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A Multi-Variable Analysis of Academic Performance Determinants Using Sleep Hours, Study Practices, and Extracurricular Engagement

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ABSTRACT

This study aimed to investigate the more influential determinants of Academic performance. For this purpose, the study taken the sleep hours and extracurricular activities to develop the association of with students' academic performance index along with some other variables like previous score, sample question papers practiced and hours studied. The data is collected from Kaggle for over 10000 students and statistical analysis are performed by using the statistical package STATA. Descriptive statistics are calculated to analyze the central tendency, dispersion, and shape of variables. Multicollinearity are checked by calculated correlation matrix and regression analysis has revealed that both extracurricular activities, sample papers practice, hour studied and sleep hours are affecting positive academic performance of students. The further by adding previous score in the model the results are significantly improved and it is indicated by the increased value of R2. One the basis of results of the study it is suggested to focus on the promotion of healthy sleep habit, enhancement of extracurricular opportunities, and implementation of comprehensive support programs to improve the academic performance index.

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1. Introduction

Understanding the determinants of academic performance is a critical area of interest in the field of applied economics and education policy. Traditional approaches often isolate individual factors, such as cognitive ability or socioeconomic status, as primary predictors of academic success. However, these approaches risk oversimplifying the complex interplay of variables that jointly influence educational outcomes. This study employs a multi-variable econometric framework to investigate the effects of sleep hours, study practices, and extracurricular engagement on academic performance. Sleep, a fundamental determinant of cognitive function, has been extensively studied in relation to productivity and human capital formation. Research suggests that insufficient or irregular sleep patterns impair memory consolidation and decision-making, both of which are crucial for academic achievement (Lo et al., 2016). Similarly, study practices, encompassing both qualitative and quantitative aspects of learning behaviors, directly shape knowledge acquisition and performance outcomes (Credé & Kuncel, 2008; Zimmerman, 2002). Besides, physical and social development as well as the competencies including problem solving, time management, and critical thinking skills are benefited from extra curricula activities (Himelfarb, Lac, & Baharav, 2014). There are hints that in addition to helping students achieve social objectives, such activities foster appropriate behavior and academic achievement (Mardila et al., 2024). There have been many research findings showing that extra curricula activities have a positive correlation with performance. For

these benefits to take effect and be particularly beneficial to students who may face challenges academically, or may avoid extra curricula activities, interrelated cooperation among the educators, counselors, and community non-profit making organizations has to be encouraged (Slater & Tiggemann, 2015).

As deduced from earlier research, sleep hours and activities outside class are on their own, related to academic performance. Problematically, though, little prior investigation has explored the interaction of these variables in a Holistic manner. Thus, the current study aims to identify how sleep hours the study practices, and extra-curriculum activities together affect students' performance at school by using a rich econometric model, which is beneficial to educational stakeholders. Lack of information on these factors of concern poses a major research question this study seeks to fill by exploring and establishing key determinants of academic performance with reference to sleep quality, study habits and extracurricular activities. However, previous studies have only focused on these factors in isolation while their joint impacts on the explained variances are poorly understood. The study explores a number of hypotheses about a relationship between sleep which influences thinking and learning and study and sport, which are activities that provide direct measures of success in academic work and the acquisition of critical skills, but can interfere with study time. Studying such interactions, the work's goal implies the identifications of their totality to enhance balanced educational approaches; consequently, it may prove beneficial for both educational attainment and academic success. The main research question of this study is, to what extent do the number of hours students sleep and participation in extra curriculum affect their performance other factors held constant? In particular, it is investigated how the duration of the night's sleep and extra curriculum activities affect the academic achievement of the students. Additionally, by adding the previous score, is there significant changes in the explained variations of academic performance of the students.

2. Literature Review

Much evidence shows that various aspects of lifestyle can influence performance in students and among them sleep patterns and participation in co-curricular activities are very sensitive. Effort has been made to understand these relationships because identifying the interactions of these elements are crucial to creating educational policies and practices that foster the environment needed for student achievement (Guest & Schneider, 2003; Rosa, 2002). Students need to realize the importance of sleep as the different researches confirm that it is highly effective in facilitating good performance in class. Walker (2018) stressed that during sleep cognition takes place and more specifically, sleep enhances such cognitive functions as memory and problem solving, which are critical for learning. As supporting evidence to the above, research studies indicate that there is a negative relationship between sleep and academic achievement and cognitive functioning (Fredriksen et al., 2004; Rosa, 2002). Rosa (2002) carried out a close scrutiny in determining the effects of disrupted sleep on school going children and as much as the result did not provide statistical evidence on the ability of sleep to affect the student's grades, the result only showed a slight trend of the fact that students who had a continuous sleep got slightly better grades than those who did not. This supports a finding made by Taras and Potts-Datema (2005) who corroborated that a lack of sleep affects the concentration of a students and overall performance.

