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WHEN DOES GOVERNMENT EDUCATION EXPENDITURE YIELD QUALITY GAINS? A NONLINEAR ANALYSIS OF FISCAL EFFECTIVENESS ACROSS ASIA

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ABSTRACT

Across Asia, this study looks at how public spending on education impacts the quality of schools and considers the possibility that there may be a point at which extra expenditure will no longer improve standards. Using a dataset from 36 Asian countries for the year 2023, we applied a spline regression model to explore how education spending by governments (expressed as a percentage of GDP), the budget allocation to education, school duration and total pupil enrolment affected educational standards. This variation can be attributed to 86.8% by the model specifications. Across all segments of the cubic function, we found that the budgetary priorities and duration of schooling have a positive and statistically significant effect on educational standards. Total school intake was not found to be significant. Below a certain GDP level, fiscal policy's marginal effect on the economy is very weak but beyond a certain threshold, such effects become quite significant. It appears that the fiscal situation in a country may mean that the way government funds for education is allocated could be more important than the amount of money available for education, at least in certain cases. From the viewpoint of public finance, the data obtained here highlights the need to consider expenditure efficiency, as well as the proper alignment of institutions, along with budgeting that is informed by results, in any moves to increase funding allocations.

Keywords: *Education finance, Government spending, Public budgeting, Education quality, Fiscal thresholds*

1. INTRODUCTION

The educational standards of the nation serve as the foundation for national success and personal achievement because they develop competent workers who propel economic growth. Quality education is universally regarded as being of the utmost importance with the United Nations setting in place a Goal (SDG 4) which makes it clear that education should be 'inclusive and of high quality and facilitate a lifelong learning opportunity for everyone. The world has achieved substantial advancements in making education accessible to all students during the last few years, but the main challenge now is to preserve academic excellence. Across the Asian continent economic disparities in various developmental stages, institutional capacities and the fiscal landscape are seen. The education systems of South Korea with its advanced economy and Vietnam with its developing economy show distinct performance levels which result in various achievements together with ongoing educational challenges.

Research on public education funding demonstrates that additional government funding will produce improvements in educational results. The system achieves better results through its allocation of more resources and its improved infrastructure and teacher education programs and its enhanced operational performance. The economic theories treat education as either a public good or merit good which allows states to enter education markets because they need to fix market problems and provide fair learning opportunities to achieve social benefits (Stiglitz & Rosengard, 2015). Human capital theory shows that education investments boost individual productivity which creates better employment prospects that drive national economic growth (Matache, 2023). However, the empirical landscape surrounding the relationship between government education expenditure and education quality is far from monolithic; It is often characterized by mixed and sometimes contradictory findings. Research by and other authors shows that higher educational funding leads to better student results, but multiple academic studies show that spending effectiveness exceeds the amount of total funding (Kyriakides et al., 2019), is the more critical determinant of educational success (Setyadi, 2022; Uchenna Obi, 2016). The efficiency perspective holds special importance for numerous low and middle-income countries (LMICs) because new funding does not always produce improved results because of problems which include resource leaks and poor institutional governance.

The different economic conditions which exist throughout Asia make the situation more complicated. A moderate positive association between public education expenditure and lower-secondary education completion rates (Ye et al., 2025). The research found that this relationship existed in an unpredictable way between different nations because their economic systems operated with different structural patterns which standard linear statistical models cannot properly analyse. The research indicates that spending effects will likely follow non-linear patterns because specific spending levels need to be reached before effects become noticeable and different spending approaches work better under specific circumstances. The complex relationship between economic growth and political stability and governance standards and cultural elements in Asia requires advanced analytical techniques because a single educational funding strategy will not work for all countries.

The research study uses spline regression as its analytical method to overcome the methodological limitations which were present in previous studies. The flexible non-parametric method enables researchers to model various functional relationships which exist between independent variables across their segmented intervals. The model design suits educational data analysis because it effectively handles non-linear relationships and threshold effects and structural breaks which frequently occur in educational datasets. The system would produce restricted educational results because it only funds education during times of budget cuts, but it would create major educational quality enhancements when it receives enough funding (Zhang & Jia, 2025). Spline regression allows researchers to analyse complex variable relationships which standard linear models fail to detect because they conceal vital policy information (Alwi et al., 2023).

The research investigates why Asian governments spend large education budgets, yet their educational quality targets fail to materialize or show unstable results. The question requires knowledge about spending locations and operational conditions which produce improved student results because it goes beyond financial expenditure. The research by Fitrianti et al., (2025) shows that government education funding which represents a percentage of GDP creates specific threshold values which determine the relationship between educational results. The study shows that education quality remains unresponsive to government funding until the budget reaches its critical points which produce a stronger connection between these two variables (Fitrianti et al., 2025). Research shows that funding growth does not solve institu-

tional issues because institutions require backing and organizations need operational strength to access funding and governance systems need to operate effectively. The research conducted by Tuan Trinh (2025) demonstrates that additional spending after these points will not generate significant results because it will lead to diminishing effectiveness. The public economics framework shows that budgetary efficiency together with institutional alignment and performance-based budgeting must accompany rising financial allocations (Asadullah et al., 2025).

The education budget share which represents the percentage of total government funding dedicated to education shows a positive relationship with all spline intervals. The way governments allocate their budgets between education and other areas determines their educational spending impact more than the total amount of education funding relative to national GDP in various Asian nations. A high education budget share indicates that politicians strongly support education which leads to improved policy stability and stronger institutional systems and enhanced program execution of spending programs (Delprato & Antequera, 2021 ;Marginson et al., 2023). The government shows its dedication to education through this choice because it will create better resource management and superior educational standards (Lin & Yu, 2023).

The combined average years of primary and lower secondary and upper secondary education serve as a significant positive factor which determines education quality. The research findings align with present academic research which supports using learning-adjusted years of schooling (LAYS) instead of depending on enrolment data (Filmer et al., 2020). High-quality education requires students to learn for extended periods through properly designed educational programs which receive adequate support from skilled teachers to develop their cognitive abilities and master new skills and build their ability to learn throughout their lives. Empirical evidence suggests that extended schooling, particularly when coupled with effective pedagogical practices, leads to deeper understanding and improved critical thinking abilities (Glawe & Wagner, 2022). Students need to stay active in structured learning spaces for long periods of time to reach their highest academic potential (Arfat et al., 2025; Angelova Jeleva, 2025).

