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Research Article

The Effect of Research and Development on Economic Growth in Ethiopia: The Untapped Potential for Prosperity

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This research measured the links between R&D and economic growth in Ethiopia employing multiple regression models. Citable journal articles, patents, technology exports, and research expenditures are the four predictor variables that are the focus of the study. GDP per capita growth is the outcome variable of the study, which serves as a proxy indicator for economic growth. The study used a panel dataset with data from a sample of 21 years between 2001 and 2021. The results show a significant link between growth of GDP per capita and citable journal articles, patents, and technology exports, demonstrating that these factors are essential for fostering economic growth. However, government expenditure on research and development has no discernible impact on economic growth, which accordingly, raises the possibility that raising research spending by itself may not be sufficient to boost the economy. These findings have tremendous policy implications because they emphasize the importance of concentrating on particular R&D initiatives that have a direct impact on economic growth. The study adds to the existing frontiers of knowledge inline with the connection between R&D and economic growth by demonstrating the value of citation-worthy journals, patents, and technology exports in fostering economic growth.

1. Introduction

The advancement of growth and development in the economy depends heavily upon research and development (R&D). R&D helps to develop new technologies, procedures, and products that can boost productivity, competitiveness, and social welfare. One of the main forces behind economic progress and growth has been identified as R&D. Long-term economic growth is primarily fueled by technical advancement, according to Solow's [1] growth model. By creating new information that may be used to create new products and processes, R&D operations promote technological advancement. Investment in R&D is also linked to higher productivity, which can result in faster economic growth. Organization for Economic Co-operation and Development research indicates that a single percent raise in R&D spending is related to a .13% increase in economic growth [2]. In a recent study, Jaffe et al. [3] used data at the level of individual companies to show that higher investment in R&D is associated with improved productivity, which in turn drives economic growth.

Another crucial component of R&D that might support economic growth is innovation. The marketing of novel goods, procedures, or technologies constitutes innovation. The development of new markets, the growth of already existing markets, and the emergence of new industries are all possible outcomes of innovation. Innovation is responsible for more than half of the economic development in the US, according to a research by the National Bureau of Economic Research [4].

Many previous researches have looked at the connections between R&D and economic growth, and the outcomes have varied depending on the setting and approaches employed. On the precise nature of this link and the ways in which R&D influences economic growth, there is still disagreement. In other words, findings varied from one author to the next. For instance, studies by Mankiw et al. [5] and Hall and Jones [6] revealed that the two are positively related, whereas other researchers found little to no association [1, 7]. Despite this, R&D is still seen as a major force behind innovation and economic expansion [8].

Yet, a lack of resources and infrastructure frequently puts a cap on R&D operations in poor nations. Due to the

significant risks and uncertainties involved, the private sector may be hesitant to commit in R&D and the government may not have the resources necessary to adequately fund these operations.

To the best of the researcher's knowledge, there is not any empirical data showing how R&D and economic growth are related in Ethiopia. However, very recently, it is undeniable that Ethiopia has made tremendous efforts to strengthen its R&D capabilities, considering the critical role that it plays in promoting economic growth. The assumption is that R&D has the ability to significantly affect Ethiopia's economic growth through the creation of new industries, advancements in technology, and higher productivity. Consequently, the intent of this research is to explain the relationship between R&D and economic growth in Ethiopia. For the purpose of this research, variables such as citable journal articles, research expenditure, patents, and technology exports were used as predictor factors, and GDP per capita growth served as an outcome variable. Thus, the following research hypotheses were created accordingly.

2. Research Hypotheses

H1: Government's expenditure on R&D has a significant effect on economic growth in Ethiopia.

H2: Citable journals have a positive impact on per-capital GDP growth as they contribute to the dissemination of knowledge and ideas.

H3: There is positive and statistically significant impact of patents application on economic growth in Ethiopia.

H4: The effect of value added technology export on economic growth is statistically significant and positive in Ethiopia.

3. Review of Related Literatures

3.1. Theoretical Framework. To explain the association between research and development, abbreviated R&D, and the growth of the economy, numerous theoretical frameworks have been put forth. Among others, one frequently mentioned model is the "endogenous growth theory," which contends that expenditure on R&D can produce novel ideas and technologies that can be used to boost productivity and innovation and hence sustain economic growth [9].