However, the positive effects of sleep on predetermined practice and wakefulness have been supported according to Wolfson and Carskadon (1998) and Fallone et al. (2005) the negative results of poor sleep which entails reduced focus and poor ability in information storage. Such physiological effects imply that students needs to adhere to fixed sleeping patterns to sustain success in school (Fallone et al., 2005; Wolfson & Carskadon, 1998). Another important area of interest is the role of co-curricular activities in the academic performance of students. These activities are supposed to expand the student's learning process and add extra valuable experience, yet they are not always helpful in improving learners' results. It was discovered that students were observed to have better social and academic skills if they engage in structured activities in the view of Marsh and Kleitman (2002), and Guest and Schneider (2003). However, the type and extent of participation are crucial; as Marsh and Kleitman (2002) articulate, there is a nonlinear relationship where benefits diminish as involvement grows excessively, highlighting the importance of balance.

Specifically, intellectual activities such as participation in different clubs or music programs are associated with positive academic outcomes because they reinforce concepts

learned in the classroom and develop cognitive skills (Eccles & Barber, 1999). However, overcommitment can lead to stress and reduced time for homework and study, which might negate these benefits (Knifsend & Graham, 2012). The interrelationship between sleep and extracurricular activities also plays an important role in academic outcomes. Gilman, Meyers and Perez (2004) observed that students who balanced sleep with moderate activity involvement generally reported better academic performance compared to their peers who either neglected sleep or were overly committed to extracurricular engagements. This balance allows for the cognitive benefits of extracurricular activities to manifest without undermining the essential restorative functions of sleep (Gilman, Meyers, & Perez, 2004).

3. Data & Methodology

3.1. Data Description

The dataset used in this research was sourced from Kaggle, a platform celebrated for hosting data science competitions and serving as a collaborative space for data scientists and machine learning specialists, operating under Google LLC. The Student Performance Dataset is an extensive collection of academic records from 10,000 students, compiled to explore the various factors that may influence a student's academic performance. This rich dataset is structured to facilitate a comprehensive analysis of individual and combined impacts of study habits, prior academic results, extracurricular engagement, sleep patterns, and practice intensity on the academic outcomes of students (Bojer & Meldgaard, 2021).

3.2. Model Specification

The relationships between the predictor variables (Extracurricular Activities, Sleep Hours) and the target variable (Performance Index) were explored using correlation analysis to measure the strength and direction of associations, Multiple linear regression analysis has been performed using STATA to model the relationship between the predictor and target variables.

Model 1

$$Performance\ Index = \beta_0 + \beta_1 SleepHours + \beta_2 ExtracurricularActivities + \beta_3 SampleQuestionPapersPracticed + \beta_4 HoursStudied + \mu$$

Model 2 (Inclusion of previous Scores)

$$Performance\ Index = \beta_0 + \beta_1 SleepHours + \beta_2 ExtracurricularActivities + \beta_3 PreviousScores + \beta_4 SampleQuestionPapersPracticed + \beta_5 Hours\ Studied + \mu$$

3.3. Variables

This research explores the association of sleep hours and extracurricular activities with students' academic performance.

3.3.1. Academic Performance

Academic performance is defined as outcomes on standardized achievement assessments (Prior, 2007).

3.3.2. Sleep Hours

According to Hirshkowitz et al. (2015), sleep refers to the natural state of rest where adults typically sleep 7 to 9 hours each night. Sleep is linked to cognitive impacts and academic performance (Hershner, 2020). So the null hypothesis stated as, "There is no statistically significant relationship between sleep hours and academic performance." Or Ho: $\boldsymbol{\beta_1} = 0$

3.3.3. Extracurricular Activities

Extracurricular activities are defined as a broad spectrum of student engagement, including involvement in governance, various clubs (ranging from athletics, music, dance, song, and literacy to athletics), debate, drama, celebrations, public events, and honor societies (Robbins & Williams, 1969). Currently, approximately one out of every four students participate in academic clubs (Miller Sadker & Zittleman, 2010). So, the null hypothesis is: There is no statistically significant relationship between extracurricular activities and academic performance. Or H_0: $\boldsymbol{\beta_2} = 0_{(\text{No. extracurricular Participation})}$.

3.3.4. Hours Studied

This quantitative measure measures the sum of the hours each of the students has spent learning. For As further illustrates the students' dedication to course work outside specified class time.