The research demonstrates that total enrolment functions as a standard education access metric which reveals substantial changes yet does not link to educational standards in any meaningful way. The first unexpected discovery proved the “learning crisis” because it demonstrated that school enrolment rates did not result in better academic achievement or better educational standards. School enrolment numbers have risen substantially since 2000, but educational facilities now face multiple obstacles which reduce the advantages of their growing student body (Mankgele, 2023). The World Bank (2020) reported that many Low- and Middle-Income Countries (LMICs) show children who go to school yet do not learn anything which proves that school attendance numbers do not match student learning outcomes. The enrolment data contains extreme outliers and uneven distribution because large countries in the sample dominate the data which makes this metric unsuitable for performing reliable quality assessments between different countries (Lopes et al., 2023).

The research findings provide essential policy guidance which helps governments to improve educational results while working under budget limitations. The research by Shaddady (2022) shows that government spending needs to exceed specific thresholds which represent GDP percentages because this establishes the minimum amount needed for public investments to produce noticeable results. The research study explains why linear models in previous studies generated different results. The research shows that education budget allocation maintains its importance throughout the study period because education budget allocation within the national budget proves more important than total budget amounts (Bchennaty et al., 2024). The situation needs both political backing and existing organizational frameworks which will keep financial backing stable and direct the program according to plan. The research findings confirm previous

studies which demonstrated that school duration impacts educational quality so governments must establish policies to extend school hours while preserving suitable educational materials (Karatsiori, 2023). The non-significant results for total enrolment demonstrate that schools need both access and proper learning spaces to achieve better academic results which should guide educational policies to move away from counting students and toward creating effective learning environments (Flynn et al., 2024). Public expenditure tracking surveys (PETS) and performance-based budgeting serve as essential tools which help organizations connect their financial resources to achievement targets (Quang Hyu & Kien Phuc, 2022; Savedoff, 2008).

The research brings new information to previous studies because it shows that nations with distinct characteristics require unique investment approaches. The research uses Spline regression as a new method to analyse recent Asian-specific cross-country data which provides detailed information about how education spending affects student performance. The research data shows more than simple linear connections because it shows essential boundary values which produce different results which should guide evidence-based policy creation. The current economic situation of Asian countries requires immediate implementation of detailed guidance which understands their specific economic conditions and their ability to handle different levels of financial strain.

The research investigates how Asian nations achieve better educational results through their public education funding which exceeds their GDP by using spline regression to find the highest effective spending levels which will assist policymakers in developing optimal education funding strategies.

2. LITERATURE REVIEW

Research has extensively studied how government spending on education affects student achievement results throughout Asian countries which face different economic and institutional conditions. Research findings about education outcomes from public investment in education show conflicting results which depend on specific educational settings. Bhanava et al., (2025) studied 35 Asian countries to determine that government education funding produces better student results in lower secondary education (Bhavana et al., 2025). The research findings showed that the relationship between variables did not follow a uniform pattern across different nations because of structural heterogeneity which standard linear models fail to detect. The researchers endorse the use of adaptable statistical models which incorporate spline regression to detect non-linear threshold points that reveal how government spending affects the system.

Research studies now show that institutional quality acts as a factor which affects how education funding affects student outcomes. Tuan Trinh (2025) studied government education funding in Southeast Asia to show that public spending on education does not produce meaningful results because educational institutions require robust institutional systems to function effectively (Tuan Trinh, 2025). The absence of proper governance in particular countries stopped education funding from leading to improved academic achievements. The research findings from Othman et al., (2024) found that Malaysian public education funding reduced service sector expansion until institutions achieved sufficient quality to direct resources properly (Othman et al., 2024). Research shows that governance systems along with administrative performance levels serve as essential middlemen which affect the success of public educational funding initiatives.

The distribution of educational funding reveals its effects through the specific educational levels which receive the allocated funds. The research by Tran (2023) analysed ASEAN nation data from 1995 to 2018 to show that public education spending led to better economic results through human capital development and enhanced literacy standards (Tran, 2023). The re-

search by Danler & Pfaff (2021) shows that education funding creates different levels of benefits which affect students from various educational backgrounds. The research showed that money spent on primary and secondary education produced better results for reducing income inequality, but higher education funding mostly maintained social gaps because wealthy families controlled most access to tertiary education (Danler & Pfaff, 2021). The research indicates that education budget size continues to matter but the composition of budget funds and the identification of budget recipients are equally important.

The research by Li et al. (2025) presents a global panel study which supports this viewpoint concluded that education investment positively affected per capita GDP growth both in the short and long term. The research results demonstrated that spending elasticity for primary and secondary education exceeded the elasticity of spending for tertiary education during the long-term period. The economic worth of educational funding gained greater significance because students performed better in PISA standardized tests which proved that national development needs excellent education systems instead of accepting more students (Li et al.,2025).

Public education funding now functions as a tool which supports the growth of inclusive economic development. The research by Clements et al. (The research by Clements et al., (2024) showed that countries which used education spending for redistributive fiscal policies obtained superior inclusive growth results in China and India and Vietnam (Clements et al., 2024). The researchers conducted a panel analysis which spanned from 1970 to 2017 to demonstrate that public education spending created two benefits: it enhanced human capital development and it minimized social and geographical inequalities between different groups. The economic situation creates problems for Asian countries because their internal economic differences between various regions remain substantial.

Considering the SDG 4 Education 2030 Agenda, which recommends that countries allocate at least 4% of GDP or 15% of total government spending to education, progress across Asia remains uneven. The UNESCO (2022) report shows that multiple Asia-Pacific nations achieved their international targets, but multiple countries face delays because of financial limitations and multiple national objectives and weak political support. The targets will lead to sustainable educational infrastructure development which will produce better educational results for low- and middle-income countries (Nivens, 2022; Cabrita et al., 2026).

