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Modeling Economic Growth in Uzbekistan: A Solow Model Approach

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Abstract

This study investigates the economic growth of Uzbekistan from 1999 to 2022 using the Solow Growth Model. The analysis employs time series data from the World Bank to estimate the contributions of physical capital, human capital, and labor force participation to real GDP growth. The results indicate that both human capital, measured by government expenditure on higher education, and physical capital, measured by gross capital formation, have statistically significant positive effects on economic growth. However, labor force participation was found to be statistically insignificant, possibly due to data limitations. The model explains 97.69% of the variation in real GDP, confirming its overall significance. The findings suggest that policymakers should prioritize investments in human capital to sustain long-term economic growth, while further research using panel data is recommended for more robust insights.

Keywords: Economic Growth, Solow Growth Model, Uzbekistan, Human Capital, Physical Capital, Labor Force Participation, Total Factor Productivity.

Introduction

Economic growth, a primary objective for nations worldwide, serves as a fundamental indicator of development and prosperity. Understanding its drivers is crucial for formulating effective economic policies. Among the various frameworks developed by economists, the Solow Growth Model, a cornerstone of neoclassical theory, provides a powerful tool for estimating growth into its parts: capital accumulation, labor expansion, and technological progress. This model has been widely applied to understand the growth directions of both developed and developing economies Arratibel et al (2007).

The economic trajectory of Uzbekistan since its independence presents a captivating case for study. The country has undergone significant reforms, leading to a period of notable economic expansion. However, the precise sources of this growth remain a subject of inquiry. Existing literature offers valuable insights yet leaves room for further investigation.

This study builds upon and contributes to this existing body of work by conducting a focused time-series analysis of Uzbekistan from 1999 to 2022. It employs an augmented Solow model that explicitly incorporates human capital, addressing a key variable debated in the literature. The primary objective is to empirically identify and measure the sources of economic growth, specifying real GDP as a function of physical capital (proxied by gross capital formation), labor (measured by the labor force participation rate), and human capital (proxied by government expenditure on higher education). By utilizing time-series data from the World Bank and conducting regression analysis in Stata, this study calculates the income elasticities of these inputs and derives the residual Total Factor Productivity (TFP).

The findings aim to clarify which factors have been most instrumental in fostering Uzbekistan's growth and to test whether the role of human capital in this context aligns with the findings of other scholars. The results hold significant implications for policymakers, indicating where future investments—whether in physical infrastructure, education, or labor market reforms—can be most effectively directed to ensure sustainable long-term economic development.

Literature review

The economic trajectory of Uzbekistan and its Central Asian neighbors (Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan) since their independence from the Soviet Union in 1991 presents an interesting case for growth analysis. These nations, enriched with varying levels of natural resources and undergoing complex transitions from planned to market economies, have experienced divergent growth paths. To understand the fundamental drivers of this growth, the Solow-Swan neoclassical growth model provides a robust and foundational framework. This literature review situates a proposed study on Uzbekistan within the existing scholarly work on economic growth in Central Asia, highlighting the relevance of the Solow model, its extensions, and the identified gaps that such a study would aim to fill.

The Solow model (Solow, 1956) remains a cornerstone of modern growth theory, stating that long-run economic growth is driven by exogenous technological progress, while capital accumulation and labor force growth determine the steady-state level of output. Its core elements—capital deepening, diminishing returns, and the convergence hypothesis—make it particularly suitable for analyzing developing, transitional economies like those in Central Asia.

A substantial body of literature has applied the Solow model to transition economies, including those of the former Soviet Union. Studies by Fischer et al. (1996) and Campos and Coricelli (2002) broadly found that initial conditions, macroeconomic

stabilization, and structural reforms were critical for growth. They implicitly tested convergence, finding that countries which reformed faster began to move towards higher income levels.

