The Impact of Education on Economic Growth in Saudi Arabia (1997-2021)

Table of Contents

1.0 Abstract

This study seeks to analyze the relationship between education expenditure and economic growth in Saudi Arabia during the period 1997–2021. To achieve this objective, a multiple linear regression model was used. The study is divided into several sections: the first presents a theoretical analysis of the relationship between education expenditure and economic growth; the second, the measurement model and the data used; and the third, the results and the analysis of the measurement. The main hypothesis of the research was accepted, as the results support the hypothesis that education expenditure significantly impacts Saudi Arabia's GDP and, consequently, its economic growth. The sub-hypotheses define the impact of the variables and their relationship to economic growth in Saudi Arabia. The coefficient of determination (R^2) of 94% indicates that the independent variables (research and development expenditure and higher education enrollment) explain most of the variance in GDP. We recommend that government agencies prioritize research and development and find innovative solutions to educational challenges, in collaboration with the private sector, to achieve beneficial results that benefit the country and contribute to Saudi Arabia's economic growth.

2.0 Introduction

The education sector is one of the most important pillars supporting economic growth and contributing to the advancement and development of society and the economy. Investing in this sector is a key strategy that plays a fundamental role in economic development. One of the results of investing in human capital is to increase its efficiency in meeting the needs of the labor market, satisfying the demands of economic development, and contributing to the country's progress.

2.1 Education Investment in Saudi Arabia

The education sector must receive support and development to ensure it produces the skilled workforce needed for the national economy. A state's focus on education represents an investment in human capital, which explains its importance in the

economy. Physical capital alone cannot compensate for a lack of natural resources or other forms of capital. Therefore, the economy tends to promote the development of human capital by investing in tangible and intangible assets, such as education and innovation.

Saudi Arabia has witnessed remarkable development in education spending:

- In 1386 AH (1966), spending reached **514 million SAR
- In 1441 AH (2019), spending on the education sector reached **193 billion SAR

Education spending now represents **18% to 20%** of the state budget, placing it among the top expenditure categories. This investment has led to:

- Establishment of numerous public universities
- Construction of schools across the kingdom
- Scholarship programs for students abroad
- Curriculum development
- Improvement of the educational environment

2.2 Vision 2030 and Education

Given the importance of education and its impact on the economy, the Saudi Vision 2030 aims to measure educational outcomes annually to ensure quality and establish new avenues for human capital development, thereby contributing to technological advancement. Saudi Arabia has become a global leader in educational investment, demonstrating its progress and positive impact on economic growth (Carl, 2015).

2.3 Research Focus

This study examines the relationship between education indicators and economic growth in Saudi Arabia from 1997 to 2021, focusing on:

- Research and development expenditure

- Tertiary education enrollment rates

- Their combined impact on GDP

3.0 Literature Review

3.1 Mwafaq M. Dandan (2013) - Educational Expenditure and Economic Growth

This study investigated the impact of public educational expenditures on economic growth in Saudi Arabia between 1994-2011. The OLS method was used to test the relationship between public expenditures and non-oil GDP. Phillips-Perron and Dicky-Fuller unit root tests showed that the series was non-stationary at the school level. Expenditures were stationary at the second difference, while the non-oil GDP and higher education expenditures were stationary at the second difference. The Johansen test of cointegration showed that there is cointegration among variables (Dandan, 2013).

3.2 Dr. Abla bint Abdul Hamid Bukhari (2016) - Testing the Hypothesis of the Causal Relationship Between Spending on Higher Education and Economic Growth in the Kingdom

Dr. Abla's study proved that continuing to spend on higher education and investing in it is necessary to raise the level of productivity and achieve economic growth. The results showed for the period (1980-2014) that there is one common factor between spending on higher education and economic growth, which enables us to determine the causal relationship between the two variables. An increase in economic growth has an impact on increasing government spending on higher education, indicating a positive relationship with statistical significance (Bukhari, 2016).

3.3 Dr. Linabaa Noureddine / Dr. Benalbad Muhammad (2017) - Investment in Education and Its Impact on Economic Growth

The aim of this study at the University of Tlemcen (2007-2017) was to focus on education and investment in human capital in terms of public finances, ways of financing it, ways of spending on it, and what the education sector offers in terms of knowledge and providing individuals with skills that lead countries to growth, development and sustainable development. Education is the first and basic means through which the human element is prepared, trained and qualified, leading to achieving the highest levels of sustainable development where the human element becomes the locomotive of sustainable development (Noureddine & Muhammad, 2017).

3.4 Faouzi Abdennour & Othman Alwagdani (2017) - Education and Inclusive Growth in Saudi Arabia (1981-2013)

This study demonstrates the causal relationship between spending on education and inclusive growth in the Kingdom of Saudi Arabia. To explore the effect of education on inclusive growth, they used the SVAR model, which shows that education has an important role in explaining the inclusive role variance, and that education maintains a sustainable effect on inclusive growth. They used the structural VAR approach with impulse response analysis and decomposition of variance. They also used the inequality-adjusted HDI growth rate for the overall growth measure, and the ratio of human resource development expenditure to GDP for education. The results indicate that education has a positive and significant impact on inclusive growth in the Kingdom of Saudi Arabia, but the contribution of education to inclusive growth is considered to be somewhat stable (Abdennour & Alwagdani, 2017).

3.5 Reda Abu Bakr Muhammad Selim & Mahmoud Al-Motaim (2019) - The Impact of the Analytical Study of the Relationship Between Education and Economic Growth in Japan (1996-2015)

The study aims to study the development of education indicators in Japan and the development of economic growth indicators in Japan. The research relied on the descriptive and analytical approach. Among the statistical methods to achieve the objectives of the study is the general temporal trend to study the development of financial indicators and the simple linear regression to study the relationship between economic growth, education, and the labor market, national savings, and high-technology exports (Selim & Al-Motaim, 2019).

3.6 Nayef bin Nizar bin Siraj Kamal (2020) - Public Spending on Education and Its Impact on Economic Growth in Saudi Arabia (1997-2017)

The study focuses on trying to find out the extent of government spending on university education and its feasibility in promoting economic growth in the Kingdom of Saudi Arabia during the period 1997-2017 AD. The study aims to investigate the nature of the existing relationship and determine whether spending on university education is a catalyst for raising economic growth rates in exchange for the huge budgets spent on it. To achieve these goals, the study described, presented, and introduced the most important related concepts and reviewed the developments witnessed by the university education sector and the reality of economic growth in the Kingdom. The results concluded that there is no relationship between spending on education and economic growth, while it was found that the increase in the number of graduates from higher education adversely affected economic growth (Kamal, 2020).