The distribution of educational resources between different locations creates a major problem because some areas receive better access to quality education than others. Zickafoose et al., (The research by Wang et al. (2024) demonstrated that educational resource distribution inequalities between urban and rural areas create greater social inequalities. The researchers demonstrated that educational funding could help decrease current learning gaps between students, but they warned that increasing student enrolment would diminish program success unless teachers create effective methods to distribute resources (Zickafoose et al., 2024).

Although several international assessments such as PISA, TIMSS, and LAYS are widely used to measure learning outcomes, this study employs the SDG 4 composite index as the dependent variable. The selected approach bases its principles on theoretical frameworks which match current educational studies that establish educational quality through four core elements which connect student starting points to fair learning access and classroom settings and student achievement results. The SDG 4 indicator monitors these particular elements which enable it to assess education quality during research studies that use data from different Asian nations because they lack shared learning assessment instruments. Development economics and education policy researchers currently employ composite education indices to analyze how structural elements and fiscal resources influence educational results. The SDG 4 index matches the research scope of this study and follows the measurement approaches which scientists have used in their recent studies.

The research studies present multiple vital findings which validate the current research investigation. The research evidence showing threshold effects which make government education spending effective only at specific spending levels justifies the application of spline regression in this study. The essential transition points in data become hidden when linear models are used because they generate wrong predictions about policy effects on the system. The research data shows education share stands as a vital factor because it demonstrates that government education funding produces superior results than raising total educational budget allocations. The research confirms school duration as an essential variable because it maintains its statistical significance in both this study and all previous investigations.

The current study demonstrates that student enrollment does not affect educational outcomes according to previous research which shows access to education does not automatically result in better learning outcomes. Student enrollment at schools does not guarantee learning success according to the World Bank (2020) because educational quality operates independently from student enrollment numbers. The spline analysis results demonstrate no statistical significance in total enrollment numbers which supports this finding while showing that quality assessment needs specific performance indicators for evaluation.

The research data shows that education funding results depend on particular conditions which need institutions to create suitable governance structures and build exceptional educational facilities to achieve success. The research data shows that education share and duration measurements generate better quality predictions than the standard gross enrollment rate does. The analysis requires spline regression as a non-linear modeling technique to detect complex relationships between policy variables. The research data validated the research approaches which demonstrated that educational policies for Asia require development through analysis of local conditions and established performance standards.

3. DATA AND METHODOLOGY

3. 1. DATA

This study used a single dependent variable representing quality education in the countries under investigation, alongside four independent variables: government expenditure for education, share education, duration and enrolment, in Asia countries with complete data on the variables used. The data used in this research consists of cross-sectional secondary data for each country at 2023, comprising 36 countries as the research units. The variables used in the study are detailed in table 1 below;

Table 1. Variabel Used

Variable	Symbol	Measurement	Source
Dependent Variable			
Quality Education	QE	Scale of Quality Education each country	SDGs Report
Independent Variable			
Government Expenditure	Gov_Exp	Government expenditure on education as a percentage of GDP (%)	UNICEF Report
Education Share	Ed Share	Government expenditure on education as a percentage of total government spending (%)	UNICEF Report
Duration	Dur	Average of duration Primary, Lower secondary and Upper secondary	UNICEF Report
Enrolment	Enr	Total of enrolment of Primary, Lower secondary and Upper secondary	UNICEF Report

Source: Author`s Source, 2025

3. 2. METHODOLOGY

A curve or surface formed by joining pieces of polynomial functions together is known as a spline. In the past, splines were actually strips of wood used in drawing and drafting to create smooth curves. These polynomial segments are useful in that they are highly versatile and very effective in processing data. One of the key elements in polynomial theory which has its roots in a particular optimisation problem is the spline. In spline function estimation, the change points or the turning points where the pattern of the data or the function varies are crucial (Dwi Octaviani et al., 2010). The spline model can produce a good fit when knot points are used to treat patterns with high frequency oscillations in the data. The spline model itself is capable of independently estimating its parameters even with dynamic data. This results in the model emulating or mimicking the data structure.

For instance, given data $(x_{1i}, x_{2i}, \dots, x_{pi}, y_i)$, where $(x_{1i}, x_{2i}, \dots, x_{pi})$ are predictors and y_i is the response, the nonparametric regression model can be expressed as follows (Suriaslan et al., 2025).

$$y_i = \sum_{j=i}^{p} f(x_{ji}) + \varepsilon_i \quad (1)$$

Where:

$$y_i = \sum_{h=0}^{q} \beta_{hj} x_{ji}^h + \sum_{i=0}^{m} \beta_{(q+1)j} (x_{ji} - k_{ij})_+^q + \varepsilon_i \quad (2)$$

The truncated function is defined as (Brugnano et al., 2024).

$$(x_{ji} - k_{ij})_+^q = \begin{cases} (x_{ji} - k_{ij})_j^q, x_{ji} \geq k_{ij} \\ 0, x_{ji} \leq k_{ij} \end{cases} \quad (3)$$

Where $k_{1j}, k_{2j}, \dots, k_{mj}$ are the knot points indicating changes in the function at specific intervals, and q represents the polynomial degree. The equation can be expanded as (Perperoglou et al., 2019).

$$\begin{aligned} y_i = {} & \beta_{01} + \beta_{1I} x_{1i} + \beta_{qI} x_{ji}^q + a_{1I}(x_{1i} - k_{1I})_+^q + \dots + a_{mI}(x_{1i} - k_{mI})_+^q + \beta_{02} + \beta_{12} x_{2i} + \\ & + \beta_{q2} x_{2i}^q + a_{12}(x_{2i} - k_{12})_+^q + \dots + a_{m2}(x_{2i} - k_{m2})_+^q + \beta_{0p} + \beta_{1p} x_{pi} + \dots + \beta_{qp} x_{pi}^q + \\ & + a_{1p}(x_{pi} - k_{1p})_+^q + \dots + a_{mp}(x_{pi} - k_{mp})_+^q + \varepsilon_i \end{aligned} \quad (4)$$

