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THE IMPACT OF INVESTMENT IN EDUCATION ON ECONOMIC GROWTH: A PANEL DATA ANALYSIS OF OECD COUNTRIES

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ABSTRACT

This broad-based research study explores the relationship between investment in education and economic growth, expanding upon the established principles of human capital theory from classic studies by Schultz (1961), Becker (1964), and Mincer (1974). This research study seeks to shed light on the complex processes by which education translates into economic success by filling the crucial gaps in knowledge: measuring the exact effect of educational expenditure, determining the main transmission mechanisms, analyzing the differences in effects for varying levels of development and distributions of economic growth, and assessing the relative significance of quality compared to quantity. For the above-stated goals, the research uses sophisticated econometric methods on a detailed panel data set of 38 countries (mostly OECD nations) from 1995 to 2023, providing 1,102 observations. The analysis uses Panel Data Models with fixed and random effects, with the Hausman test validating the suitability of the fixed effects model. The research also applies Quantile Regression to analyze the results across the distribution of economic growth. To properly model endogeneity and reverse causality, Three-Stage Least Squares (3SLS) instrumental variable models are used, in addition to Mediation Analysis based on the Baron & Kenny method to measure the strength of specific transmission mechanisms. Thorough diagnostic testing, including Augmented Dickey-Fuller and Phillips-Perron tests for stationarity, Johansen cointegration test, Variance Inflation Factor test, Breusch-Pagan test for heteroscedasticity, and Durbin-Watson test for autocorrelation, was performed, with corrections as needed (robust standard errors) to ensure proper inference. Sensitivity analyses, including the removal of outliers, sub-period analysis, and alternative metrics, were also conducted to confirm the validity of the results. Core Relationship: Educational investment is a strong driver of economic growth ($p<0.01$). A 1% GDP increase in education investment increases growth by 0.52% per annum, and additional schooling years increase GDP per capita by 10.3%. Transmission Channels: R&D is the main channel (40.3% of education's effect), followed by productivity, technological innovation, and institutional quality (11.5%). Heterogeneous Effects: The effect of education becomes stronger at higher levels of growth (coefficient increases from 0.387 to 0.621 across percentiles). Tertiary education is the main driver of growth in developed countries ($\beta=0.682$), and secondary education in emerging countries ($\beta=0.731$). Quality vs. Quantity: Cognitive skills (PISA scores) are much more important than years of schooling. When both are included, the effect of schooling

decreases by 72% (from 1.032 to 0.284), but PISA scores remain significant (β=0.452). Robustness: All diagnostic tests were valid—stationarity was achieved, and cointegration in the long run was confirmed, with no serious multicollinearity (max VIF=3.87), and correct heteroscedasticity adjustments. This research provides conclusive evidence that educational investment powerfully drives economic growth, delivering returns substantially exceeding those of physical capital, though its effectiveness depends critically on strategic allocation—particularly directing approximately 40% to R&D activities—and adaptation to a country's developmental stage, while unequivocally demonstrating that education quality matters more than quantity. Based on these findings, the study advances five concrete policy recommendations: first, increase public education spending to at least 5-6% of GDP; second, prioritize R&D funding as the primary transmission mechanism; third, match strategies to development level by focusing on primary and secondary education for developing nations and tertiary education for advanced economies; fourth, intensify quality improvement through targeted programs to raise PISA performance; and fifth, launch immediate COVID-19 remedial programs for disadvantaged groups to prevent temporary disruptions from crystallizing into permanent human capital deficits.

KEYWORDS: Economics of Education, Human Capital Theory, Economic Growth, Panel Data Analysis, Econometric Models.

1. INTRODUCTION

Throughout the course of human history, education has been one of the basic building blocks of social and economic development. Yet the economic view of education as a productive investment only fully emerged in the second half of the twentieth century. In the modern world, marked by the rapid pace of technological change, global competition, and economic transformation, quality education has moved beyond its role as a basic human right to become a strategic economic imperative and a necessary prerequisite for economic growth and global competitiveness. Those countries that make intensive and strategic investments in educating their citizens will generally realize higher economic growth rates, greater flexibility in response to global economic and technological changes, and a superior standard of living for their citizens.[1]

Recent empirical findings have clearly identified the significant economic benefits of investment in education. For example, a recent groundbreaking study conducted by [2] at China's top Tsinghua University, one of the top institutions in Asia, revealed that the total macroeconomic (social) return on investment in education in China since the initiation of economic reforms in 1978 is above an impressive 20%. This is four times higher than the return on physical investment, which is stuck at a meager 5%, making education investment the most profitable investment opportunity from a macroeconomic point of view. The report ended with a recommendation to boost investment in education and cut inefficient investment in physical assets, especially in industries with overcapacity.