3.7 Nahla Ahmed Abu Al-Ezz (2020) - Public Spending on Education and Its Impact on Economic Growth in Rwanda (2000-2017)

The study focuses on public spending on education and its impact on economic growth. The study aims to analyze the relationship between public spending on education and economic growth in Rwanda. To achieve this goal, the study used the Autoregressive Distributed Lag (ARDL) model. The study was divided into an introduction and four main axes. The first axis deals with theoretical analysis of the relationship between education and economic growth, and the second axis presents the measurement model used and the data used in the analysis. The third axis deals with the presentation and analysis of the measurement results, while the

fourth axis presents the conclusion of the study and its most important recommendations. The study concluded that there is a long-term equilibrium relationship between public spending on education and economic growth in Rwanda, and that public spending on education has a positive impact on economic growth in Rwanda (Al-Ezz, 2020).

3.8 Hanaa Abdelaty Hasan Esmail (2020) - The Contribution of Education Expenditure in Saudi Universities to Achieve Economic Development (2003-2019)

This study illustrates the relationship between spending on education and economic development. To explore this relationship, the author used the weighted least square (WLS) multiple regression model. The study took GDP as a dependent variable, with GDP per capita, research and development, education expenditure, and exports as independent variables. The research and development variable was excluded because it did not have enough impact on economic growth, while the result showed that the three variables have an impact on GDP, which indicates a positive relationship between education and the economy. The (WLS) model is effective in Saudi Arabia. The study recommended that there be a competitive generation in the labor market in various fields with the aim of the educational renaissance of the state (Esmail, 2020).

3.9 Saadaoui et al. (2021) - The Effect of Education Expenditure on Economic Growth in Saudi Arabia (1990-2017)

After studying the impact of education on economic growth, we conclude that there is a statistically significant relationship between education expenditures and economic growth, especially spending on higher education, as it contributes significantly to economic growth in the Kingdom and has positive effects. In the long run, if spending on education is raised by 1%, it will lead to an increase in economic growth by 0.89%. We conclude from that the positive relationship between education and economic growth. Therefore, the state must raise the percentage of spending on education to ensure sustainable development in education and raise the efficiency of education in all regions of the Kingdom (Saadaoui et al., 2021).

3.10 Walaa bint Ibrahim Al-Eid (2021) - The Impact of Investment in Education on Economic Growth in the Kingdom of Saudi Arabia (1978-2015)

The study examined the impact of investment in human capital in education on the economy during the period (1978-2015). The study used GDP as a dependent variable, investment spending on education and students enrolled in public education and higher education as independent variables. The study applied the autoregressive distributed lag model (ARDL). The results showed that there is a co-integration relationship between the variables of the study. After estimating the error correction vector model, the results showed that the adjustment parameter met its conditions to be negative. Some variables contradicted economic theory, such as those enrolled in public education, and investment spending on education appeared inverse and insignificant, while those enrolled in higher education appeared to have a positive and significant effect. Based on the results, the study recommends the need to pay attention to investing in education in the Kingdom because of its important role in raising the level of economic growth (Al-Eid, 2021).

3.11 Dr. Badr bin Salem Al-Badrani & Ms. Rawan bint Abdul-Razzaq Al-Ahmadi (2023) - The Impact of Investment in Human Capital (Education Sector) in the Kingdom of Saudi Arabia on Economic Growth (2013-2022)

After studying the independent variables and their impact on the dependent variable and creating a regression model, we conclude that the two independent variables (numbers of workers with secondary school and bachelor's degrees) are not indicative and do not have explanatory power, while the last independent variable (education allocations from the general budget) is indicative and interpreted in the sense that more spending on education hurts the gross domestic product, which is the only variable that is predicted and has an impact on the gross domestic product (Al-Badrani & Al-Ahmadi, 2023).

3.12 Summary of Literature Review

The literature presents mixed findings regarding the relationship between education spending and economic growth in Saudi Arabia:

Study	Period	Key Finding
Dandan (2013)	1994-2011	Cointegration between education expenditure and non-oil GDP
Bukhari (2016)	1980-2014	Positive causal relationship from growth to higher education spending
Abdennour & Alwagdani (2017)	1981-2013	Positive impact of education on inclusive growth
Kamal (2020)	1997-2017	No relationship; graduates negatively affect growth
Esmail (2020)	2003-2019	Positive relationship between education and economy
Saadaoui et al. (2021)	1990-2017	1% increase in education spending → 0.89% increase in growth
Al-Eid (2021)	1978-2015	Mixed results; higher education has positive effect
Al-Badrani & Al-Ahmadi (2023)	2013-2022	Only budget allocations affect GDP

This study aims to contribute to this literature by using the most recent data (1997-2021) and focusing on both research and development expenditure and tertiary enrollment as key education indicators.

4.0 Importance of the Study

The importance of this study lies in demonstrating the relationship between education spending and economic growth during the period 1997–2021. The study will focus specifically on educational variables, such as school enrollment rates, with the aim of raising current educational standards and strengthening the Kingdom's economy.

This study also focuses on providing information on research and development to demonstrate its impact on the Kingdom's economic growth. Furthermore, it offers recommendations and solutions in the field of research and development, as well as a plan to accelerate the Kingdom's growth.

Key Contributions:

1. Empirical Evidence: Provides updated empirical evidence on the education-growth nexus in Saudi Arabia using data up to 2021, including the COVID-19 pandemic period.

2. Policy Relevance: Offers insights for policymakers in the context of Saudi Vision 2030, which emphasizes human capital development as a key driver of economic diversification.

3. Dual Focus: Examines both input (R&D expenditure) and output (tertiary enrollment) indicators of education, providing a comprehensive view of the education sector's contribution to economic growth.

4. Methodological Rigor: Applies multiple linear regression with diagnostic tests to ensure robust and reliable results.

5.0 Problem Statement

Despite significant government investment in education, amounting to approximately 20% of the national budget, doubts persist about the actual impact of this spending on Saudi Arabia's economic growth. The relationship between educational indicators and GDP is complex and can be influenced by various factors, including:

- The quality of education versus the quantity of spending
- The alignment between educational outcomes and labor market needs
- The time lag between educational investment and economic returns
- The role of research and development in driving innovation and productivity

This study addresses the following research questions:

1. What is the impact of spending on education on the GDP in Saudi Arabia?

2. How does research and development expenditure affect the GDP?

3. What is the relationship between tertiary education enrollment and GDP?

6.0 Objectives

The study aims to analyze and examine the impact of education on the economic growth of the Kingdom of Saudi Arabia from 1997 to 2021 on gross domestic product, and to determine if there is a relationship between the variables and the nature of that relationship.