The method used for Spline Regression estimation is Ordinary Least Squares (OLS). The OLS model can be expressed as follows (Naser et al., 2022)

$$y = X\beta + \varepsilon \quad (5)$$

Based on Equation $y = X\beta + \varepsilon$, the residuals are expressed as

$$\varepsilon = y - X\beta \quad (6)$$

A key aspect of non-parametric spline regression is the selection of the optimal number of knots. The choice of the best Spline function is dependent on data characteristics at particular intervals and is made by a Generalized Cross Validation (GCV) function at its lowest.

$$\text{GCV}(k_1, k_2, \dots, k_j) = \frac{MSE(k_1, k_2, \dots, k_j)}{(n^{-1} Trace[I - A(k_1, k_2, \dots, k_j)])^2} \quad (7)$$

The coefficient of determination measures the model's explanatory power

$$R^2 = \frac{\hat{\beta}^T X^T y - n\bar{y}^2}{y^T y - n\bar{y}^2} \; x \; 100\% \quad (8)$$

Complex data types can be effectively modelled using spline regression which models the non-linear relationships between the independent and dependent variables. This is particularly

useful in the analysis of a set of complex data which includes interactions between government expenditure, education share, duration and the number of enrolments. In a more sophisticated approach to the analysis of quality education in Asia diverse nations, spline regression could be employed. This method is quite different from more straightforward linear models which don't adjust for variation in the rate of change within the dataset.

4. RESULTS ANALYSIS

4. 1. DESCRIPTIVE STATISTICS

The summary statistics for the dependent and independent variables employed in this study are provided in Table 2. Strong quality of education is shown by the quality of education indicator which is used as the criteria variable with an average rating and a standard deviation which suggests that educational standards are high throughout the country with a slight variation between different regions. Education as a percentage of total government expenditure and education as a percentage of the GDP both show moderate variation amongst the independent variables. This implies there are different priorities for education fiscally. Education duration tends to be uniform across observations because schooling duration exhibits low variance. The total number of students enrolled is characterised by its very large degree of variability. This is indicated by both its high standard deviation and the wide difference between the highest and lowest values.

Significant disparities in population exist among different geographic areas as seen in the student enrollment numbers. Each group exhibits a particular set of properties which describe its statistical characteristics. These distributions are skewed in the direction of the variable that determines education quality and the length of education. It is more common for the quality of education and its duration to be high, whereas a country's share of education expenditure and government expenditure on education are usually low. Enrolment exhibits strong positive skewness and also kurtosis which is unusually high, suggesting the existence of several outliers in the data and a distinctly non-normal distribution. The data available suggests the financial resources received by educational institutions vary and this in turn impacts the academic results achieved.

Table 2. Summary Statistic

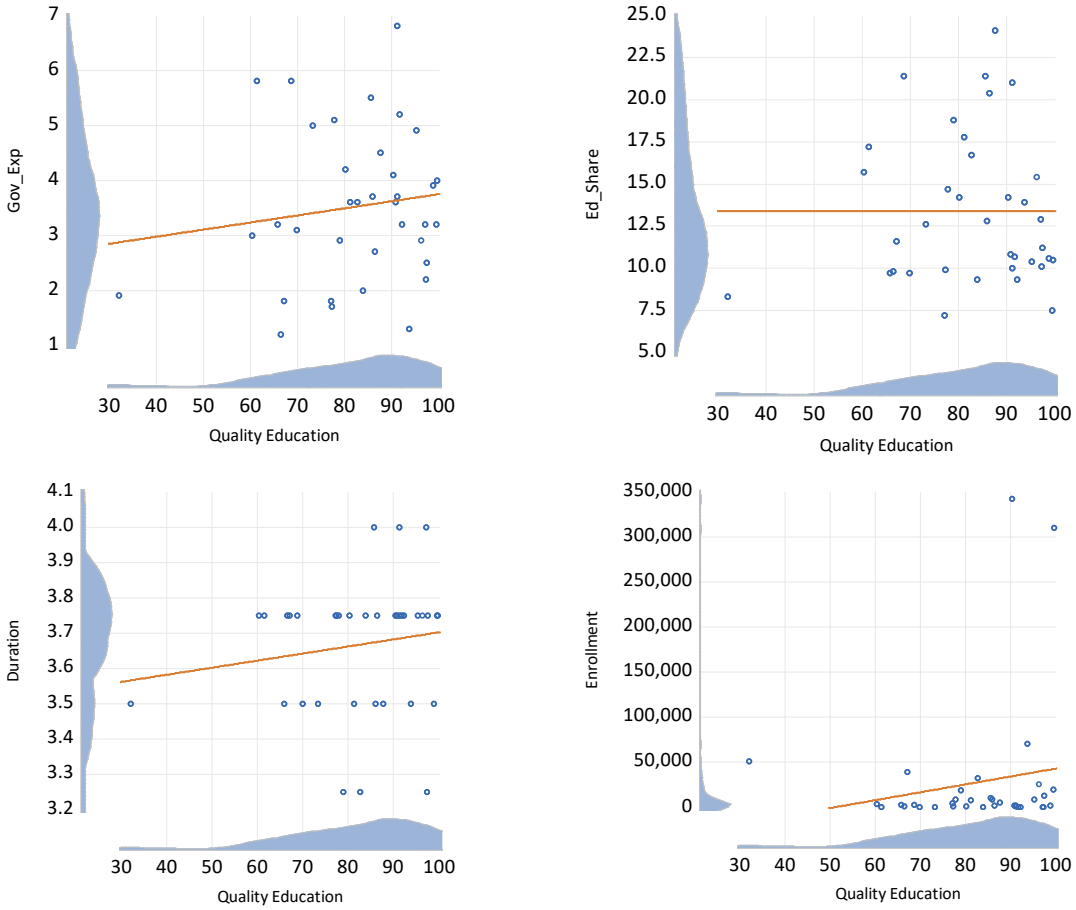
Statistic	QE	Gov_Exp	Ed_Share	Dur	Enr
Mean	82.6487	3.5222	13.3833	3.6667	27885.5000
Variance	208.9179569	1.893206349	19.77571429	0.035714286	5624855920
Std. Dev	14.4539945	1.375938352	4.446989351	0.188982237	74999.03946
Skewness	-1.34600319	0.35265331	0.796146522	-0.60696647	3.795154413
Kurtosis	2.753812369	-0.36248133	-0.32539313	0.325668449	13.88447394
Minimum	32	1	7	3	105
Maximum	100	7	24	4	341691

Source: Author`s calculation, 2025

The Figure 1 scatter plots demonstrate the relationship between Quality Education as the dependent variable and four independent variables. While the first graph demonstrates a slight positive relationship between government expenditure on education as a percentage of GDP and the quality of education, it does appear that the country with the highest expenditure has the best educational standards. The data points show wide-ranging differences between them. In contrast the graph illustrating the link between educational quality and government expenditure on education as a proportion of government spending shows a nearly flat relationship, suggesting that there is a very weak relationship between the two.