Likewise, the cost-benefit analysis carried out by [3] on educational investments in the United States, conducted at UCLA, showed that effective educational interventions produce social returns of between $2 and more than $10 for every dollar invested, depending on the type of intervention and beneficiaries. The analysis also showed that educational investments targeting disadvantaged groups produce even higher social returns not only in terms of improved economic outcomes but also in terms of reducing socioeconomic disparities.

The intellectual antecedents of education economics can be traced back to the classical economists, specifically Adam Smith, who in his classic book 'The Wealth of Nations' [4] highlighted the significance of skills acquired and education as a type of fixed capital. Nevertheless, the integrated theory of human capital did not take shape in its present form until the 1960s, thanks to the groundbreaking contributions of three extraordinary economists. First, Theodore W. Schultz wrote a revolutionary paper in 1961 titled 'Investment in Human Capital,' which was published in the American Economic Review, where he systematically argued for the first time that education is not only a consumption or a consumptive process but a productive process that generates a type of capital known as human capital.[5]

This capital, like physical capital, can accumulate and is responsible for the rise in productivity and, consequently, income. Schultz was later awarded the Nobel Prize in Economics in 1979 for his pioneering contributions to development economics, including his theory of human capital.

Second, Gary S. Becker further developed these ideas in his influential book of 1964, "Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education," which provided a coherent economic framework that linked investments in education and training to their return in the form of increased earnings. Becker defined two types of human capital: general human capital, which can be applied to different firms and industries, and firm-specific human capital, which is specific to a particular firm or industry.[6]

This difference has a great significance in comprehending the dynamics of the labor market and training investments. Becker was awarded the Nobel Prize in Economics in 1992 for his work in applying microeconomic principles to explain a broad spectrum of human behavior and social interactions, including human capital theory.

Third, Jacob Mincer specifically emphasized the quantitative link between education and wages, formalizing in 1974 what is now called the 'Mincer Equation'—a widely used labor economics model even to this day to quantify the returns to education and work experience on wages. Mincer's simplest equation specifies that the logarithm of wages is a linear function of education and a quadratic function of work experience (to capture diminishing returns). Notwithstanding its seeming simplicity, the Mincer equation has proved to be a robust and highly popular model in applied research, having been developed and extended over the years to include other variables such as education quality, major, and family background.[7]

In the current scenario, countries across the world, irrespective of their levels of economic development, are confronted with various complex challenges associated with education finance and achieving the optimal balance between quality and quantity. On the one hand, there are constant

demands to enhance education expenditure to match the growing population and enhance the quality of educational services being provided. On the other hand, there are stringent financial constraints and limited budgets, which increase competition for government finances among various sectors. [8]

As per the recent World Bank report entitled 'Education Finance Watch 2024,' developing countries are required to allocate an additional 4.5% to 5.5% of their GDP towards education in order to meet the targets of the Sustainable Development Goals on education (SDG 4) by the year 2030. This is a huge task, especially in the wake of the economic crises that have engulfed the world over the past few years, starting from the global financial crisis of 2008-2009, followed by the outbreak of the COVID-19 pandemic in 2020-2021, and most recently due to high inflation and the cost of living crisis in 2022-2023.[9]

According to the report 'Education at a Glance 2025' published by the Organisation for Economic Co-operation and Development (OECD, 2025), the average spend on education (primary to tertiary level) by OECD nations was 4.7% of the GDP in 2022, with large discrepancies between nations, ranging from 3.2% in Turkey to 6.8% in Israel. It is important to note that nations that spend more on education have better educational outcomes (as measured by international test scores like PISA) and faster economic growth rates, although this is not always a linear relationship.[10]

In addition to the funding issues, there are major qualitative issues that the global education sector is facing. The COVID-19 pandemic has brought unprecedented crises to the education sector globally. Learning institutions were closed in most countries for a long time, leading to a significant loss of learning, especially among children from poor families and rural areas who did not have access to online learning. It is estimated that the 'learning poverty' rate (the percentage of 10-year-olds who cannot read and understand a simple text) increased from 57% before the pandemic to about 70% in low- and middle-income countries, which is a major setback in the global fight to enhance learning outcomes.[11]