3.3.5. Previous Scores

This quantitative variable captures the results that the students have attained in the previous rating. It has been used as an academic performance predictor and historical academic performance benchmark and can be utilised for monitoring past or future academic performance trends.

3.3.6. Extracurricular Activities

This nominal variable reveals the students' extra-curricular involvement. The responses include 'Yes' or 'No' for the aspect of the engagement level in such activities giving a dimension by which to measure the level of relay of Holistic development to academic achievement.

3.3.7. Sleep Hours

As a measure of health and lifestyle, this continuous quantifiable variable is an estimate of the number of hours a student sleeps per day. Cumulative conventional academic knowledge is a valuable variable suggesting how sleep plays a crucial role for cognition and learning.

3.3.8. Sample Question Papers Practiced

This quantitative variable examines the extent of sample question papers a particular student has attempted. As might be expected, this level of practice and preparation may be related to the student's mastery of the content and their testing aptitude.

3.3.9. Performance Index

The dependent variable of the dataset of the present study is quantitatively measured Performance Index that depicts the overall academic performance of each student. The index varies from 10 to 100 and the results show the higher levels of performance. These combined about a rounded integer value semester academic capacities and accomplishments of the student.

3.4. Statistical Analysis

STATA software is used for performing multiple regression, statistical analysis of the student performance dataset. Descriptive statistics are calculated to analyze the central tendency, dispersion, and shape of variables.

3.5. Limitations

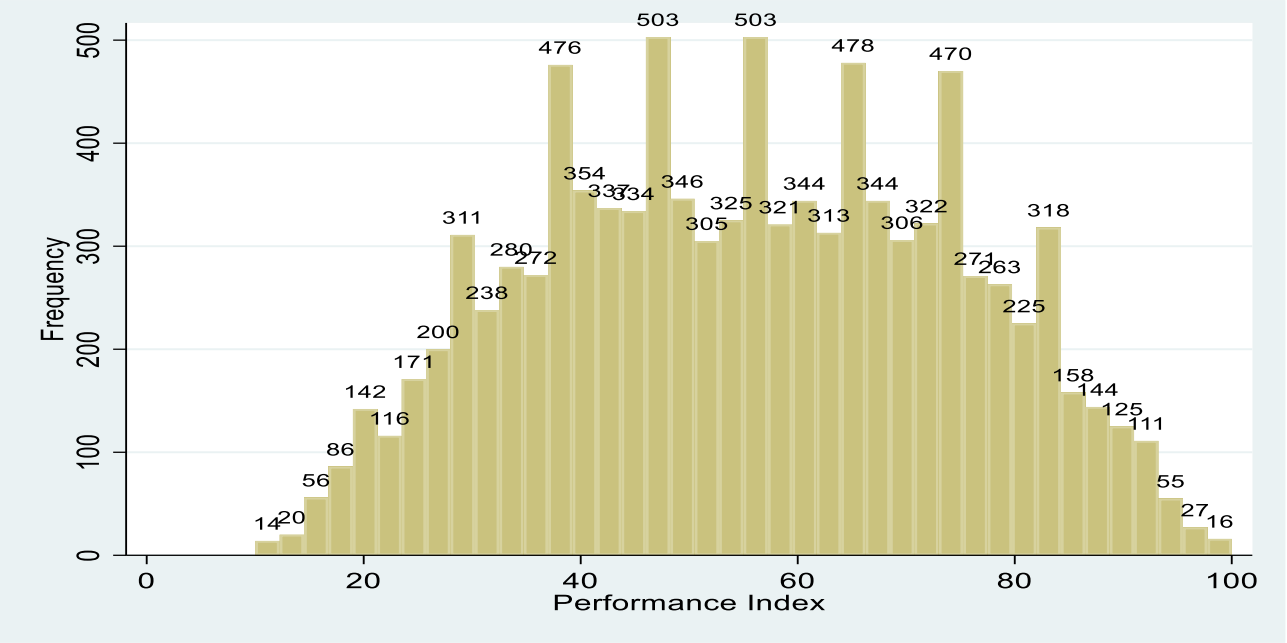
In this study, several limitations have been identified which could influence the interpretation of the findings. The study's reliance on quantitative data hinders the exploration of deeper mechanisms and causal relationships, despite its high structure and statistical strength. Qualitative data, such as interviews or focus groups, could provide more context and richer insights into students' lifestyles and behavior. The broad definition of sleep quality and extracurricular activities in the data set may exclude relevant details impacting academic performance, limiting the generalization of the findings. The selection bias in the study may include predominantly students from certain educational settings, affecting the generalizability of the results. The use of a single Performance Index to represent academic success may not capture the diverse dimensions of intellectual and creative output. Additionally, confounding variables like socioeconomic status, nutritional habits, and family environment were not held constant, potentially causing bias or incomplete conclusions regarding the influence of sleep and extracurricular activities.