R&D is viewed in this framework as a major contributor to economic growth through technological advancement. Citable journal articles, which are a reflection of the volume and quality of research being produced in a certain subject over time, are one way to measure R&D [10].

Investment in research, which shows the amount of resources being committed to R&D activities, is another crucial indicator of R&D [11]. Another crucial predictor variable is patents which show the intellectual output of businesses and the rate at which new concepts and technologies are developed [12].

Last but not least, technology exports can be viewed as a gauge of R&D activity since they show how well businesses are able to use their technological capabilities to compete in international markets [13]. In this research, it is the amount of technology-related products produced and exported to beneficiaries.

Together, these predictor factors can support in the explanation of the connection between R&D and economic growth. They specifically contend that spending on R&D can boost productivity, innovation, and competitiveness, all of which can stimulate economic growth and development.

3.2. Empirical Literature. It is widely acknowledged that R&D is a key engine for economic expansion. Using citable journal articles, R&D expenditure, patents, and technology exports as predictor variables, this study seeks to undertake an empirical literature review of how R&D affects per-capita GDP growth. The review concentrates on recent studies and offers statistical proof to back up the conclusions.

Using panel data analysis, Czarnitzki and Delanote [14] looked at the impact of R&D investment on economic growth in 27 member states of the European Union (EU). They discovered that a 1% increase in R&D spending led to a rise in per-capita GDP growth of .039%. In addition, they discovered that high-tech industries benefited more from R&D investment than low-tech ones. Similar findings were made by Aizenman and Jinjarak [15], who discovered that in high-income nations, a 1% increase in R&D spending as a proportion of GDP resulted in a .12% rise in economic growth. Utilizing a dynamic panel data model, Xie and Zhang [16] examined the connections between R&D spending, patenting, and economic growth in 37 nations. According to their research, a unit percent of increase in R&D spending resulted in an increase of .068% in GDP per capita growth. A 1% increase in patenting was shown to be associated with a .017% rise in GDP per capita growth, further supporting the conclusion that patenting has a significant effect on economic growth.

The effect of investment in R&D spending on Pakistan's GDP was analyzed by authors Munir and Ahmad [17] using a vector autoregression (VAR) model. According to their research, a 1% increase in investment in R&D eventually caused a .032% rise in GDP per capita growth. Using a dynamic panel data model, Kaya and Kaya [18] investigated the impact of R&D on economic growth in the context of Turkey. Accordingly, they figured out that an increase in R&D spending of 1% corresponded to a rise in per capita gross domestic product of .039%. Investment in R&D was found to have a greater impact on the manufacturing sector than the services sector.

On the other hand, a number of empirical investigations have discovered no correlation or even inverse relationships between research spending and economic growth. For instance, Wang and Zhou [19] used a panel data model to find that there was no meaningful correlation between R&D spending and economic development in China. Kwak and Lee [20] discovered a similar inverse association between R&D expenditure and South Korea's economic worth. Tregenna [21] also performed research in 35 nations and discovered indirect effects of one on the other, spending and growth in economy, with diminishing returns at higher R&D spending levels. In

other words, after a certain point, increased R&D spending might not significantly boost economic growth.

In a different investigation, Mohnen et al. [22] looked at the relationship links R&D spending and economic advancement in 21 OECD nations and discovered a negative correlation between the two variables.

These studies suggest that the relationship between research expenditure and economic growth may not always be positive or significant. Policymakers should carefully consider the context and specific characteristics of their economy when developing R&D policies.

Kuo and Lin [23] explored the relationship between exports of technology and economic growth in Taiwan. They found that a unit increase in technology exports led to an increase in GDP per capita growth by .074%. The effect of technology exports was found to be stronger in high economies compared to lower economies. For example, Keller [13] found that high-income economies can absorb and use technology more efficiently than developing countries due to their better technological infrastructures, skilled labor forces, and established institutions.