The third plot shows how longer school years relate to better academic performance through its small positive connection but most data points remain fixed at particular values. Lastly, the fourth plot demonstrates the relationship between quality education and total enrollment. The regression line shows a small positive trend but the data distribution reveals many outliers and wide variation which proves that enrollment size does not reliably predict better education quality. The visualizations show education inputs have different strengths of connection to quality results because enrollment data shows the biggest spread and creates the weakest direct link.

Figure 1. Scatter Plot Towards Dependent Variable and Independent Variable



Source: Author`s calculation

4. 2. RESULTS ANALYSIS USING SPLINE APPROACH

Selecting the appropriate point at which the knot is placed is the initial step in the Spline method when analyzing the potential for quality education as the dependent variable in relation to various independent variables. The ideal location of the knots is determined by finding the lowest Generalised Cross-Validation (GCV) value that each knot produces.

Table 3. GCV Values Produced by Each Knot Point

Knot Point	GCV Value
Knot Point 1	240.1153
Knot Point 2	210.0843
Knot Point 3	150.6085

Source: Author`s calculation, 2025

With a value of 150.6085, Table 3 demonstrates that Knot Point 3 generates the minimum GCV value. Thus, Knot Point 3 will be used to model the Asia Countries's quality education rate. The following model equation serves as a representation of the modeling.

$$\begin{aligned}\hat{y} = {} & 1.28782 + 1.57587Gov\_Exp_1 + 0.94053(Gov\_Exp_2 + 1.657143) + \\ & + 0.21392(Gov\_Exp_3 + 2.000000) + 0.3338(Gov\_Exp_4 + 2.228571) + \\ & + 7.5323Ed\_Share_1 + 2.14908(Ed\_Share_2 + 8.579592) + \\ & + 2.55640(Ed\_Share_3 + 9.614286) + 2.96372(Ed\_Share_4 + 10.303082) + \\ & + 4.7722Dur_1 + 0.5678(Dur_2 + 3.311224) + 0.5489(Dur_3 + 3.357143) + \\ & + 0.5301(Dur_4 + 3.387755) + 0.68742Enr_1 + \\ & + 0.41455(Enr_2 + 27989.57) + 0.68034(Enr_3 + 48903.00) + \\ & + 0.33916(Enr_4 + 62845.29)\end{aligned}$$

Next, parameter testing was conducted using two types of tests: simultaneous parameter testing and individual parameter testing in Table 4.

Table 4. Simultaneous Parameter Test

Source	Df	SS	MS	F	P-Value
Regresi	16	5149.911	296.861	4.930245	0.0319504
Error	19	2335.609	85.8014		
Total	35	7485.52			

Source: Author`s calculation, 2025

The statistical value yields a p-value of 0.0319504. When compared to the significance level of the decision is to reject . This result indicates that at least one variable significantly influences the formed model. Rejecting suggests the need for individual testing to identify which variables significantly impact the model in Table 5.

Table 5. Individual Parameter Test

Variable	Parameter	Estimator	P-value	Note
Constant	β_0	1.28782	9.242198e-09	Significant
Gov_Exp	β_1	1.57587	0.03314861	Significant
	β_2	0.94053	0.00824852	Significant
	β_3	0.21392	0.7833418	Not Significant
	β_4	0.33380	0.6684558	Not Significant
Ed_Share	β_5	7.53236	1.016429e-08	Significant
	β_6	2.14908	3.785539e-06	Signficant
	β_7	2.55640	1.20793e-06	Significant
	β_8	2.96372	5.230298e-07	Significant
Dur	β_9	4.77216	7.13297e-09	Significant
	β_{10}	0.56786	1.404317e-09	Significant
	β_{11}	0.54899	1.379991e-09	Significant
	β_{12}	0.53013	1.354464e-09	Signifikan
Enr	β_{13}	0.68742	0.0064672	Significant
	β_{14}	0.41555	0.0184231	Significant
	β_{15}	0.68034	0.2853537	Not Significant
	β_{16}	0.33916	0.2768555	Not Signifikan

Source: Author`s calculation, 2025

The final step in this analysis is determining the coefficient of determination to show the goodness-of-fit of the model in explaining quality education in the Asia region using the variables of government expenditure, education share, duration and enrollment.

$$R^2 = \frac{SS_{Regresi}}{SS_{Total}} x\ 100\% = \frac{5149.911}{7485.52} x\ 100\% = 68.79\%$$

Based on these calculations, the R^2 value is 68.79%, indicating that the variables used in the model explain 68.79% of the variation in the quality education rate of the Asia-Pacific countries. The remaining percentage is explained by other variables not included in the study.

4. 3. MODEL INTERPRETATION RESULTS

The findings demonstrate that the factors of government expenditure, education share, duration and enrollment had a significant impact on the quality education rate in Asia Nations after the spline method analysis was completed and the residual assumptions were verified. Based on the variables employed, the prospects for improving quality education in each Asia nation will then be investigated.