Studies on Kazakhstan, such as those by Kutan and Wyzan (2005), heavily emphasize the role of oil and gas in driving capital accumulation and growth, aligning with the Solow model's focus on physical capital. However, they also point to "Dutch disease" effects and the volatility of resource-driven growth. For Uzbekistan, which possesses significant gold, natural gas, and cotton reserves, the literature is more nuanced. Early studies by Pomfret (2000) argued Uzbekistan's gradualist and state-controlled transition model, arguing that it distorted investment and hindered TFP growth. More recent analyses, including from the World Bank and IMF, acknowledge a period of rapid growth post-2017, following a wave of market-oriented reforms, liberalization, and a surge in FDI—all factors that can be effectively modeled as shocks to capital accumulation and TFP in a Solow framework.

While the broader Central Asian context is reasonably well-studied, there is a specific gap in applying a formal Solow model to Uzbekistan's entire post-independence period (1991-present). Many existing studies are descriptive or focus on specific sectors or policies. A comprehensive Solow model approach that accounts for the distinct phases of Uzbekistan's history—the deep recession of the 1990s, the stagnant but stable 2000s under heavy state control, and the high-growth reform period since 2017—is largely absent. Such a study could quantitatively decompose growth into contributions from capital, labor, and TFP, providing a clearer picture of the shifting drivers of the Uzbek economy over time.

Mankiw, Romer, and Weil (1992) successfully augmented the Solow model to include human capital, a factor highly relevant to Central Asia. The region inherited high literacy rates from the Soviet era, but the quality and relevance of this human capital in a market context have been questioned. For Uzbekistan, modeling human capital's contribution is essential, as the government has prioritized educational reform.

The existing literature establishes that the Solow model provides a valid and useful framework for understanding the broad contours of economic growth in Central Asia. However, a focused, quantitative study applying this model specifically to Uzbekistan, with comparisons to its regional peers, is a necessary contribution.

Methodology

This study employs annual time-series data for Uzbekistan from 1999 to 2022, sourced from the World Bank's World Development Indicators. To analyze the drivers of economic growth, it estimates an augmented Solow growth model, building on the

framework of Mankiw, Romer, and Weil (1992) and Melihovs and Davidsons (2006). The baseline Cobb-Douglas production function is specified as follows:

$$Y_i = A_i\ K_i^{\alpha}\ L_i^{\beta}\ H_i^{\gamma}$$

- Y_i is the real GDP in year t.
- A_i is the Total Factor Productivity (TFP) in year t*t*.
- K_t is the real physical capital stock, proxied by **real gross capital formation**.
- L_t is labor, proxied by the **labor force participation rate** (% of total population ages 15+).
- H_t is human capital, proxied by **real government expenditure on tertiary education**.

First of all, to get relevant measurements for the model nominal GDP, nominal gross capital formation, government expenditure in current USD were transferred into real variables via using GDP deflator. Secondly, to compute percentage relationship between variables, natural logarithms for real GDP, real gross capital formation, real human capitalization were taken. Also, by running the regression residual terms can be predicted which are equal to ln total factor of productivity (TFP). Then taking antilog of it, pure TFP for each year is received. Thus, the study comes to the following model: The theoretical foundation of this research is the neoclassical Solow Growth Model (Solow, 1956). The model states that output is produced using capital and labor, with technological progress being the primary driver of long-run per capita growth. A key feature of the model is the assumption of constant returns to scale, meaning that doubling all inputs will double output. The model's core implications include diminishing returns to capital: as an economy accumulates more capital per worker, the additional output generated by each new unit of capital declines. This study utilizes the augmented Solow model proposed by Mankiw et al. (1992), which explicitly incorporates human capital as a distinct factor of production (Schiliro, 2017). Limitations of the Solow's growth model: 1) the model was built in accordance with features of closed economy; 2) mismatch of hidden share of income that comes from capital and national accounting information (Barossi-Filho, Silva and Diniz, 2005).

Results

The ordinary least squares (OLS) regression was conducted to estimate the specified model. The results indicate a strong model fit, with an R-squared value of 0.9769, meaning the independent variables explain 97.69% of the variation in real GDP over

the study period. An F-test for the overall significance of the model rejects the null hypothesis that all coefficients are jointly zero ($p < 0.05$), confirming that the regression is statistically significant.

H_0: $\beta_1 = \beta_2 = \beta_3 = 0$

H_a: At least one of the is not equal to zero

Signif F <0.05 so we reject the H_0. Overall, this regression model is statistically significant by this outcome it can be accomplish that overall, the endogenous variables are reliable to forecast the exogenous variable (Table 1).