4. Results and Discussion

4.1. Descriptive Statistics

After calculating descriptive statistics, frequency counts and percentages are calculated to understand the distribution for categorical variables such as extracurricular activities. A histogram is created to visualize the dependent variable.

Figure 1: Histogram of Performance Index



The histogram in Figure 2 represents the distribution of the "Performance Index" of students. The histogram illustrates the frequency of students across different performance index scores, which range from 10 to 100. The x-axis represents the performance index scores, and the y-axis shows the frequency of students achieving these scores. From a visual inspection, the distribution appears somewhat normal but slightly right-skewed, indicating that there are more students with scores on the lower end of the scale compared to the higher end. The peak of the histogram seems to be around the mid-range score, which aligns with the mean score of approximately 55.22 as mentioned in the summary statistics. This central clustering suggests that most students perform around this average level, with fewer students achieving very high or very low scores.

Table 1: Frequency table of Extracurricular Activities

Extracurricular |Activities	Freq.	Percent	Cum.
No	5,054	50.54	50.54
Yes	4,946	49.46	100.00
Total	10,000	100.00	

The table 1 presents a nearly even distribution of students participating in extracurricular activities (49.46%) and those not participating (50.54%). This balance is crucial as it provides a nearly equal comparison group for analyzing the impact of extracurricular activities on academic performance. With a total of 10,000 students, the sample size is substantial, lending robustness and generalizability to the statistical analysis intended to explore the impact of extracurricular activities on academic performance.

The average performance index of 55.22 with a standard deviation of 19.21 indicates variability in academic performance among students. The range from 10 to 100 highlights extreme cases of low and high academic achievers. This binary variable (0 = no participation, 1 = participation) with a mean close to 0.5 shows the balanced nature of the sample in terms of participation. Students average about 6.53 hours of sleep per night, but with a standard deviation of 1.69, indicating some students get significantly more or less than this average. Indicates a mean of approximately 5 hours studied daily, but with a broad spread (standard deviation of 2.59), suggesting differing levels of study habits among students. Reflects on preparation practices, with students practicing around 4.58 sample papers on average, but variability is high (std. dev. = 2.87). The mean previous score is moderately high at 69.44, with a relatively large standard deviation (17.34), pointing to varied past academic performances among the students.

Table 2: Summary Statistics

Variable	Obs	Mean	Std.dev	Min	Max
Performance indexc	10,000	55.2248	19.21256	10	100
Extracurricular Activities	10,000	.4946	.4999958	0	1
Sleep Hours	10,000	6.5306	1.695863	4	9
Hours Studied	10,000	4.9929	2.589309	1	9
Sample Questions paper Practiced	10,000	4.5833	2.867348	0	9
Previous Score	10,000	69.4457	17.34315	40.	90