Specific Objectives:

- To understand the relationship between GDP and school enrollment in higher education (total %)

- To study the relationship between GDP and spending on research and development (% of GDP)

- To provide evidence-based recommendations for education policy in Saudi Arabia

7.0 Hypotheses

Main Hypothesis:

H_1: There is a significant impact of education on economic growth in Saudi Arabia.

Sub-Hypotheses:

H_{1a}: There is a positive relationship between Research and Development Expenditure (% of GDP) and GDP (current US$)

H_1b: There is a significant relationship between school enrollment in tertiary education (% gross) and GDP (current US$)

8.0 Methodology

8.1 Research Design

This study uses a quantitative research design with multiple linear regression analysis to study the relationship between educational indicators and economic growth in Saudi Arabia during the period 1997-2021.

8.2 Data Source

Secondary data was obtained from the **World Bank Development Indicators** database for the period 1997-2021 (25 years).

8.3 Variables

| Variable Type | Variable Name | Description | Source |

| Dependent (Y) | GDP | Gross Domestic Product (current US$) | World Bank |

| Independent (X2) | R&D Expenditure | Research and development expenditure (% of GDP) | World Bank |

| Independent (X3) | Tertiary Enrollment | School enrollment, tertiary (% gross) | World Bank |

8.4 Model Specification

The study uses the multiple linear regression (least squares) model estimated using E-views program:

$Y = f(X2, X3)$

$GDP = \beta_1 + \beta_2(X2) + \beta_3(X3) + \varepsilon$

Where:

- β_1 → constant (intercept)
- β_2 → coefficient of Research and development expenditure (% of GDP)
- β_3 → coefficient of School enrollment, tertiary (% gross)
- ε → error term

8.5 Analytical Techniques

The study employs the following analytical techniques:

1. Descriptive statistics
2. Multiple linear regression analysis
3. Hypothesis testing (t-test, confidence intervals)
4. Diagnostic tests (heteroskedasticity, autocorrelation, Durbin-Watson)

9.0 Results

9.1 Descriptive Statistics

Table 1: Descriptive Statistics (1997-2021)

Date: 05/14/23 Time: 17:10
Sample: 1997 2021

	Y	X2	X3
Mean	4.87E+11	28149458	41.88062
Median	5.20E+11	28483797	31.56049
Maximum	8.34E+11	35997107	71.40964
Minimum	1.47E+11	19938377	17.32280
Std. Dev.	2.48E+11	5448297.	19.54661
Skewness	-0.079590	-0.004336	0.406352
Kurtosis	1.435353	1.590504	1.576023
Jarque-Bera	2.576520	2.069535	2.800206
Probability	0.275750	0.355309	0.246572
Sum	1.22E+13	7.04E+08	1047.015
Sum Sq. Dev.	1.47E+24	7.12E+14	9169.677
Observations	25	25	25

Interpretation of Descriptive Statistics:

- GDP (Y): The mean GDP is 4.87E+11, with a median of 5.20E+11 and a standard deviation of 2.48E+11, indicating substantial variation in economic output over the study period.

- Research and Development (X2): The mean R&D expenditure is 28,149,458, with a median of 28,483,797 and standard deviation of 5,448,297, showing relatively stable growth in R&D investment.

- Tertiary Enrollment (X3): The mean enrollment rate is 41.88%, with a median of 31.56% and a standard deviation of 19.55%, indicating significant growth in higher education participation, especially after 2010.

The Jarque-Bera probabilities (>0.05) for all variables indicate that the data follow a normal distribution, satisfying one of the classical linear regression assumptions.

9.2 Regression Analysis

Table 2: Regression Results

Dependent Variable: Y (GDP)

Method: Least Squares

Sample: 1997-2021

Included observations: 25

Dependent Variable: Y
Method: Least Squares
Date: 05/14/23 Time: 17:40
Sample: 1997 2021
Included observations: 25

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.66E+11	1.55E+11	-6.238551	0.0000
X2	57395.78	9000.180	6.377181	0.0000
X3	-3.88E+09	2.51E+09	-1.547382	0.1360

R-squared	0.941045	Mean dependent var	4.87E+11
Adjusted R-squared	0.935685	S.D. dependent var	2.48E+11
S.E. of regression	6.28E+10	Akaike info criterion	52.67709
Sum squared resid	8.68E+22	Schwarz criterion	52.82336
Log likelihood	-655.4637	Hannan-Quinn criter.	52.71766
F-statistic	175.5825	Durbin-Watson stat	1.214776
Prob(F-statistic)	0.000000		

9.2.1 Estimated Regression Equation

$Y = -9.66E+11 + 57{,}395.78\ X2 - 3.88E+09\ X3 + \varepsilon$

Coefficient Interpretation:

- β_1 (intercept point): When the values of X2 and X3 are zero, GDP is estimated at -9.66E+11. This negative intersection has no economic relevance, but it fulfills the mathematical function of the regression line.

- β_2 (R&D coefficient): If research and development spending (X_2) increases by one unit (US$1), gross domestic product (Y) will increase by approximately US$57,396, assuming that the higher education enrollment rate remains constant. This coefficient is statistically significant at the 1% level ($p < 0.01$).

- β_3 (Higher Education Coefficient): If the higher education enrollment rate (X_3) increases by one percentage point, gross domestic product (Y) will decrease by approximately 3.88×10^9 US dollars, assuming that R&D spending remains constant. However, this coefficient is not statistically significant ($p = 0.136 > 0.05$).