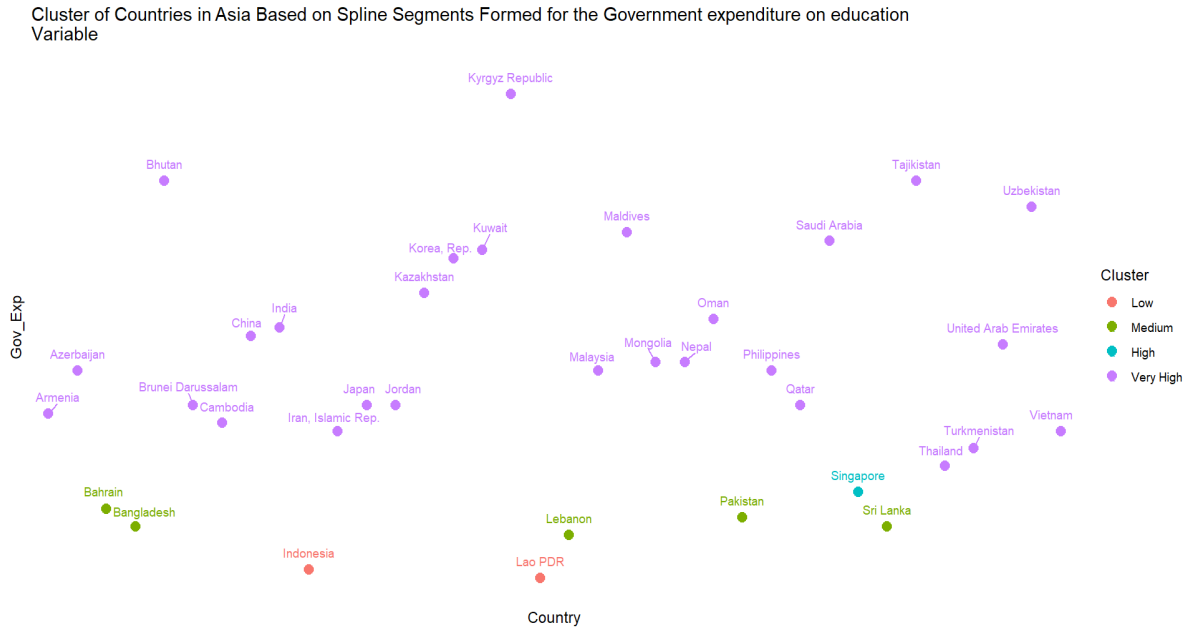
If education share, duration and enrollment are considered constant, the influence of the government expenditure variable on the quality education rate of Asia countries is as follows.

$$\hat{y} = 1.57587 Gov\_Exp_1 + 0.94053(Gov\_Exp_2 + 1.657143) + \\ + 0.21392(Gov\_Exp_3 + 2.000000) + 0.3338(Gov\_Exp_4 + 2.228571)$$

$$\hat{y} = \begin{cases} 1.57587;\ Gov\_Exp < 1.657143 \\ 2.5164;\ 1.657146 \leq Gov\_Exp > 2.00000 \\ 2.73032;\ 2.00000 \leq Gov\_Exp > 2.228571 \\ 3.06415;\ Gov\_Exp < 2.228571 \end{cases}$$

Based on the equation model, it is identified that four clusters of countries are formed based on the government expenditure influencing the quality education rate in Asia countries, as determined by the spline segments created. The regional clusters formed can be observed in Figure 2 below:

Figure 2. Cluster of Asian Countries based On Spline Segments Formed for Government Expenditure



Source: Author`s calculation, 2025

The analysis produces the following results: The estimated slope of the spline function equals 1.57587 when government expenditure stays below 1.657143 percent of total spending. If a country has government expenditure between 1.657143 and 2.000000 percent, the slope increases to 2.51640, meaning that the responsiveness of education quality to additional spending becomes stronger in this interval. The marginal effect reaches its most severe point when government spending ranges from 2.000000 percent to 2.228571 percent because the slope reaches 2.73032. The model shows its highest marginal effect at 3.06415 when government spending exceeds 2.228571 percent of national income. The values demonstrate how education spending produces increasing effects at each threshold which indicates a strengthening relationship between spending and results.

If government expenditure, duration and enrollment are considered constant, the influence of the education share variable on the quality education rate of Asia countries is as follows.

$$\hat{y} = 7.5323Ed\_Share_1 + 2.14908(Ed\_Share_2 + 8.579592) + 2.55640\ (Ed\_Share_3 + \\ + 9.614286 + 2.96372(Ed\_Share_4 + 10.303082)$$

$$\hat{y} = \begin{cases} 7.5323;\ Ed\_Share < 8.579592 \\ 9.68138;\ 8.579592 \le Ed\_Share > 9.614286 \\ 12.23778;\ 9.614286 \le Ed\_Share > 10.303082 \\ 15.2015;\ Ed\_Share < 10.303082 \end{cases}$$

Based on the equation model, it is identified that four clusters of countries are formed based on the education share influencing the quality education rate in Asia countries, as determined by the spline segments created. The regional clusters formed can be observed in Figure 3 below.

Figure 3. Cluster of Asian Countries based On Spline Segments Formed for Education Share

Source: Author`s calculation,2025

The analysis produces the following results: The estimated slope of the spline function becomes 7.5323 when a country spends less than 8.579592 percent of its budget on education. If a country has an education budget share between 8.579592 and 9.614286 percent, the slope increases to 9.68138, meaning that the responsiveness of education quality to additional budget allocation becomes stronger in this interval. The marginal effect produces more extreme re-

sults when education funding ranges between 9.614286% and 10.303082% of the total budget because the slope reaches 12.23778. The model shows its highest marginal effect at 15.2015 when a nation devotes more than 10.303081 percent of its budget to education. The values show how education budget distribution leads to growing effects at each subsequent threshold without showing any modification in the underlying relationship.