4. Methodology

The study is all about a quantitative research design to examine the effect of R&D on economic growth in Ethiopia. This design allows the researcher to collect and analyze numerical data from various sources. It is based on secondary data collected from the World Bank database (https://databank.worldbank.org/source/world-development-indicators) [24] and Scimago journal and country ranking 2022 (https://www.scimagojr.com/journalrank.php) [25]. The data cover the period from January 2001 to December 2021. The study employed multiple regression analysis to investigate the relationship between the two. The analysis involved testing the significance of the coefficients of the predictors on the response variable (economic growth).

5. Model Specification

Theoretical models suggest that investment in R&D can lead to technological diffusion, which ultimately can drive economic growth [26]. Empirical studies have also found evidence of a positive correlation between R&D and economic growth [27, 28]. In this model specification, the researcher examines the effect of four independent variables—citable journals, R&D expenditure, patents, and technology exports—on GDP per capita growth as the dependent variable.

The model specification is as follows:

$$Y = \beta 0 + \beta 1\,(\text{citable journals}) + \beta 2\,(\text{R\&D expenditure} + \beta 3\,(\text{patents}) + \beta 4\,(\text{technology exports}) + \epsilon, \tag{1}$$

where:

(i) Y represents GDP per capita growth as the dependent variable, which represents the percentage change in GDP per capita over time.

(ii) $\beta 0$ represents the average value of GDP per capita growth when all independent variables are equal to zero.

(iii) $\beta 1$ is citable journals produced in Ethiopia over a period of time that captures the level of scientific knowledge produced by a country.

(iv) $\beta 2$ represents R&D expenditure by government as a percentage of GDP that reflects the amount of resources a country devotes to R&D.

(v) $\beta 3$ is patents that measures the level of intellectual property and innovation applied to a legally established authorities.

(vi) $\beta 4$ denotes the percentage of value added medium and high technology exports out of the total manufactured that captures the extent of country's ability to commercialize its technological innovations to the rest of the world.

(vii) ϵ is the error term that captures the unobserved factors that affect GDP per capita growth but are not included in the model.

The coefficient $\beta 1$ indicates an increase in the number of citable journals that leads to an increase in GDP per capita growth. Previous studies have shown that scientific knowledge can promote economic growth, which supports this [29]. Furthermore, $\beta 2$ is expected to be positive, which shows that rising R&D spending results in rising GDP per capita growth [28].

The coefficient $\beta 3$ indicating that a rise in the number of patents will result in a rise in GDP per capita growth and is also supposed to be positive. This is supported by previous research, which has found that technological innovation can drive economic growth [7]. The coefficient $\beta 4$ is also expected to be positive, which depicts an increase in technology exports assumes to an increase in GDP per capita growth. This relationship has been documented in the literature [13].

Hence, the multiple regression model is given as follows:

$$Y = \beta 0 + \beta 1(X1) + \beta 2(X2) + \beta 3(X3) + \beta 4(X4) + \epsilon, \tag{2}$$

where $X1$, $X2$, $X3$, and $X4$ represent the independent variables, as mentioned above.

This model can be estimated using multiple linear regression analysis, where the coefficients of the independent variables are estimated using ordinary least squares method. It is used for the estimation of coefficients in regression model to summarize the sum of squared differences between observed and predicted values [30]. The significance and direction of the coefficients can be used to test the hypotheses that citable journals, R&D expenditure, patents, and technology exports have a positive and statistically sound effect on GDP per capita growth.

Another important consideration was that before running the model, the variables have gone through the underlying assumptions including but not limited to normality,