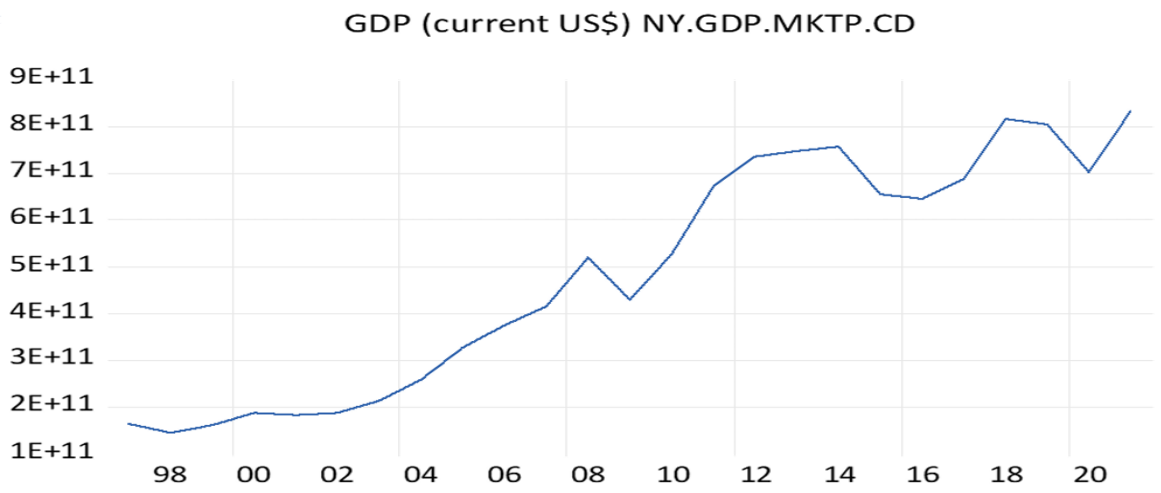
9.2.2 Model Fit

- R-squared = 0.941045: The independent variables (R&D expenditure and higher education tuition) explain 94.1% of the change in GDP. This indicates an excellent fit.

- Adjusted R-squared = 0.935685: After adjusting for the number of predictors, the model still explains 93.6% of the change in GDP, confirming its robustness.

- F-statistic = 175.58 (p = 0.000): The overall model is highly significant, meaning that at least one of the independent variables has a significant impact on GDP.

9.3 Graphical Analysis



Graph 1: GDP Trend in Saudi Arabia (1997-2021)

Interpretation:

This line graph illustrates the evolution of Saudi Arabia's Gross Domestic Product (GDP) between 1997 and 2021. GDP experienced several fluctuations during this period:

- 1997-2002: Relative stability with moderate growth

- 2003-2008: Period of significant growth, driven by high oil prices and economic reforms

- 2009: Sharp decline due to the global financial crisis

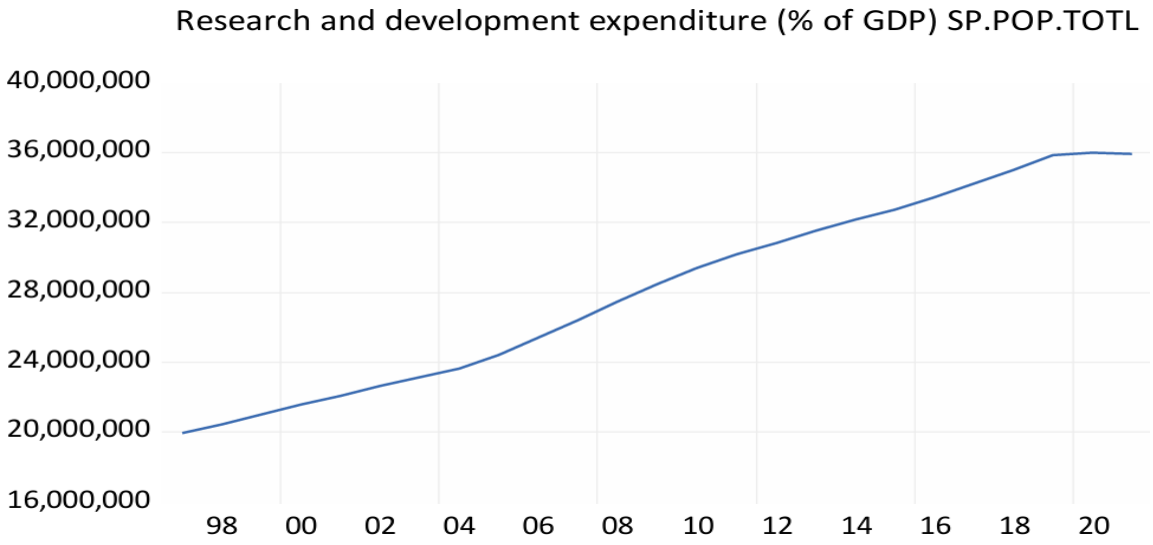
- 2010-2014: Strong recovery and growth, peaking in 2014

- 2015-2016: Decline due to falling oil prices

- 2017-2019: Gradual recovery

- 2020: Decline due to the COVID-19 pandemic and the oil price crisis

- 2021: Strong recovery as economy rebounded



Graph 2: Research and Development Expenditure Trend (1997-2021)

Interpretation:

This line graph shows the trend in research and development expenditure in Saudi Arabia:

- 1997-2005: Stable but low levels of R&D spending

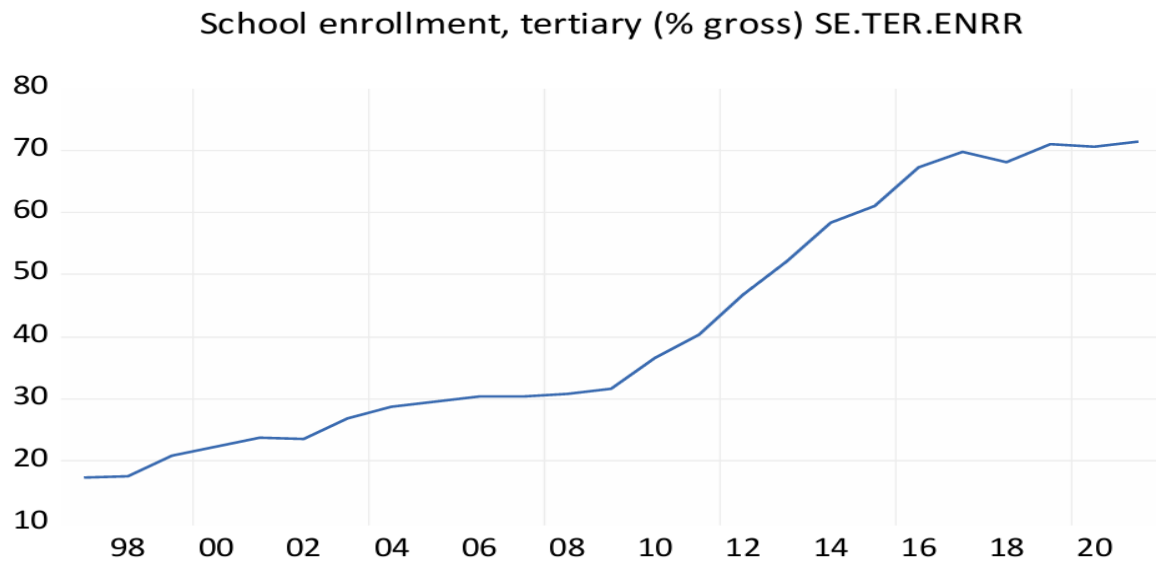
- 2006: Notable increase in R&D investment

- 2007-2018: Gradual and steady growth

- 2019-2020: Significant increase, reaching the highest level in 2020

- 2021: Slight decline but still at elevated levels

The increasing trend in research and development spending reflects Saudi Arabia's growing awareness of the importance of innovation and a knowledge-based economy, particularly in line with the goals of Vision 2030.