Figure 2: Mean of Variables

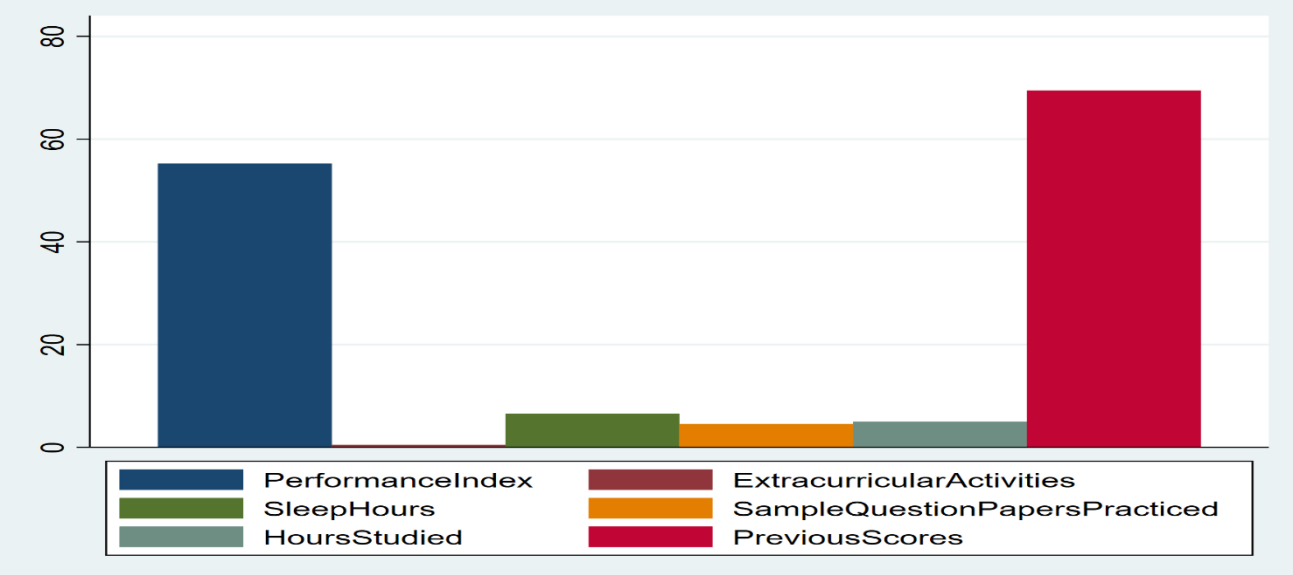


Figure 3, titled "Mean of Variables," visually presents the average values of several critical variables from the study. The average Performance Index is 55.22, indicating that while some students perform well, there's substantial room for improvement across the board. This index serves as a baseline for evaluating the impact of other variables on academic outcomes. The mean for extracurricular activities is 0.49, reflecting a balanced distribution between participants and non-participants, which is ideal for comparative analysis to assess the impact of these activities on academic performance. The previous score has a higher average of 69.44, suggesting that students generally had better historical academic performance, and this variable may be a strong predictor of current performance.

The average hours studied per day is 4.99, highlighting the commitment outside school hours that students are making towards their education. This variable is crucial for exploring the correlation between study time and academic results. Lastly, the mean number of sample question papers practiced stands at 4.58, indicating the level of exam preparation and familiarity with the format, which could directly influence performance outcomes. Together, these means not only establish a foundational understanding of the study's variables but also facilitate deeper statistical analysis to explore how these factors interrelate and influence academic performance.

4.2 Correlation Matrix

To define the association among the variables this study computed a correlation matrix in STATA. The Correlation coefficient (r) has a value between -1 and +1. If the value of r is closer to -1 this means that there is a strong negative relationship between two variables. If the value of r is closer to zero, then the relationship is negative and weak like in Previous Scores and Hours Studied (r = -0.0124) and Extra-curricular Activities and Sleep Hours (r = 0.0232). While if the value of r is closer to + 1 then the relationship is positive and strong like Performance Index and Previous Scores (r = 0.9152). If r is closer to 0 then the relationship will be weak and positive as shown in the table.

Table 3: Correlation matrix for Performance index, Extracurricular activities, Sleep Hours, Hours Studied, Sample Question Paper Practiced, Previous Scores

Variable	Performance index	Extra curricular activities	Sleep Hours	Hours Studied	Sample Question Papers Practiced	Previous Scores
Performance index	1					
Extracurricular Activities	0.0234	1				
Sleep Hours	0.0481	-0.0232	1			
Hours Studied	0.3737	0.0038	0.012	1		
Sample Questions paper Practiced	0.0433	0.0131	0.0040		1	
Previous Score	0.9152	0.0081	0.0059	-0.0124	0.0040	1

The correlation matrix presented in Table 3 provides valuable insights into the relationships between various factors and the performance index of students. The most notable finding is the strong positive correlation of 0.9152 between the performance index and the students' previous scores. This suggests that a student's past academic performance is a strong predictor of their current academic achievement, highlighting the importance of building a strong academic foundation. In contrast, the correlations between the performance index and other factors, such as extracurricular activities (0.0234), sleep hours (0.0481), and practicing sample question papers (0.0433), are relatively weak. This means that although these things might have some say on one's performance, their significance is much less than that of previous results. Surprisingly, the relationship between the participation in extra curricula activities and sleep hours has a very low negative coefficient, thereby actually equal -0.0232 though statistically insignificant. However, the actual numbers are quite small indicating the fact that this correlation is actually a very weak one between the two variables in question. The moderate positive rho of 0.3737 between the performance index and the number of hours studied indicate that time and effort spent in studying computed for a notable variation in performance results. This is especially good evidence in supporting the fact that students need proper study skills and time management to be even effective in their course. Therefore, the cross tabulation validates the fact that there is a complex interplay of factors that define achievement, but past performance is the most influential. These insights can inform educational interventions and strategies aimed at enhancing student outcomes by focusing on strengthening academic foundations and supporting effective study habits.