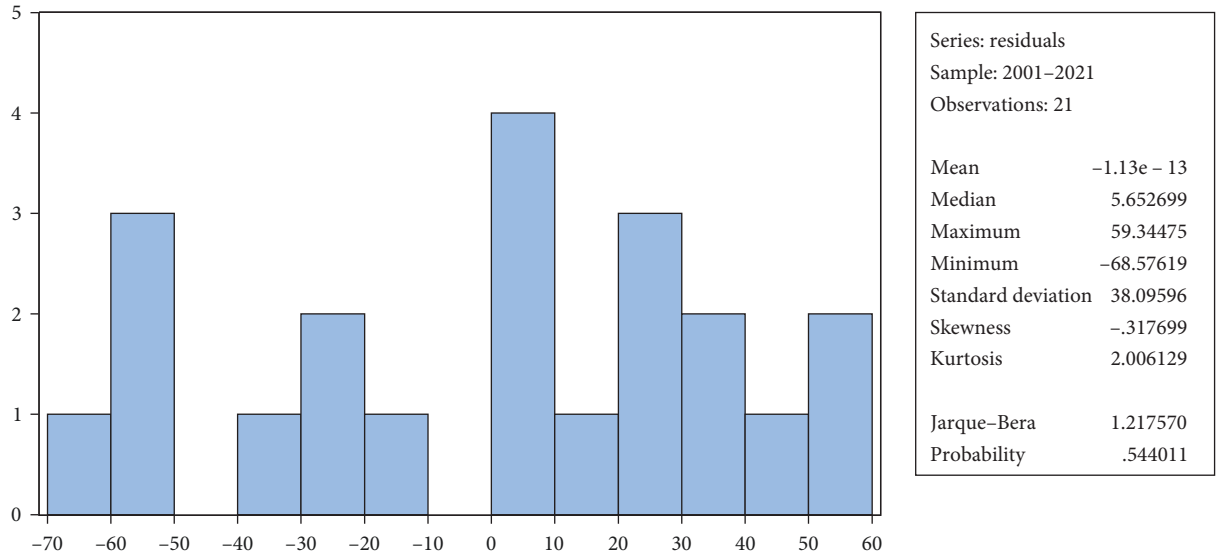

Figure 1: Histogram normality test (residual diagnostic test).

Table 1: Colleniarity test (coefficient diagnostic test).

Variable	Coefficient variance	Uncentered VIF	Centered VIF
C	1,608.532	18.62006	NA
Citable_Journal_Articles	3.84e − 05	3.967906	2.180859
Research_and_Development	15,801.25	21.88757	6.217350
Patent_Applications__Res	5.069726	3.803423	1.449455
MED_High_Tech_Exports__V	36.19381	65.25383	6.494878

Variance inflation factors. Date: 03/19/23. Time: 18:09. Included observations: 21.

Table 2: Linearity test.

Wald test			
Equation: untitled			
Test statistic	Value	df	Probability
F-statistic	103.1868	(4, 16)	<.01
Chi-square	412.7472	4	<.01
Null hypothesis: C(2) = C(3) = C(4) = C(5) = 0			
Null hypothesis summary			
Normalized restriction (= 0)		Value	Standard error
C(2)		.036486	.006196
C(3)		20.88898	6.016129
C(4)		5.741583	2.251605
C(5)		133.9384	125.7030

multicolianiarity linearity tests, respectively, for which the results are shown in Figure 1 and Tables 1 and 2.

6. Results and Discussion

6.1. Descriptive Statistics. Table 3 shows the descriptive statistics of both the predictor and response variables treated in the study. The maximum values show that the dependent variables have progressed over time. All in all, all the variables show a given level of improvement over time despite the magnitude and scale of increment.

Similarly, Figure 2 shows the trends of the variables treated in the study over period. Despite the fluctuation observed in some cases, there exist relatively better improvements in the variables across time. To be specific, as it is shown on the left side, an increasing trend was observed for citable journal

Table 3: Descriptive analysis of variable treated in the study.

	Number of observations	Minumum	Maximum	Mean	Standard deviation
Patents	21	.00	18.00	6.3333	5.09248
Res_expenditure	21	.01	.60	.2927	.18892
GDPPCG	21	255.10	834.96	505.8291	197.20577
Cit_jour_articles	21	261.00	8,876.00	2,005.3810	2,270.06023
Tech_exports	21	6.26	16.70	11.8425	4.03448

Source: WDI and Scimago Journal Ranking, 2022.