Graph 3: Tertiary Enrollment Trend (1997-2021)

Interpretation:

This line graph shows the changes in tertiary education enrollment rates:

- 1997-2005: Moderate and stable enrollment rates

- 2006-2010: Beginning of significant growth

- 2011-2017: Accelerated growth, reaching peak in 2017

- 2018-2021: Continued high enrollment rates with some fluctuation

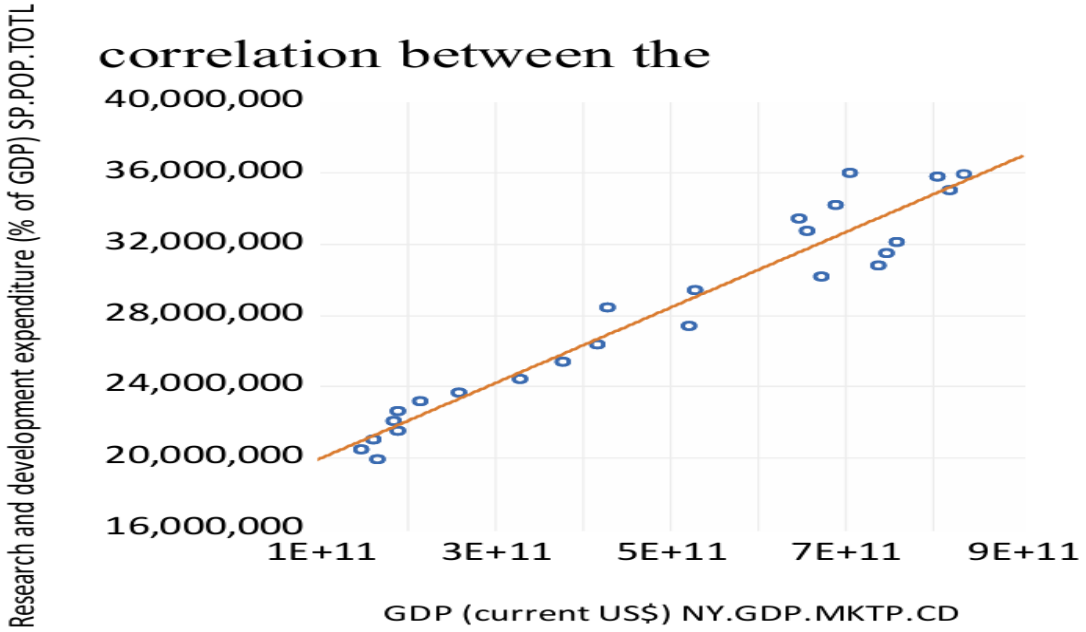
The dramatic increase in tertiary enrollment after 2010 corresponds to:

- Expansion of university infrastructure

- Establishment of new public and private universities

- Government scholarship programs

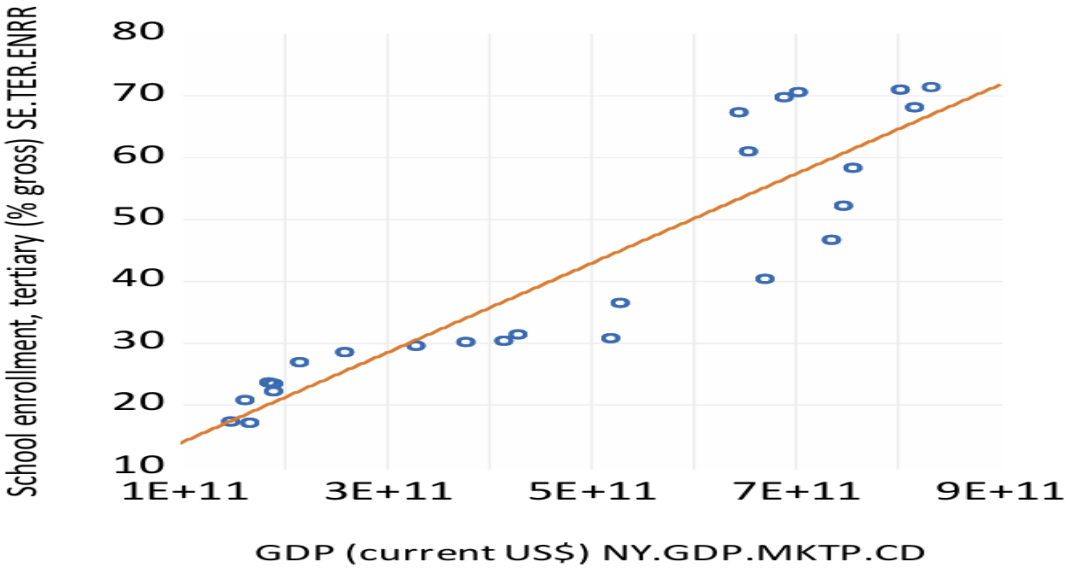
- Increased awareness of the importance of higher education



Graph 4: Scatter Plot - GDP and R&D Expenditure

Interpretation:

This Scatter Plot shows a strong positive correlation between R&D spending and GDP. The upward trend indicates that as R&D spending increases, GDP tends to rise as well. This visual evidence supports the findings of the regression analysis, which suggest that R&D spending has a significant positive impact on economic growth.



Graph 5: Scatter Plot - GDP and Tertiary Enrollment

Interpretation:

This scatter plot shows a positive correlation between tertiary enrollment and GDP. However, the relationship appears less consistent than with R&D. The upward-sloping pattern suggests that higher tertiary enrollment is generally associated with higher GDP. Still, the relationship may be influenced by other factors and time lags. This visual pattern aligns with the regression finding that tertiary enrollment is not statistically significant when controlling R&D expenditure.