4.3 Multicollinearity

All the correlation coefficients are very close to zero. In Extracurricular Activities and Sleep Hours, the very small negative correlation (-0.0232) between these variables indicates there is almost no linear relationship between how much students participate in extracurricular activities and how many hours they sleep. This suggests that changes in one are not associated with systematic changes in the other. In Hours Studied and Sleep Hours, a correlation of 0.012 similarly indicates an extremely weak positive relationship between the hours a student studies and the hours they sleep. In Hours Studied and Extracurricular Activities, the correlation of 0.0038 is negligibly small, suggesting no meaningful relationship between these variables. Based on the correlation matrix analysis, it can be inferred that there is no significant multicollinearity among the variables included in the study. The correlation coefficients between the variables do not indicate strong correlations approaching ±1, suggesting that the variables are not highly interrelated. This absence of multicollinearity indicates that the variables can be included in regression models without concerns about inflated standard errors or unstable coefficient estimates due to high correlations among predictors. The independence of the variables supports the reliability and validity of the regression analysis results, allowing for a more accurate interpretation of the individual effects of each variable on the outcome of interest.

4.4 Regression Results

When previous scores are excluded from the analysis in Model 1 of the present study, a number of patterns are observed. The results have indicated that Existential authenticity has a

positive and trace relation with Performance Index where one unit increase in Existential authenticity lead to 0.90 unit increase in academic performance. Likewise, the education hours are discovered more important in increasing the Performance Index positively, now increase by 0.54 units the Performance Index for each added sleep hour. Hours Studied presents a strong association, with each additional hour studied increasing the Performance Index by 2.85 units.

Table 4: Regression Results of Model 1

Source	SS.	Df	MS.	Number of obs=10,000
				F(4, 9995) = 419.78
Model	530866.529	4	132716.632	**Prob > F** = 0.0000
Residual	3159988.12	9,995	316.15689	**R-squared** = 0.1438
Total	3690854.65	9,999	369.122377	**Adj R-squared**=0.1435
				Root MSE = 17.781

Performance index	Coefficient	Standard Errors	t	P>|t|	[95%.....conf.interval]	
Extracurricular Activities	.9034716	.3557655	2.54	0.011	.2060996	1.600844
Sleep Hours	.5442633	.1048825	5.19	0.000	.3386724	.7498542
Hours Studied	2.852992	.0078736	40.29	0.000	2.632624	2.901895
Sample Questions paper Practiced	.2429281	.0620297	3.92	0.000	.1213374	.3645189
Constant	36.29352	.8534385	42.53		34.6206	37.96643

Additionally, practicing sample question papers also positively affects performance, with each additional paper practiced raising the Performance Index by 0.24 units. Collectively, these findings underline the importance of balanced student life that includes adequate sleep, engagement in extracurricular activities, and dedicated study hours in enhancing academic outcomes. The model's overall fit, while lower in explanatory power compared to when previous scores are included, still demonstrates significant relationships between these current behaviors and academic performance.

Table 5: Regression Results of Model 2

Source	SS.	df	MS.	Number of obs=10,000
				F(4, 9995) > 99999.00
Model	3649340.25	5	729868.049	**Prob > F** = 0.0000
Residual	41514.4031	9,994	4.15393267	**R-squared =** 0.9888
Total	3690854.65	9,999	369.122377	**Adj R-squared=** 0.9887
				Root MSE = 2.0381

Performance index	Coefficient	Standard Errors	t	P>|t|	[95%.....conf.interval]	
Extracurricular Activities	.6126042	.0407809	15.02	0.011	.5326654	.692543
Sleep Hours	.4805349	.0120224	39.97	0.000	.4569686	.5041011
Hours Studied	2.852992	.0078736	362.35	0.000	2.837558	2.868426
Sample Questions paper Practiced	.1938013	.0071104	27.26	0.000	.1798635	.207739
Previous Score	1.018438	.0011754	866.45	0.000	1.016134	1.020742
Constant	-34.07548	.1271446	-268.01	0.000	-34.32471	-33.82625

The table 5 shows that the coefficient for Sleep Hours is 0.4805349 with a t-value of 39.97 and a p-value of 0.000. Since the p-value is less than the significance level of 0.05, we can reject the null hypothesis (H_0). This means that there is a statistically significant relationship between sleep hours and academic performance. The table shows that the coefficient for Extracurricular Activities is 0.6126042 with a t-value of 15.02 and a p-value of 0.011. Since the p-value is less than the significance level of 0.05, we can reject the null hypothesis (H_0). This means that there is a statistically significant relationship between extracurricular activities and academic performance. In summary, based on the information provided in the table, both the null hypotheses (H_0) for the relationship between sleep hours and academic performance, as well as the relationship between extracurricular activities and academic performance, will be rejected. The alternative hypotheses (H_1) will be accepted, indicating that there are statistically significant relationships between these variables and academic performance.