Critical Analysis & Research Gap

While classical Human Capital Theory, pioneered by **Schultz (1961)** and **Becker (1964)**, emphasized the accumulation of human capital as an independent driver of economic expansion, it often overlooked the qualitative dimension of education. Traditional models primarily focused on 'quantity' (e.g., years of schooling), failing to account for the dynamic interaction between educational quality and a nation's technological absorptive capacity. A critical research gap exists in understanding how cognitive skills—measured by standardized outcomes like **PISA**—interact with **R&D** expenditures to catalyze growth. This study addresses this gap by integrating qualitative educational metrics with innovation indicators within a unified econometric framework, moving beyond the linear assumptions of early growth models.

2. Research Problem and Main Questions

Notwithstanding the general theoretical agreement among economists on the significance of education to economic growth and development, and despite the existence of many applied studies that have confirmed the positive relationship between the two, there are still some important research questions that need to be answered. The basic research problem of this study is the need for a better understanding of the causal relationship between educational investment and economic growth, the channels through which this causal relationship works, the measurement of the magnitude of each channel, and the differences in the effect due to various economic, social, and educational factors.

More specifically, this study aims to answer the following main research questions, carefully crafted to address significant gaps in the existing literature:

1. What is the magnitude of the quantitative impact of educational expenditure on GDP growth rates in OECD countries?
2. How does the impact of investment in education on economic growth vary across different levels of growth (using Quantile Regression)?
3. To what extent does the quality of education (as measured by PISA scores) influence innovation and economic growth compared to the quantity of education (e.g., years of schooling)?

3. Research Objectives

This study aims to:

1. Quantify the impact of educational expenditure on economic growth rates in OECD countries using appropriate econometric models.
2. Estimate the elasticity of economic growth with respect to educational expenditure by calculating regression coefficients and testing their statistical significance.

3. Examine the mediating role of innovation and productivity in the relationship between education and economic growth using mediation analysis techniques.
4. Compare the direct and indirect effects of educational investment to assess the relative contribution of innovation and productivity to economic growth.

4.Methodology:
4.1Equations and Instruments
4.1.1. Fixed Effects Model (FE)
"To account for time-invariant country-specific characteristics, the study employs a Fixed Effects (FE) model as follows:"

$$Growth_{it} = \beta_0 + \beta_1 Edu\_Exp_{it} + \beta_2 Quality_{it} + \alpha_i + \mu_{it}$$

4.1.2 Quintile Regression (QR)

$$Q_\tau(GDPGrowth_{it}) = \beta_0^{(\tau)} + \beta_1^{(\tau)} EduSpend_{it} + \beta_2^{(\tau)} X_{it}$$

Purpose:
To capture heterogeneous effects of educational investment across different points of the growth distribution.

4.1.3. Three-Stage Least Squares (3SLS) & Endogeneity
"To address potential endogeneity and reverse causality between educational investment and GDP growth, a Three-Stage Least Squares (3SLS) instrumental variable approach is utilized. We employ lagged educational expenditures and demographic dependency ratios as Instrumental Variables (IV). These instruments are correlated with educational investment but exogenous to the growth error term, ensuring that the estimated coefficients represent a one-way causal effect from education to economic performance."

:First Stage (Instrumental Equation)

$$EduSpend_{it} = \pi_0 + \pi_1 Z_{it} + \pi_2 X_{it} + u_{it}$$

:Second Stage (Structural Equation)

$$GDPGrowth_{it} = \beta_0 + \beta_1 \widehat{EduSpend}_{it} + \beta_2 X_{it} + \varepsilon_{it}$$

Instruments:

- Lagged educational expenditure
- Dependency ratio
- Regional education averages

These instruments satisfy both relevance and erogeneity conditions, ensuring causal interpretation.

4.1.4 Mediation Analysis

$$M_{it} = \alpha_0 + \alpha_1 EduSpend_{it} + \alpha_2 X_{it} + u_{it}$$

$$GDPGrowth_{it} = \gamma_0 + \gamma_1 EduSpend_{it} + \gamma_2 M_{it} + \gamma_3 X_{it} + \varepsilon_{it}$$

Mediators:

- R&D
- Total Factor Productivity (TFP)
- Innovation (Patents)

5. APPLIED FINDINGS
5.1 Comprehensive Descriptive Statistics
This section provides a detailed description of the descriptive statistics for all the variables used in our analysis. It is important to understand the distributional properties of our data in order to interpret the results of the regression analysis. Table 1 below provides a summary of the key variables used in this study, which include 1,102 observations of 38 OECD and partner countries over the period of 1995-2023.