9.4 Hypothesis Testing

9.4.1 T-Test Results

Coefficient Confidence Intervals
Date: 05/20/23 Time: 01:38
Sample: 1997 2021
Included observations: 25

		90% CI		95% CI		99% CI	
Variable	Coefficient	Low	High	Low	High	Low	High
C	-9.66E+11	-1.23E+12	-7.00E+11	-1.29E+12	-6.45E+11	-1.40E+12	-5.30E+11
X2	57395.78	41941.17	72850.39	38730.55	76061.01	32026.47	82765.09
X3	-3.88E+09	-8.19E+09	4.26E+08	-9.08E+09	1.32E+09	-1.10E+10	3.19E+09

Interpretation:

- X2 (Research and Development): Since the p-value (0.0000) is less than 0.05, we reject the null hypothesis. Research and development spending has a statistically significant impact on GDP.

- X3 (Higher Education): Since the p-value (0.1360) is greater than 0.05, we do not reject the null hypothesis. Higher education enrollment does not have a statistically significant impact on GDP in this model.

9.4.2 Confidence Interval Test

Table 3: Confidence Intervals for Coefficients

Variable	Coefficient	90% CI	95% CI	99% CI
C	-9.66E+11	[-1.23E+12, -7.00E+11]	[-1.29E+12, -6.45E+11]	[-1.40E+12, -5.30E+11]
X2	57,395.78	[41,941.17, 72,850.39]	[38,730.55, 76,061.01]	[32,026.47, 82,765.09]
X3	-3.88E+09	[-8.19E+09, 4.26E+08]	[-9.08E+09, 1.32E+09]	[-1.10E+10, 3.19E+09]

Interpretation:

- X2: The confidence intervals for the R&D coefficient do not include zero at any level (90%, 95%, 99%), confirming its statistical significance.

- X3: The confidence intervals for the higher education enrollment coefficient include zero at all levels, confirming its lack of statistical significance.

9.5 Diagnostic Tests

9.5.1 Heteroskedasticity Test (Breusch-Pagan-Godfrey)

Table 4: Heteroskedasticity Test Results

Heteroskedasticity Test: Breusch-Pagan-Godfrey Null hypothesis: Homoskedasticity			
F-statistic	3.190988	Prob. F(2,22)	0.0607
Obs*R-squared	5.621504	Prob. Chi-Square(2)	0.0602
Scaled explained SS	4.297814	Prob. Chi-Square(2)	0.1166

Null

Hypothesis: Homoskedasticity (constant variance of errors)

Interpretation:

Since all probability values (0.0607, 0.0602, 0.1166) > 0.05, we fail to reject the null hypothesis. This indicates that there is no heteroskedasticity in the model—the error terms have constant variance, satisfying one of the classical linear regression assumptions.

9.5.2 Autocorrelation Test (Breusch-Godfrey Serial Correlation LM Test)

Table 5: Autocorrelation Test Results

Breusch-Godfrey Serial Correlation LM Test: Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	2.620551	Prob. F(2,20)	0.0975
Obs*R-squared	5.191040	Prob. Chi-Square(2)	0.0746

Null Hypothesis: No serial correlation up to 2 lags

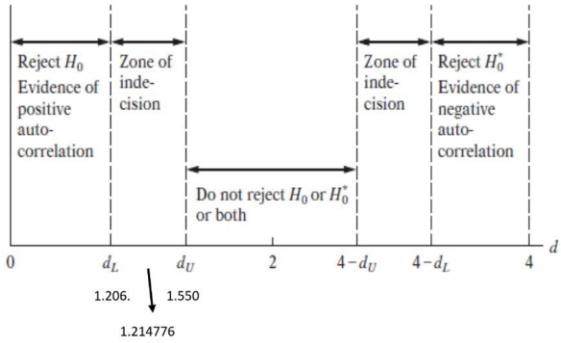
Interpretation:

Since the probability values (0.0975, 0.0746) are greater than 0.05, we do not reject the null hypothesis. This indicates that there is no sequential correlation between the error limits, which satisfies another classic hypothesis of linear regression.

9.5.3 Durbin-Watson Test

d- calculated = 1.214776

d- upper = 1.550 , d-lower = 1.206



Durbin-Watson calculated value = 1.214776

Critical values at 5% significance level (k=2, n=25):

- dL (lower bound) = 1.206

- dU (upper bound) = 1.550

Decision Rule:

- If d < dL → Reject H_0 (positive autocorrelation)

- If d > 4-dL → Reject H_0 (negative autocorrelation)

- If dU < d < 4-dU → Fail to reject H_0 (no autocorrelation)

- If dL ≤ d ≤ dU → Inconclusive

Result:

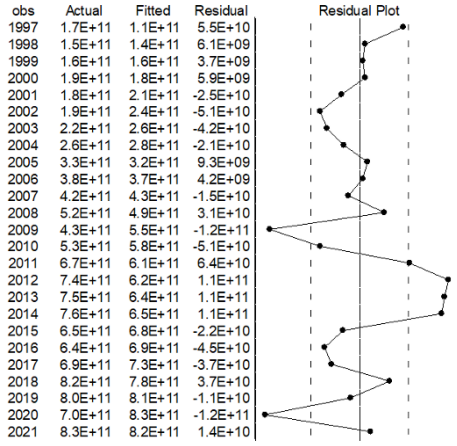
1.206 (dL) < 1.214776 (d) < 1.550 (dU)

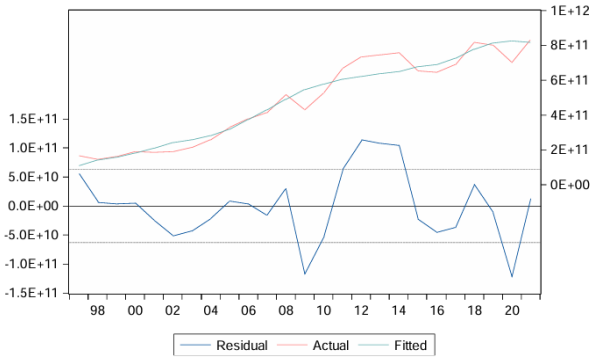
Interpretation:

The Durbin-Watson statistic falls within the non-deterministic range, meaning that autocorrelation cannot be definitively established. Since the Broich-Godfrey test did not indicate sequential correlation, we relied on this result, acknowledging that the Durbin-Watson test does indicate some degree of uncertainty. For future research, using standard errors consistent with heterogeneous variance and autocorrelation (HAC) will provide more accurate estimates.