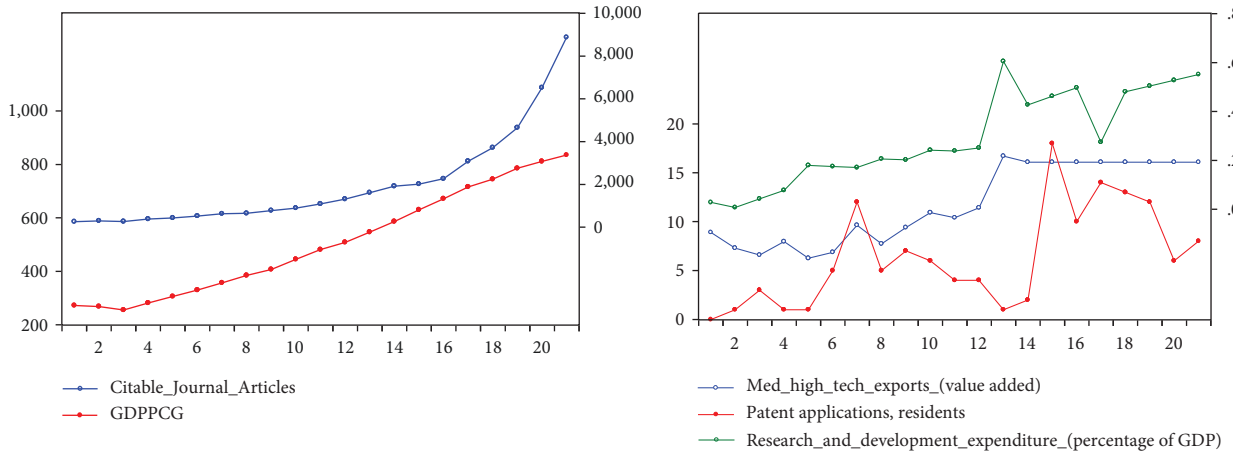

Figure 2: Trends of the variables over time (source: based on WDI and Scimago Journal Ranking, 2022).

Table 4: Predictors coefficients of the regression model.

Variable	β	Standard error	t-stat.	p-Value
C	109.7152	40.10651	2.735595	.0147
Number of citable journal articles	.036486	.006196	5.888918	<.01*
R&D expenditure (GDP (%))	133.9384	125.7030	1.065514	.3025
Number of patent application	5.741583	2.251605	2.549996	.0214*
Medium and high tech. export (value added)	20.88898	6.016129	3.472164	.0031*
R^2	.962682	—	—	—
Adjusted R^2	.953352	—	—	—

Dependent variable: GDP per capita growth. Method: least squares. Included observations: 21. Source: WDI and Scimago Journal Ranking, 2022. * indicates that p is significant ($p < 0.05$).

articles and GDPPCG from the base year of the study. Likewise, the trends for research expenditure is increasing, and the pattern for technology export and patents application has shown a similar manner even though some level of fluctuations were seen.

6.2. Linear Estimations (Multiple Linear Regression Analysis). Table 4 shows the relationships of the coefficients of the predictor variables vis-à-vis the outcome variable, economic growth proxed by per-capita GDP growth. According to the analysis, citable journal articles had a statistically sound and positive effect on economic growth ($\beta = .036486$, $t = 5.888918$, $p < .01$). More specifically, the analysis shows an increase in one article increase in the citable journal articles was associated with a .036486% increase in economic growth, on average. On the other hand, it was found out that research expenditure did not have a significant effect on economic growth ($\beta = 133.9384$, $t = 1.065514$, $p = .3025$). Specifically, it is found that no evidence to suggest that a one unit increase in the amount of money spent in research was associated with a significant change in economic growth holding all other variables constant. While R&D expenditure can have a positive or no impact on economic growth, the relationship is not always straightforward. Factors such as the type of research being conducted, the level of collaboration between researchers and industry, and the effectiveness of government policies all play a role in determining the impact of research on economic growth.

Another important variables treated in this study are patents applications and export of value added medium and high technologies manufactured. As can be clearly seen from the table, the coefficients ($\beta = 5.741583$, $t = 2.549996$,

$p = .0214$) and ($\beta = 20.88898$, $t = 3.472164$, $p = .0031$) for the patent application and export of technologies variable, respectively, portrayed a unit (one patent) increase in patent increases economic growth as measured by GDP per capita growth by 5.74% and likely increase a unit of increase in the amount of value added technology exported leads to an increase in the per capita GDP by 20.89%. The p-values also indicate that the probability of observing this relationship by chance is low, which entails a confidence in the significance of the coefficients (Table 3). However, it is crucial to note that the presence of correlation does not necessarily imply a cause-and-effect relationship, and it is possible that other factors may play a tremendous role in the growth of the economy other than the explanatory variables treated in this study.