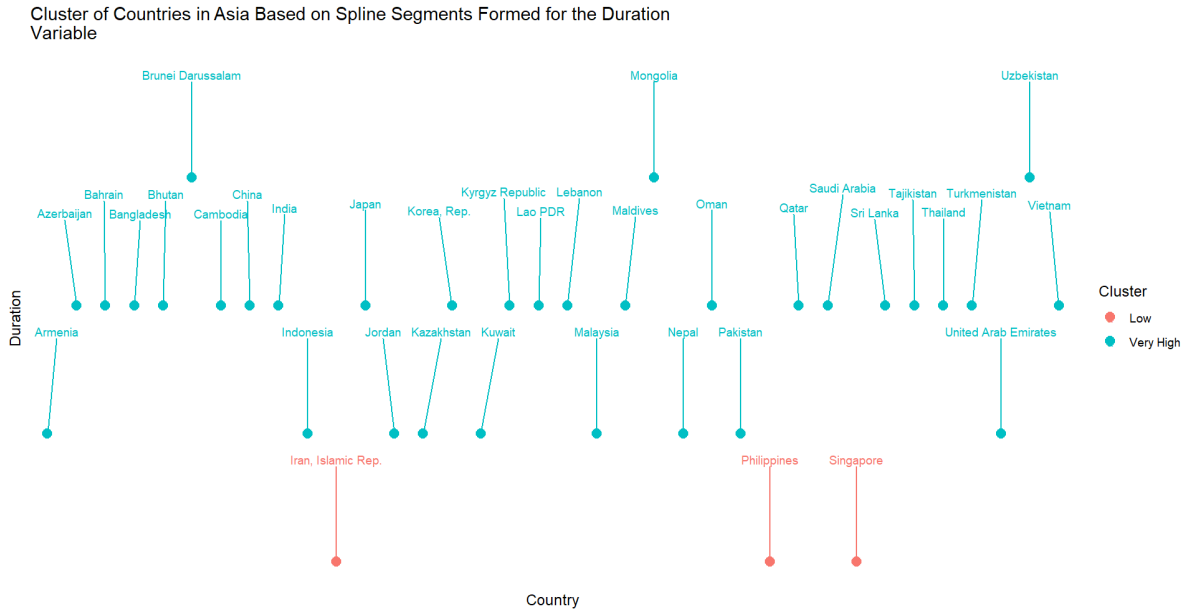
If government expenditure, education share, and enrollment are considered constant, the influence of the duration variable on the quality education rate of Asia countries is as follows.

$$\hat{y} = 4.7722Dur_1 + 0.5678(Dur_2 + 3.311224) + 0.5489(Dur_3 + 3.357143) + \\ + 0.5301(Dur_4 + 3.387755)$$

$$\hat{y} = \begin{cases} 4.7722;\ Dur < 3.311224 \\ 5.3400;\ 3.311224 \leq Dur > 3.357143 \\ 5.8889;\ 3.357143 \leq Dur > 3.387755 \\ 6.4190;\ Dur > 3.387755 \end{cases}$$

Based on the equation model, it is identified that two clusters of countries are formed based on the duration influencing the quality education rate in Asia countries, as determined by the spline segments created. The regional clusters formed can be observed in Figure 4 below.

Figure 4. Cluster of Asian Countries based On Spline Segments Formed for Duration



Source: Author`s calculation, 2025

The analysis produces the following results: The estimated slope of the spline function equals 4.7722 when a country's schooling duration remains below 3.311224 years. The slope value reaches 6.4190 when schools maintain operation for longer than 3.387755 years because this duration creates an enhanced relationship between school duration and student academic results. The values demonstrate how various elements affect each other through their mathematical relationships instead of presenting improved category prediction results.

If government expenditure, education share, and duration are considered constant, the influ-

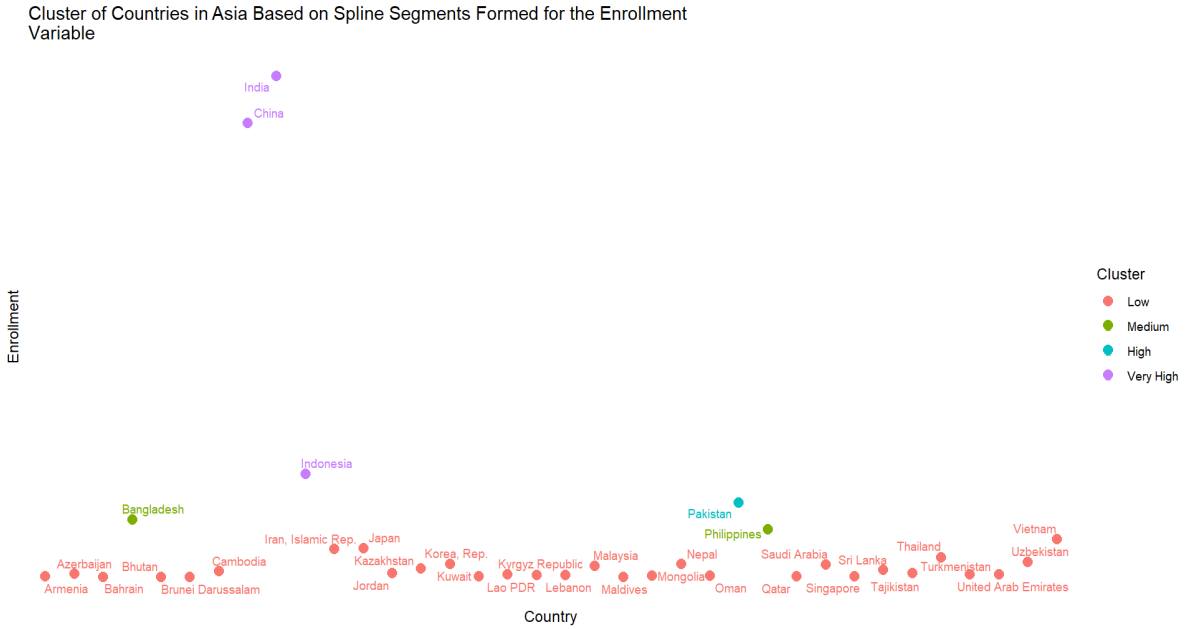
ence of the enrollment variable on the quality education rate of Asia countries is as follows.

$$\hat{y} = 0.68742Enr_1 + 0.41455(Enr_2 + 27989.57) + 0.68034(Enr_3 + 48903.00) + \\ + 0.33916(Enr_4 + 62845.29)$$

$$\hat{y} = \begin{cases} 0.68742;\ Enr < 27989.57 \\ 1.10197;\ 27989.57 \le Enr > 48903.00 \\ 1.78231;\ 48903.00 \le Enr > 62845.29 \\ 2.12147;\ Enr > 62845.29 \end{cases}$$

Based on the equation model, it is identified that four clusters of countries are formed based on the enrollment influencing the quality education rate in Asia countries, as determined by the spline segments created. The regional clusters formed can be observed in Figure 5 below.