9.6 Actual, Fitted, Residual Graph

obs	Actual	Fitted	Residual
1997	1.7E+11	1.1E+11	5.5E+10
1998	1.5E+11	1.4E+11	6.1E+09
1999	1.6E+11	1.6E+11	3.7E+09
2000	1.9E+11	1.8E+11	5.9E+09
2001	1.8E+11	2.1E+11	-2.5E+10
2002	1.9E+11	2.4E+11	-5.1E+10
2003	2.2E+11	2.6E+11	-4.2E+10
2004	2.6E+11	2.8E+11	-2.1E+10
2005	3.3E+11	3.2E+11	9.3E+09
2006	3.8E+11	3.7E+11	4.2E+09
2007	4.2E+11	4.3E+11	-1.5E+10
2008	5.2E+11	4.9E+11	3.1E+10
2009	4.3E+11	5.5E+11	-1.2E+11
2010	5.3E+11	5.8E+11	-5.1E+10
2011	6.7E+11	6.1E+11	6.4E+10
2012	7.4E+11	6.2E+11	1.1E+11
2013	7.5E+11	6.4E+11	1.1E+11
2014	7.6E+11	6.5E+11	1.1E+11
2015	6.5E+11	6.8E+11	-2.2E+10
2016	6.4E+11	6.9E+11	-4.5E+10
2017	6.9E+11	7.3E+11	-3.7E+10
2018	8.2E+11	7.8E+11	3.7E+10
2019	8.0E+11	8.1E+11	-1.1E+10
2020	7.0E+11	8.3E+11	-1.2E+11
2021	8.3E+11	8.2E+11	1.4E+10





Interpretation:

This graph shows:

- Actual GDP: The observed values over time

- Fitted GDP: The values predicted by the model

- Residuals: The difference between actual and fitted values

The close alignment between actual and fitted values visually confirms the high R-squared value (94.1%). The residuals appear randomly distributed around zero, supporting the model's validity.

10.0 Discussion

10.1 Interpretation of Findings

The results of this study provide important insights into the relationship between education indicators and economic growth in Saudi Arabia:

10.1.1 Research and Development (R&D) Expenditure

The strong positive relationship between R&D spending and GDP (β_2 = 57,395.78, $p < 0.01$) confirms that R&D investment contributes significantly to economic growth. This finding is consistent with:

- Bukhari (2016), who found a positive causal relationship between higher education spending and growth.

- Saadawi et al. (2021), who estimated that a 1% increase in education spending leads to a 0.89% increase in growth.

- Ismail (2020), who found that education spending has a positive impact on GDP.

The mechanism behind this relationship likely involves:

1. R&D driving innovation and productivity improvements
2. Development of new technologies and processes
3. Enhancement of human capital quality
4. Diversification of the economy beyond oil

10.1.2 Tertiary Enrollment

The lack of a statistically significant relationship between higher education enrollment and GDP (β_3 = -3.88E+09, p = 0.136) warrants careful interpretation. Several factors could explain this unexpected result:

Possible explanations:

1. Time lag effect: There is often a significant time lag between higher education enrollment and its contribution to economic growth. Graduates need time to enter the labor market, gain experience, and become productive members of society.

2. Quality vs. Quantity: The focus on increasing enrollment may not be accompanied by a similar focus on the quality of education and its relevance to labor market needs.

3. Skills mismatch: There may be a mismatch between the skills offered by higher education institutions and those required by the labor market, leading to a lack of job opportunities or unemployment among graduates.

4. Crowding-out effect: The rapid expansion of higher education may have temporarily constrained resources, impacting quality before the anticipated benefits materialize.

5. A recent phenomenon: The significant increase in higher education enrollment occurred primarily after 2010, and the full economic benefits of this increase may not yet be fully reflected in current data.

This finding is consistent with the following:

- Kamal (2020) found no relationship between education spending and growth, and that the increase in the number of graduates negatively impacted growth.

- Al-Eid (2021) obtained mixed results, showing that some educational variables had statistically insignificant effects.

- Al-Badrani and Al-Ahmadi (2023) found that only budget allocations (not the number of graduates) affected GDP.

10.1.3 Model Strength

The high R-squared value (94.1%) indicates that the chosen education indicators effectively explain most of the variation in GDP. This suggests that education is indeed a crucial factor in Saudi Arabia's economic growth, even though the specific channels (R&D more than enrollment) may differ from expectations.

10.2 Implications for Saudi Vision 2030

The findings point to important implications for the Saudi Vision 2030:

1. Investment in Research and Development: The significant positive impact of research and development reinforces the Vision 2030 focus on innovation and the knowledge economy, justifying continued and increasing investment in R&D.

2. Quality of Education: The lack of statistical significance in higher education enrollment rates indicates the importance of the Vision 2030 focus on improving the quality of education and aligning curricula with labor market needs.

3. Human Capital Development: The findings underscore the importance of comprehensive human capital development strategies that go beyond simply increasing university enrollment and include skills development, lifelong learning, and innovation.

11.0 Conclusion

11.1 Summary of Findings

This study examined the impact of education on Saudi Arabia's economic growth between 1997 and 2021 using multiple linear regression analysis. The main findings are summarized below:

1. Robust overall model: Education indicators explain 94.1% of the variance in GDP, underscoring the critical role of education in economic growth.

2. Significant impact of R&D spending: R&D spending shows a statistically significant positive impact on GDP, with each additional dollar invested in R&D associated with an estimated increase of $57,396 in GDP.

3. There is no statistically significant relationship between higher education enrollment rates and GDP when controlling for R&D spending, suggesting that the quantity of education alone may not drive growth without considering its quality and relevance.

4. Model validity: Diagnostic tests confirm that the model meets the main assumptions (absence of variance within variance, absence of sequential correlation), which supports the reliability of the results.

11.2 Main Conclusion

Education is one of the most important drivers of economic growth in Saudi Arabia. High-quality higher education enables students to obtain master's and doctoral degrees, secure well-paying jobs, and foster innovation across all fields. The high coefficient of determination (R^2) (94%) indicates that the variables (research and development, school enrollment, and higher education) have a significant impact on GDP.

After conducting estimations and tests, the results partially supported the research hypothesis. The relationship between education and economic growth is positive with respect to investment in research and development, while higher education enrollment requires more research. This means that increased strategic spending

on education (especially research and development) translates into improved GDP and, consequently, stronger economic growth in Saudi Arabia.