Table 1: Comprehensive Descriptive Statistics for Main Variables (N=1,102)

Variable	Mean	Std. Dev.	Minimum	Maximum	Obs.
GDP per capita growth (%)	1.87	2.91	-8.43	11.52	1,102
Education spending (% of GDP)	4.89	0.89	2.41	7.18	1,102
Mean years of schooling	11.23	1.47	7.89	14.12	1,102
Tertiary education attainment (%)	34.72	12.85	12.34	58.91	1,102
Physical capital investment (% GDP)	22.47	4.38	15.23	35.67	1,102
R&D expenditure (% of GDP)	2.12	0.78	0.45	4.87	1,102
PISA Math Score	489.34	32.67	410.12	564.23	798

Source: Author's calculations based on OECD (2025), World Bank (2024), UNESCO data

5.1.1 Detailed Analysis of Descriptive Statistics
The descriptive statistics shown in Table 1 indicate several key features of our data. First, looking at the dependent variable, GDP per capita growth rate, we see that the mean is 1.87% with large variability (standard deviation of 2.91%). This large variability, where the standard deviation is greater than the mean, indicates large heterogeneity in economic performance. The minimum of -8.43% represents extreme economic downturns during the global financial crisis of 2008-2009 and the COVID-19 pandemic of 2020, while the maximum of 11.52%

represents exceptional growth periods in the rapidly developing Asian economies, especially during the technological boom periods.[12]

With respect to our key independent variable, education expenditure as a percentage of GDP, the sample standard deviation of 0.89 percentage points indicates moderate variation among countries, which may be due to various national priorities, capacities, and structures of the educational systems. The range of 2.41% (Greece during its fiscal crisis) to 7.18% (Denmark, which has been one of the highest spenders) indicates the broad range of strategies adopted by developed countries for educational investments. This is particularly important for our analysis, as it ensures that there is sufficient statistical power to detect the relationship between educational investment and growth outcomes.[13]

The mean years of schooling variable, which stands at 11.23 years on average, shows that a large number of countries in our dataset have reached a level of near universal completion of primary and secondary education. The standard deviation of 1.47 years is a measure of the convergence achieved in basic educational attainment levels among OECD countries, although large differences still exist between the lowest of 7.89 years (Turkey in the 1990s) and the highest of 14.12 years (Germany in recent years, reflecting its dual education system and high participation rates in vocational training). The near saturation level of basic education quantity makes basic education quality variables like PISA scores important in explaining variations in economic outcomes.[14]

5.2 Correlation Analysis and Multicollinearity Assessment

Before moving on to the multivariate regression analysis, it is important that we look at the bivariate correlations between our variables and check for possible concerns of multicollinearity. Table 2 below shows the correlation matrix for our key variables of interest. It is important that we understand the correlations in order to make sense of the independent effects that are estimated in our regression models.

Table 2: Correlation Matrix of Main Variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)
(1) GDP growth	1.000					
(2) Edu spending	0.387***	1.000				
(3) Years schooling	0.412***	0.623***	1.000			
(4) Tertiary educ	0.356***	0.547***	0.689***	1.000		
(5) R&D spending	0.445***	0.512***	0.587***	0.634***	1.000	
(6) PISA score	0.423***	0.478***	0.561***	0.523***	0.612***	1.000

*Note: *** p<0.01, ** p<0.05, * p<0.1. Pearson correlation coefficients shown.*

5.2.1 Interpretation of Correlation Patterns

The correlation matrix in Table 2 above shows a number of interesting patterns. First, it is clear that all the variables related to education are significantly positively correlated with GDP growth, which provides some preliminary evidence for our hypothesis that investment in education leads to economic growth. The correlation between education expenditure and GDP growth is large and statistically significant ($r=0.387$, $p<0.01$), and suggests that countries with higher expenditure on education are likely to have higher rates of economic growth, although this does not necessarily imply causality.[15]

It is worth noting that the correlation coefficient between R&D spending and GDP growth is the largest ($r=0.445$, $p<0.01$) among all the educational variables, which foretells our subsequent result that R&D is the main transmission channel through which education affects economic growth. This result indicates that those countries which invest in education and have a strong research infrastructure will have better growth performance. The correlation coefficient between PISA scores and GDP growth ($r=0.423$, $p<0.01$) also supports the view that the quality of education, rather than just its quantity, is a crucial factor in determining economic performance.

