & Strulik, H. (2010). The History Augmented Solow model. *Leibniz Universitat Hannover*, 1-22.

Ding, S., & Knight, J. (2009). Can the augmented Solow model explain China's remarkable economic growth? A cross-country panel data analysis. *Journal of Comparative Economics, 37*, 432-452.

Durlauf, S. N., Andros, K., & Minkin, A. (2000). The Local Solow Growth Model. *Department of Economics, University of Wisconsin*, 1-10.

Hagemann, H. (2009). Solow's 1956 Contribution in the Context of the Harrod-Domar Model. In H. Hagemann, *History of Political Economy* (pp. 67-87). Duke University Press.

Hoeffler, A. E. (2000). The augmented Solow model and the African growth debate. *OXFORD BULLETIN OF ECONOMICS AND STATISTICS*, 135-158.

Jarque, C. M., & and Bera, A. K. (1987). A Test for Normality of Observations and Regression Residuals. *International Statistical Review, 55*, 163-172.

Lee, K., & Smith, R. a. (1997). Growth and Convergence in a Multi-Country Empirical Stochastic Solow Model. *Journal of Applied Econometrics, 12*, 357-392.

Mankiw, N. G., Romer, D., & Weil, D. N. (1990). A Contribution to the Empirics of Economic Growth. *NATIONAL BUREAU OF ECONOMIC RESEARCH*, 1-48.

Murthy, N. V., & Chien, I. (1997). The empirics of economic growth for OECD countries: Some new findings. *Economics Letters, 55*, 425-429.

Nkalu, Chigozie Nelson, E., & Richardson Kojo, C. Q. (2018). Testing the Validity of the Solow Growth Model: Empirical Evidence from Cross-Country Panel Data. *American Economic & Social Review, 3*, 18-22.

Soejoto, A., Cahyono, H., & and Solikhah, N. (2017). Effect of Solow Variable to the Economic Growth in Southeast Asia. *International Journal of Economics and Financial*, 277-282.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 65-94.

Sumer, K. K. (2012). Testing The Validity of Economic Growth Theories with Seemingly Unrelated Regression Models: Application to Turkey In 1980-2010. *Applied Econometrics and International Development, 12-1*, 63-72.

The World Bank. (2022). *GDP growth (annual %)*. Retrieved April 3, 2024, from https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

The World Bank. (2022). *Population growth (annual %)*. Retrieved April 3, 2024, from https://data.worldbank.org/indicator/SP.pop.grow

The World Bank. (2024). *Employment to population ratio, 15+, total (%) (modeled ILO estimate)*. Retrieved April 3, 2024, from https://data.worldbank.org/indicator/SL.EMP.TOTL.SP.ZS

The World Bank. (2024). *Gross capital formation (% of GDP)*. Retrieved April 3, 2024, from https://data.worldbank.org/indicator/NE.GDI.TOTL.ZS

The World Bank. (2024, 04 02). *South Asia*. Retrieved from The World Bank: https://www.worldbank.org/en/region/sar/overview

White, H. (1980). A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for. *The Econometric Society, 48*, 817-838.

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