12.0 Recommendations

Based on the findings of this study, we propose the following recommendations:

12.1 Research and Development

R1: Increase R&D Investment to 2% of GDP by 2030

- The current R&D expenditure level is below the global average for developed economies

- Target: Increase from approximately 0.5% to 2% of GDP by 2030

- This would align Saudi Arabia with Vision 2030's innovation goals and OECD countries

R2: Establish Sector-Specific R&D Centers

- Create specialized research centers in priority sectors (energy, water, healthcare, AI, biotechnology)

- Partner with leading international research institutions

- Allocate at least 30% of R&D budget to applied research with commercial potential

R3: Create Incentives for Private Sector R&D

- Offer tax incentives for companies investing in R&D

- Establish matching grant programs for industry-university research collaborations

- Target: Increase private sector share of R&D funding to 50% by 2030

12.2 Higher Education Quality

R4: Establish a National Skills Alignment Council

- Create a council with representatives from the Ministry of Education, the Ministry of Human Resources, and major employers

- Review and update university curricula every 3 years based on labor market needs

- Develop competency frameworks for all majors

R5: Expand Cooperative Education Programs

- Mandate that all university programs include at least one semester of practical training

- Partner with the private sector to provide 50,000 annual internship opportunities by 2025

- Create a national platform connecting students with training opportunities

R6: Strengthen University-Industry Research Partnerships

- Establish joint research centers between universities and major companies

- Create a fund to support collaborative research projects

- Target: 500 industry-funded research projects annually by 2030

12.3 Educational Access and Equity

R7: Expand Access to Quality Education in All Regions

- Ensure equitable distribution of educational resources across all regions of the Kingdom

- Develop distance learning infrastructure for remote areas

- Provide additional support for students from underserved communities

R8: Enhance Scholarship Program Effectiveness

- Align scholarship programs with national priority sectors
- Track graduate employment outcomes and adjust programs accordingly
- Strengthen post-graduation support for returnees

12.4 Monitoring and Evaluation

R9: Develop an Education-Economy Dashboard

- Create a real-time dashboard tracking key indicators:
  - Education expenditure by level and region
  - Graduate employment rates by major
  - R&D investment and patent applications
  - Skills gaps and labor market needs
- Update quarterly and make publicly available

R10: Conduct Regular Impact Assessments

- Commission independent evaluations of major education initiatives every 3 years
- Use findings to inform budget allocations and policy adjustments
- Publish results to ensure transparency and accountability

12.5 Future Research Directions

R11: Study of the relationship between education and growth

- Research to determine the optimal range between investment in education and economic returns
- Use of distributed lag models to monitor delayed effects

R12: Study of quality indicators beyond enrollment

- Incorporation of educational quality indicators (test scores, international rankings, graduate competencies)

- Development of educational quality indicators specific to the Kingdom of Saudi Arabia

R13: Conducting comparative studies with other Gulf countries

- Comparison of the relationship between education and growth in the Kingdom of Saudi Arabia with the United Arab Emirates, Qatar, and Kuwait

- Identification of good practices and lessons learned

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14.0 Appendices

Appendix A: Raw Data (1997-2021)

Table A1: Complete Dataset Used in the Analysis

Year	Y (GDP in current US$)	X2 (R&D Expenditure)	X3 (Tertiary Enrollment % gross)
1997	1.65964E+11	19,938,377	17.32280
1998	1.46775E+11	20,472,580	17.50532
1999	1.61717E+11	21,009,660	20.97185
2000	1.89515E+11	21,547,390	22.32137
2001	1.84137E+11	22,085,929	23.82769
2002	1.89606E+11	22,623,415	23.47262
2003	2.15808E+11	23,150,847	26.91347
2004	2.58742E+11	23,661,808	28.70963
2005	3.28460E+11	24,397,644	29.54273
2006	3.76900E+11	25,382,870	30.33104
2007	4.15965E+11	26,400,068	30.41106
2008	5.19797E+11	27,437,353	30.80211
2009	4.29098E+11	28,483,797	31.56049
2010	5.28207E+11	29,411,929	36.62677
2011	6.71239E+11	30,150,945	40.41565
2012	7.35975E+11	30,821,543	46.67548
2013	7.46647E+11	31,482,498	52.23613
2014	7.56350E+11	32,125,564	58.29673
2015	6.54270E+11	32,749,849	61.05635
2016	6.44936E+11	33,416,270	67.33551
2017	6.88586E+11	34,193,123	69.69832
2018	8.16579E+11	35,018,133	68.03989
2019	8.03616E+11	35,827,362	70.90088
2020	7.03368E+11	35,997,107	70.63198
2021	8.33541E+11	35,950,396	71.40964

Source:World Bank Development Indicators (2023)

Appendix B: Variable Definitions and Sources

Table B1: Variable Descriptions

Variable	Definition	Unit	Source
GDP	Gross Domestic Product	Current US$	World Bank
R&D Expenditure	Research and development expenditure	Current US$	World Bank
Tertiary Enrollment	School enrollment, tertiary (% gross)	Percentage	World Bank

Notes:

- Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown.

- Tertiary education includes universities, teacher training colleges, and higher professional schools.

Appendix C: E-Views Output

Table C1: Complete Regression Output

Appendix D: Diagnostic Test Outputs

Table D1: Heteroskedasticity Test (Breusch-Pagan-Godfrey)

Table D2: Breusch-Godfrey Serial Correlation LM Test

Appendix E: List of Figures

Figure	Title
Graph 1	GDP Trend in Saudi Arabia (1997-2021)
Graph 2	Research and Development Expenditure Trend
Graph 3	Tertiary Enrollment Trend
Graph 4	Scatter Plot: GDP and R&D Expenditure
Graph 5	Scatter Plot: GDP and Tertiary Enrollment
Graph 6	Actual, Fitted, Residual Graph

Instructions for creating figures:

1. Use Excel or E-Views to generate the graphs

2. Export as PNG files with 300 DPI resolution

3. Save in the `/visualizations` folder

4. Update the file paths in the document if necessary

Appendix F: Glossary of Terms

Term	Definition
GDP	Gross Domestic Product - the total monetary value of all finished goods and services produced within a country's borders
R&D	Research and Development - creative work undertaken systematically to increase knowledge and use it to devise new applications
Tertiary Education	Higher education beyond secondary school, including universities, colleges, and professional schools
Multiple Linear Regression	Statistical technique that uses several explanatory variables to predict the outcome of a response variable

R-squared	Statistical measure representing the proportion of variance for a dependent variable explained by independent variables
Heteroskedasticity	Situation where the variability of a variable is unequal across the range of values of a second variable that predicts it
Autocorrelation	Correlation between the errors at different points in time
Durbin-Watson	Test statistic used to detect autocorrelation in the residuals from regression analysis