In analyzing the inter-correlations between the independent variables, we find that the correlation coefficients between years of schooling and tertiary education attainment are moderately high ($r=0.689$), and between tertiary education and R&D spending ($r=0.634$). Although these correlation coefficients are large, they are still below the critical level of 0.80, which is generally regarded as problematic for multicollinearity. Our subsequent VIF test (reported in Table 8) also shows that multicollinearity is not a serious problem in our regression analysis, since all VIF values are well below 10.[16]

5.3 Regional and Temporal Variations in Educational Investment

In order to better understand the heterogeneity of investment patterns in education across different geographic regions and time periods, Table 3 below provides a disaggregated analysis of education spending, educational attainment, and growth outcomes across broad geographic regions and two different time periods. This type of decomposition is important for understanding our econometric modeling strategy and policy recommendations.

Table 3: Education Investment and Growth by Region and Time Period

Region / Period	Edu Spend (% GDP)	Years School	Tertiary (%)	GDP Growth	N
Nordic Countries					
1995-2009	6.45	11.89	38.2	2.34	75
2010-2023	6.78	12.56	45.8	1.87	70
Western Europe					
1995-2009	5.12	11.34	32.4	1.98	120
2010-2023	5.34	12.01	38.7	1.23	112
East Asia (Japan, Korea)					
1995-2009	4.23	11.67	41.2	2.87	30
2010-2023	4.67	12.78	52.3	2.12	28
Anglo-Saxon Countries					
1995-2009	5.67	12.12	36.8	2.45	90
2010-2023	5.89	12.89	44.2	1.78	84
Southern Europe					
1995-2009	4.45	9.67	28.3	1.89	75
2010-2023	4.12	10.45	34.1	0.34	70

Source: Author's calculations. Nordic: Denmark, Finland, Iceland, Norway, Sweden. Western Europe: Austria, Belgium, France, Germany, Netherlands, Switzerland. Anglo-Saxon: Australia, Canada, Ireland, UK, USA.

5.3.1 Regional Patterns and Temporal Trends

Table 3 highlights the significant regional diversity in the patterns of educational investment and their correlation with economic growth. The Nordic nations have always shown the highest levels of education expenditure (6.45% of GDP during 1995-2009, which increased to 6.78% during 2010-2023), accompanied by high educational attainment and, importantly, a relatively high rate of economic growth, despite their already high income levels. The Nordic nations' pattern of high public investment, comprehensive welfare systems, and a focus on quality and equity in education seems to support economic growth even in mature, high-income economies, defying the expected slowdown in growth rates in technologically advanced countries.[17]

The East Asian nations (Japan and South Korea) form an interesting case. They have a moderate level of expenditure on education (4.23% and 4.67% respectively, compared to the Nordic nations) but still have a remarkably high rate of attainment in higher education (41.2% going up to 52.3%) and have had a high rate of economic growth, especially in the initial period (2.87% average annual growth rate in 1995-2009). This indicates that East Asian nations have been able to achieve high educational outcomes in a different manner, perhaps through a strong cultural focus on education, highly competitive entrance exams, high levels of private household spending on education, and effective allocation of resources in the education system. The fall in growth rates in the latter period (to 2.12%) is probably due to natural convergence as these economies have reached the technological frontier rather than any deficiency in education.[18]

The trend noticed in the Southern European nations is more alarming. The amount spent on education is not substantial (4.45% to 4.12%), the level of educational attainment is lower compared to other regions (9.67 to 10.45 years of schooling) by a substantial amount, and economic growth has been poor, particularly since 2010 (0.34% average). This region has been facing severe sovereign debt crises and the resultant austerity measures, which appear to have impacted educational spending adversely. The plight of this region appears to be exacerbated by financial difficulties, demographic issues (aging population), and inflexible economic systems, making it extremely difficult for this region to bank on education for economic development.

5.6 Marginal Effects and Non-Linear Relationships

To inform policymakers about the implications of varying levels of educational investment, Table 9 reports the marginal effects of educational spending on GDP growth for different levels of initial spending. The results show that there are significant

nonlinearities in the relationship between education and growth, with diminishing returns to education depending on the level of initial spending and other factors such as R&D intensity.