According to regression result, the significance of variables is high than 2 which shows that almost all of the are statistically significant at 5% confidence level by the rule of thumb, despite the labor force participation rate because it's p-value=0.054 which is higher than 0.05. By the way, this issue might be solved become increasing number of observations. This test was conducted in order to see that the coefficient of these parameters differ from 0.

Linear restriction test:

H_0: $\beta_1 + \beta_2 + \beta_3 = 1$

H_a: $\beta_1 + \beta_2 + \beta_3 \neq 1$

$t_{stat} = \frac{\beta 1 + \beta 2 + \beta 311}{Stdev(\beta 1 + \beta 2 + \beta 3)} = -\frac{0.14}{2.63} = |0.05|$, $t_{critical} = 1.96$ reject H_0 because $t_{critical} > t_{stat}$ which means there in no constant return to scale.

Table 1. Regression results

Source	SS	df	MS		
Model	10.1060806	3	3.36869352	Number of obs	= 24
Residual	.239257892	20	.011962895	F(3, 20)	= 281.60
				Prob > F	= 0.0000
Total	10.3453385	23	.449797325	R-squared	= 0.9769
				Adj R-squared	= 0.9734
				Root MSE	= .10938

lnrGDP	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnCap	.3538667	.0803002	4.41	0.000	.1863635	.5213699
lnrHC	.4667578	.080543	5.80	0.000	.2987481	.6347675
lfpar	.0350749	.0171613	2.04	0.054	-.000723	.0708729
_cons	4.828767	1.089472	4.43	0.000	2.556168	7.101366

The estimated regression equation is:

$$lnrGDP = 4.83 + 0.35lnCap + 0.47lnrHC + 0.04lfpar$$

- A 1% increase in real physical capital is associated with a 0.35% increase in real GDP, holding all else constant.

- A 1% increase in real human capital (government spending on higher education) is associated with a 0.47% increase in real GDP, holding all else constant. This underscores the pivotal role of education investment in Uzbekistan's growth.
- The coefficient for the labor force participation rate is positive but statistically insignificant (p-value = 0.054). This suggests that, within this model and dataset, changes in the labor force participation rate are not a robust predictor of output variation. This may be due to measurement issues, the relatively small sample size, or the fact that the sheer size of the labor force matters less than its productivity, which is better captured by the human capital variable.

Checking for basic econometric assumptions

1. The dependent variables are not constant, and they change through 23 years.

2. Variance Inflation Factor (VIF) for all variables was well below 10, indicating that multicollinearity is not a concern.

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vif
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Variable	VIF	1/VIF
lnrHC	8.22	0.121616
lnCap	7.24	0.138087
lfpar	1.39	0.718122
Mean VIF	5.62	

3. A Breusch-Pagan test failed to reject the null hypothesis of constant variance ($p > 0.05$), indicating no significant heteroscedasticity.

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. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lnrGDP

         chi2(1)      =     0.57
         Prob > chi2  =   0.4514
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4. The Dubrin-Watson test shows that between 0 and 2 there is autocorrelation. This is a common issue in time-series data and suggests that the standard errors may be underestimated.

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. dwstat

Durbin-Watson d-statistic(  4,    24) =  1.413416
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Conclusion

Economic growth has been increasing rapidly in Uzbekistan since the government implemented a new policy. This study has applied an augmented Solow model to

identify the sources of economic growth in Uzbekistan from 1999 to 2022. Solow growth model was used as it is one of the best models to estimate the economic growth of the country. According to the results obtained above, we can conclude that the capital and human capitalization is positively related to the dependent variable and plays the significant role on estimating economics growth of Uzbekistan. However, in the contrast to previous research, the labor force participation rate is not statistically important in this research. Policy implications are clear: to foster sustainable economic growth, Uzbek policymakers should prioritize and maintain strategic investments in human capital through education funding. Simultaneously, efforts should be made to improve the efficiency of capital allocation to counteract diminishing returns. For future research, this study recommends expanding the analysis to a panel data framework that includes other Central Asian economies. This would increase the degrees of freedom and allow for more robust statistical inference.

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