Figure 5. Cluster of Asian Countries based On Spline Segments Formed for Enrollment



Source: Author`s calculation,2025

The analysis produces the following results: The estimated slope of the spline function for countries with annual enrollment below 27,989 persons amounts to 0.68742 which shows how education quality responds to enrollment growth in this specific range. If a country has enrollment between 27,989 and 48,903 persons per year, the slope increases to 1.10197, meaning that the responsiveness of education quality to changes in enrollment becomes stronger in this interval. The marginal effect reaches its peak when student enrollment numbers between 48,903 and 62,845 students per year because the slope value reaches 1.78231. The model shows its highest marginal effect at 2.12147 when annual enrollment numbers exceed 62,845 students. The values demonstrate system operation transitions between different levels instead of displaying performance data across various operational levels.

5. DISCUSSION

The research results show how government education funding creates non-linear relationships which affect educational standards in Asian nations. The spline regression model enables us to identify particular fiscal points which reveal how public investment impacts educational results. The observed patterns in this study should be understood as correlated data which shows different patterns between different expenditure periods. The research results enhance cur-

rent understanding because they demonstrate educational quality reactions to funding changes which occur when public funding exceeds particular levels.

The research findings about government education spending relative to GDP show that the data responds differently based on specific threshold values. The relationship between education quality and expenditure levels becomes insignificant when spending reaches below 1.65 percent of GDP. The research shows that organizations will achieve their best spending results when they keep their expenses between 2.00 percent and 2.23 percent. The observed patterns should be treated as changes to the relationship function instead of being considered as separate quality categories. The research findings support Tuan Trinh (2025) who demonstrates that institutional absorptive capacity together with governance conditions determine the extent to which spending produces learning results. The research data contains cross-sectional information which shows descriptive patterns yet fails to reveal the underlying relationships between variables.

The total government budget shows a positive relationship with education funding throughout all spline intervals. The indicator shows which countries use their assigned funds instead of depending on GDP for their fiscal system assessment. Student achievement shows stronger connections with educational spending when nations allocate more than 10.3 percent of their budget to education but this evidence does not establish that education funding leads to improved student outcomes. This is consistent with Delprato & Antequera (2021) and Marginson et al. (2023), who argue that prioritization can facilitate policy continuity. The research needs to consider two potential issues which are reverse causality and omitted variables.

The duration of student attendance at school creates a direct link between their educational experience quality. The slopes of countries with average schooling durations longer than 3.38 years become more pronounced which supports the use of learning-adjusted years of schooling (LAYS). However, the results cannot confirm whether longer schooling causes improvements in quality, only that the two variables tend to move together within this dataset. This aligns with literature by Glawe & Wagner (2022) and Arfat et al. (The study (2025) shows this relationship but it cannot establish cause-and-effect relationships because of its methodological constraints.

The research data shows that student enrolment numbers have no effect on student academic achievement. The World Bank (2020) supports the “learning crisis” narrative because students who start school do not automatically learn new information during their time in education. The results show no significant relationship because different countries have populations that vary greatly in size.

The research contains various policy implications but readers need to approach these findings with careful consideration. The research shows that education quality shows increased correlation with spending levels when institutions spend more than specific thresholds yet the study’s design prevents researchers from establishing which variable affects the other. The education budget distribution shows its position in the priority list but it does not show if schools decide their own financial resources or if other institutional factors affect their funding decisions. The study shows that students who spend more time in school achieve better results which supports the importance of both school duration and teaching methods yet it does not establish any cause-and-effect relationships. The non-significant results for enrollment show that policy-based access expansion will not result in better quality unless organizations make core organizational changes.

The research results show patterns which serve as indicators but do not prove cause-and-effect relationships through their statistical calculations. The authors demonstrate that education fiscal effectiveness follows non-linear patterns which depend on specific contexts yet the model fails to explain educational outcomes because it lacks necessary control variables and uses

data from only one year. The research presents its first results which will direct future studies while policymakers need to assess how particular conditions influence the connection between monetary policies and academic achievement.

6. CONCLUSION

The research investigates how government education funding affects educational standards in Asian countries through an analysis of particular spending amounts which produce varying educational quality results. The research shows that spending and quality have related patterns but it does not prove that one factor causes the other. The study shows that the relationship between spending and quality becomes stronger when public funds exceed specific financial thresholds. The educational quality receives direct positive effects from budget allocations for education which produce results that match student duration in educational institutions. The enrollment data fails to establish any meaningful connection which supports the theory that having access to healthcare services does not guarantee better outcomes.

The research findings demonstrate that education funding relationships between governments and schools exist as multiple interconnected systems. The observed patterns provide useful descriptive information but they do not prove that higher education spending will lead to better educational outcomes. Education requires financial support for education which must operate effectively with strategic planning to achieve meaningful student learning outcomes.

The evaluation process for education budget decisions by governments requires them to study how fiscal thresholds affect their funding decisions. The research findings need to be considered by policy makers who should evaluate factors which this study did not measure including governance quality and teacher effectiveness and spending efficiency. Similarly, while higher budget shares may reflect strong political will, the associations identified here do not establish that such increases will necessarily lead to quality gains.

The implementation of education reforms requires schools to extend their operating hours while simultaneously providing financial support for teaching method improvements and teacher education and curriculum creation. The current policies need to move away from simply increasing student enrollment because they should focus on creating better learning spaces and teaching assistance programs. The study results fail to determine which specific educational interventions would produce the best results.

The research contains particular limits which affect its research findings. The analysis of cross-sectional data prevents researchers from tracking time-based changes and they cannot establish cause-effect relationships or detect enduring patterns from short-term observations. The spline regression method reveals non-linear relationships but it fails to account for how different institutions and cultural backgrounds and socioeconomic conditions affect the success of public spending programmes.

Future studies need longitudinal panel data to analyze how educational quality responds to public funding changes which occur at different time intervals. The analysis requires three additional elements which include governance indicators together with teacher workforce characteristics and implementation capacity measures. The research methods of qualitative analysis help scientists discover operational processes which standard fiscal records fail to show.

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