Table 9: Estimated Marginal Effects of Education Spending on GDP Growth

Baseline Education Spending (% GDP)	Marginal Effect (% points)	95% CI Lower	95% CI Upper	Implied Return (%)
Low Spenders (<3.5%)	0.68***	0.54	0.82	19.4%
Medium-Low (3.5-4.5%)	0.59***	0.47	0.71	13.2%
Medium (4.5-5.5%)	0.52***	0.41	0.63	9.5%
Medium-High (5.5-6.5%)	0.43***	0.32	0.54	6.6%
High Spenders (>6.5%)	0.31***	0.18	0.44	4.8%
Test: Difference High vs Low	**F=12.45*** **	p<0.001	Significant	-

*Note: Marginal effects estimated using interaction terms between education spending and spending level categories. Implied return calculated as (marginal effect / baseline spending) × 100. *** p<0.01, ** p<0.05, * p<0.1*

5.6.1 Interpretation of Diminishing Returns

Table 9 offers key evidence of the existence of diminishing marginal returns to investment in education, which has highly significant implications for policymakers. The countries that currently spend less than 3.5% of their GDP on education, which include lower-middle-income countries or countries that have experienced economic crises, have the highest marginal returns, with an additional 1 percentage point of GDP spent on education associated with a 0.68 percentage point increase in annual growth rates (95% CI: 0.54-0.82). The social rate of return of 19.4% is significantly higher than the returns to investment in physical capital.[19]

As spending levels rise, marginal returns decline systematically but remain economically significant even at high levels. For countries already investing more than 6.5% of GDP—primarily Nordic nations—the marginal effect drops to 0.31 percentage points (95% CI: 0.18-0.44), with an implied return of 4.8%. While this represents diminishing returns, it nonetheless remains positive and statistically significant, suggesting that even high-spending countries benefit from additional educational investment, though opportunity costs relative to alternative investments become more relevant at these levels.

The F-test for difference between high and low spenders yields F=12.45 (p<0.001), confirming that these marginal effects differ statistically significantly. This non-linearity has important policy implications: countries should target investment levels appropriate to their development stage and current spending. For most OECD countries currently spending 4-5% of GDP, the analysis suggests substantial room for productive expansion toward the 5.5-6.5% range, where marginal returns remain attractive at 6-7%. Beyond 6.5%, the case for further expansion depends increasingly on education quality, R&D linkages, and opportunity costs relative to other growth-promoting investments.[20]

6.CONCLUSION

- This extensive research, using 15 statistical tables and sophisticated econometric analysis of data from 38 countries over 29 years, offers conclusive evidence that educational expenditure is a strong driver of economic growth, with returns well in excess of those on physical capital. The results show: (1) a strong positive link (β=0.521, p<0.01) between educational expenditure and economic growth, (2) the R&D channel as the main transmission mechanism (40.3% of the effect), (3) varying effects depending on development status and type of education, (4) quality being more important than quantity (PISA β=0.452 vs. years β=0.284), and (5) positive but diminishing marginal returns to expenditure at all levels. Policymakers are advised to raise educational expenditure to 5-6% of GDP, focus on quality rather than quantity, the study provides robust and consistent evidence supporting the positive correlation between educational quality and economic expansion, acknowledging the inherent limitations of observational panel data.

Policy Recommendations

Based on the findings of this study, which provide moderately strong and consistent evidence in line with existing literature, the following policy recommendations are proposed, while accounting for cross-country structural differences:

1. Promote gradual and context-specific increases in educational investment

Increasing public spending on education is recommended, with the 5–6% of GDP benchmark serving as a flexible reference point rather than a universal target, given variations in fiscal capacity and institutional structures across countries.

2. Expand R&D investment in a context-sensitive manner Rather than adopting fixed thresholds (e.g.,

40%), policymakers should incrementally increase R&D expenditure based on economic development levels, innovation capacity, and institutional efficiency.

3. Differentiate education policies by development level Education investment should be aligned with development stages:

o Developing countries: prioritize primary and secondary education

o Advanced economies: focus on higher education and research

4. Prioritize education quality alongside quantity Improvements in education quality (e.g., PISA performance) appear to have a stronger association with growth than additional years of schooling; however, this relationship depends on complementary factors such as labor market conditions and innovation systems.

5. Address COVID-19 learning losses through targeted interventions

Immediate remedial policies are recommended to mitigate long-term human capital losses, particularly among disadvantaged groups, while recognizing cross-country differences in pandemic impact.

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