The table 5 illustrates the regression results, such as t-Test of individual parameters of independent variables, which reveal that all estimators are highly significant as t-cal>2 and p-value<0.05. The values R^2=.9888 and adjusted R^2 =.9887 indicate the goodness of fit is 98% whereas F (5,9994) =99999 indicates the overall significance of the model. The regression results show that performance index has a positive relationship with extracurricular activities. A unit change in extracurricular activities results in a change of 0.61 units in the performance index. Similarly, Sleep Hours and Sample Question Papers Practiced also have a positive association with the performance index. A unit change in sleep hours results in a change of 0.48 units in the performance index whereas a unit change in the sample question papers practices results in a change of 0.19 units in the performance index. Previous Scores and Hours Studied have a greater influence than any other variables. A unit change in the Hours Studied results in a change of 2.85 units in the Performance Index. A unit change in Previous Scores results in a change of 1.02 units in the Performance Index. The rvfplot, or Residuals vs Fitted Values plot, is indeed a diagnostic tool used in regression analysis to check for heteroskedasticity and non-linearity in a linear regression model.

4.5 Comparison of Model 1 with Model 2

In Model 1, previous scores are excluded from the predictor variables, and only extracurricular activities, sleep hours, hours studied, and sample questions paper practiced are considered. The R-squared value for Model 2 is substantially lower (0.1438) compared to Model 2, indicating that this model explains a smaller proportion of the variance in the dependent variable. Without the inclusion of previous scores, the explanatory power of Model 1 is diminished, resulting in a weaker overall fit to the data. In Model 2, previous scores are included as one of the predictor variables alongside extracurricular activities, sleep hours, hours studied, and sample questions paper practiced. Model 1 yields a high R-squared of 0.9888 on the dependent variable, which demonstrates the models ability to Eclipse explain a vast portion of the variation in performance index. The previous scores add to the result by enhancing the clarify of the model, campus and community impacts this is cleared by a high coefficient estimate for the previous scores of 1.02 and the p-value of 0.000.

4.6 Diagnostic Checking of Heteroscedasticity

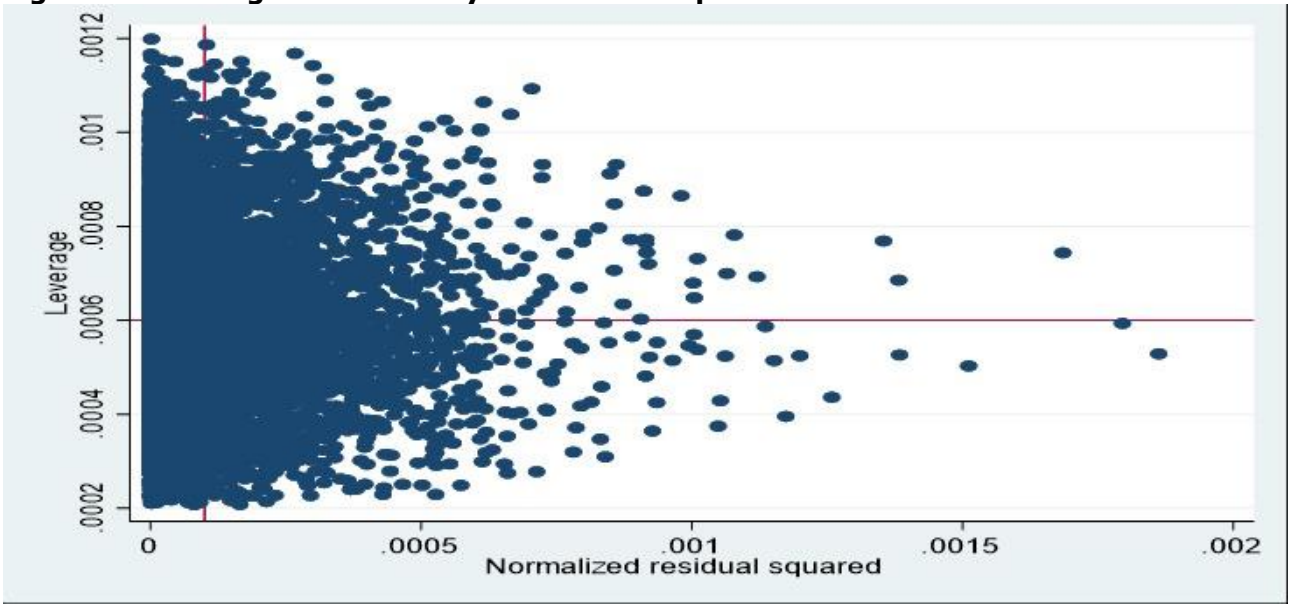
From the dataset of Kaggle, several insightful findings are derived, which would improve the assessment of the reliability and validity of our generated models. Interestingly, exclusion of outliers provides a major input towards achieving preciseness and neutrality within the models' scope of predicting events. This characteristic precludes any negative influence of the outliers on the evaluations, and consequently the models will maintain more accurate representation of the underlying trends. Moreover, since the mean of the residuals was confirmed to not significantly differ from zero, this means that the986 statistical assumptions of the models hold." This makes it clear that the residuals— the differences between observation and the estimates of the model are normally distributed, akin to expectation under the applied model suggesting that the empirical data is well explained by the model. Overall, these factors collectively suggest that the models are effectively capturing and predicting the dataset's dynamics, providing a solid foundation for making reliable inferences about the data.