Evidence from some literatures suggest that there is a positive relationship between R&D expenditure and economic growth. Czarnitzki and Delanote [14] and Aizenman and Jinjarak [15] found that increasing R&D investment led to an increase in GDP per capita growth in both high-tech and high-income countries, respectively. Additionally, Xie and Zhang [16] showed that there was a positive effect of R&D expenditure on economic growth across a sample of 37 countries. On contrary, other authors like Wang and Zhou [19], Kwak and Lee [20], Tregenna [21], and Mohnen et al. [22] found out no statistical significance relationship between the two variables.

In support of these findings, in this study, the researcher did not find a statistically significant evidence on the relationship between research expenditure and economic growth in Ethiopia. This finding may be attributed to the unique characteristics of the Ethiopian economy, which may affect the relationship between R&D expenditure and economic growth. For example, the Ethiopian economy may be experiencing constraints in absorbing and utilizing the knowledge generated through R&D, leading to limited impacts on economic growth. Additionally, it is possible that the R&D investment in Ethiopia is not targeted toward sectors that have a direct impact on the economy. Furthermore, the reason behind why investment in R&D did not demonstrate an effect on economic growth in our study is perhaps due to the possibility of R&D expenditure being directed toward less productive research activities especially in higher education institutes.

7. Conclusion

In conclusion, the study provides empirical evidence on the effect of R&D on economic growth in Ethiopia. The multiple linear regression models indicate that citable journals, patents, and technology exports have a significant and positive effect on GDP per capita growth, while research expenditure does not show any sound statistical evidence effect on economic growth.

The results suggest that policymakers in Ethiopia should focus on increasing the number of citable journals, promoting patent registration, and encouraging technology exports to boost economic growth. Increasing research expenditure alone may not be enough to stimulate economic growth unless it is accompanied by other specific R&D activities that directly impact the economy.

The implications of the findings are significant for Ethiopia's development agenda, particularly in the areas of innovation and technology transfer. The study underscores the need for the government to invest more resources, particularly in areas that directly impact the economy and should be associated with strong monitoring and evaluation tools as state funded researches seem to be less productive. To expound the idea, in order to ensure efficiency and productivity of state funded research projects, those who are responsible for research management should apply specific research monitoring and evaluation tools such as but not limited to LogFrame, key performance indicators (set standards and quantities of research out on a given period of time t and associate funding with quality and number of research outputs), and data management and analysis softwares. Moreover, it highlights the need for policies that promote collaboration between the government, universities, and the private sector to foster innovation and technology transfer.

Overall, the study provides insights into the complex relationship between R&D and economic growth in Ethiopia and contributes to the existing literature on the subject. Future research could explore other variables that may affect the way how R&D affects economic growth in Ethiopia, such as education and infrastructure development to see how education and training is linked to R&D activities.

Data Availability

Dataset of this research is available from the corresponding author and can be submitted upon request by the journal.

Additional Points

Limitations. A limitation arises from the intricate nature of economic systems, as multiple factors beyond the chosen variables can impact economic growth. Factors such as political instability, global economic conditions, and sociocultural factors from outside sources can complicate the process of determining the specific impact of R&D on economic growth. Furthermore, the study's timeframe and the availability of data may impose limitations, restricting the capacity to capture dynamic fluctuations over a prolonged duration. It is essential to acknowledge these constraints in order to interpret the study's results accurately and to explore further research opportunities that can explore the complex connection between research and development (R&D) and economic growth. In addition, the use of a linear model might be a significant limitation of this study, which might oversimplify the complex nature of the relationship between R&D variables and economic growth. Economic systems possess inherent dynamism and nonlinearity, and employing a linear model may fail to sufficiently capture the intricate interconnections and feedback loops within these processes.

Conflicts of Interest

The author declares that there is no potential conflict arising due to computing interest.

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