The results show that there is no heteroskedasticity. The results from the heteroskedastic linear regression analysis are summarized in Table 6, which includes data from 10,000 observations. The table highlights the model's strong predictive power, indicating that the model as a whole is statistically significant. The coefficients for each predictor variable show strong effects. For example, "Extracurricular Activities" has a coefficient of 4.216648, with a standard error of 0.3771353, resulting in a Z-score of 11.18 and a p-value of 0.00, which confirms its significant positive impact. Similarly, "Sleep Hours" and "Hours Studied" also show significant positive impacts with coefficients of 4.136687 and 3.918897 respectively, both achieving p-values of 0.000. "Sample Questions Paper Practiced" has a coefficient of 1.087023 with a Z-score of 17.03, reinforcing its positive contribution to the model. The constant term (_cons) is 5.922048 with an exceptionally low standard error of 0.0141421, leading to a Z-score of 418.75, which underlines the model's robustness.

Table 6: Diagnostic Checking of Heteroskedastic Linear Regression

Heteroskedastic linear Regression ML estimation				**Number of obs =** 10,000		
Log likelihood= -43799.62				**Wald chi2(4) =** 81615.56 **Prob >chi2 =** 0.0000		
Performance index	**Coefficient**	**Std. err.**	**z**	**P>|z|**	**[95%.....conf.interval]**	
Extracurricular Activities	4.216648	.3771353	11.18	0.000	3.477476	4.955819
Sleep Hours	4.136687	.0675362	61.25	0.000	4.004318	4.269055
Hours Studied	3.918897	.0685765	57.15	0.000	3.784489	4.053304
Sample Questions paper	1.087023	.0638481	17.03	0.000	.961883	1.211263
Practiced						
Insigma2	5.922048	.014121	418.75	0.0000	5.89433	5.949766
Constant						

Figure 6: Leverage vs Normality of Residual Squared



5. Conclusion and Policy Recommendations

This study delved deeply into the multifaceted factors influencing academic student performance, specifically examining the relationship between performance index, extra-curricular activities, and sleep duration. The results indicate a significant correlation between the two independent variables including sleep duration and participation in extracurricular activities with performance index. This implies that students who practice enough sleep and other activities outside classroom normally perform better in their studies. But interestingly the difference of the R squared value of two regression equations brought one finding to light that previous academic scores surpass all other variables in terms of importance in determining performance. This highlights the enduring influence of prior academic achievements as a strong predictor of future success (Geraci et al., 2023), suggesting the importance of ongoing support and reinforcement of foundational learning. These insights offer valuable implications for educators, policymakers, and stakeholders, emphasizing the need for holistic approaches that consider both academic and non-academic factors in fostering student success.

The study stresses issues to do with sleep, extra-curricular activities, sleep hours and student academic performance. It indicates that a good sleep should be a priority for schools to enhance learning by availing information on how to implement improved sleep. In general, students also seem to benefit from being involved in some co-curricular activities as well. A number of initiatives that are designed and implemented at the initial level include either general, or targeted tutorial, mentoring, as well as academically related enrichment activities that can benefit students in filling in learning gaps of various kinds. It critically important that holistic support programs should that are seen to support academic purposes should be able to address

academic requirements as well as non-academic, which should take into consideration a balance between the academic and personal responsibilities.

It became clear that to enhance learning and student outcomes professors could use data analytics to predict possible influences likely to affect their academic performance. Schools, parents as well as students can come up with mutual teamwork of developing the support system that will encourage both academic success as well as social-emotional development. These recommendations, if realized, would go along way in helping educational institutions foster favorable conditions that can facilitate the academic success of students and at the same time producers' overall student well-being.

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