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Are level of preparation and lecture attendance related in the role of influencing students' academic performance?

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Abstract

Researchers in higher education have empirically demonstrated the positive influence of level of preparation and lecture attendance on students' academic performance. However, no researcher has yet investigated if level of preparation and lecture attendance complement to or substitute of one another. Based on data collected from undergraduate management students in a public university in the Midwest, we demonstrate a complementary relationship between lecture attendance and level of preparation. We also found that this complementary relationship is more prevalent for higher-performing students. We suggest possible reasons for the interesting results, and outline the implications of the results for higher education.

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1. Introduction

Empirical research in higher education support that both lecture attendance (e.g., Dobkin et al., 2010; Cortright et al., 2011; Lin, 2012; and Lin, 2014), and level of preparation (i.e., studying time) (e.g., Metcalfe et al., 2011; Lindo et al., 2012; Grodner and Rupp, 2013; and Oreopolous et al., 2018) are important factors in determining a student's academic achievement. However, some students who frequently skip classes in a given course may still perform well in that course. This characteristic seems to indicate that some students benefit more from out-of-class study time than from attending classes. It is also possible that the frequency of attending lectures and the level of preparation may be substitute for one another. A thorough literature review did not yield any major study that investigated this important issue – the relationship between lecture attendance and level of preparation. Therefore, the main purpose of this research is to investigate whether or not level of preparation and lecture attendance are related. This topic is important because educators need to understand student behavior and use that understanding in assisting students to achieve success.

In this study, we will use a complementarity test to investigate whether a relationship (i.e., complementary or substitute) exists between lecture attendance and level of preparation. Thus, we develop the first research question: Are lecture attendance and level of preparation related? We hypothesize that this relationship will be complementary in nature, i.e., students' performance in a course is the best when we attend classes regularly as well as study the course material outside the classroom. If the result shows that they are substitutes, it explains why some students who frequently skip classes still perform well in that class.

In addition, some empirical evidence (e.g., Woodfield et al., 2006) suggested that gender could affect students' attending behavior – female students attending classes more frequently than male students, so we hypothesize that gender could play an important role in this issue. For that reason, we develop the second research question: Is gender a factor in determining whether lecture attendance and level of preparation may be related?

Moreover, as stated above, students' performance in a course is the best when they attend classes regularly as well as study the course material outside the classroom. Since higher-performing students frequently attend classes and study regularly, we hypothesis that the complementary relationship is most likely occur in the higher-performing group. Hence, we develop the third research question: Would the complementary relationship between lecture attendance and level of preparation most likely occur in the higher-performing students group?

This paper is organized as follows. First, we briefly review selected articles related to this topic. Second, we offer details on data sources and measurement. Third, we present the development of our econometric models for the complementarity test. Fourth, we present our findings and explain whether our hypotheses are supported. Next, we discuss the results. Finally, we conclude by outlining the practical implications of the results of our study.

2. A Brief Literature Review

The relationship between level of preparation and lecture attendance has not been researched thoroughly in the academic literature. Our research is meant to bridge this important void in the education literature. This research is related to the topics of study time (preparation level) and lecture attendance in the role of influencing students' academic performance. Below, we briefly review the literature in these two topics.

The role of study time in students' academic performance has been widely investigated. For example, Stinebrickner and Stinebrickener (2008) used employed unique longitudinal data to examine the causal effect of study time on grade performance. As a result, their findings suggest that study time and grade performance are positively and significantly correlated. In 2011, Metcalfe et al. studied the relationship between student effort and educational attainment. They used the England football team to identify the education production function. They found a strongly significant effect of study effort on student academic performance – the effect is even more significant for male students than for female students.

Lindo et al. (2012) also used football as a case study. They conducted a survey to investigate the relationship between collegiate football success and non-athlete student performance. They found that the success of football team in the football season significantly reduces male grades relative to female grades. This is because, according to their findings, male students are more likely than female students to increase alcohol consumption, decrease studying, and increase partying in response to the success of the football team. Their findings imply that students would perform better if they studied more. Moreover, Grodner and Rupp (2013) conducted an experiment to examine how homework assignments affect both test and course grades. They found that students who submit homework have significantly better exam performance and higher retention rates. They concluded that requiring homework and doing homework are important indicators for student learning outcomes. Therefore, their findings imply that the higher level of preparation the better grade performance is.

While a number of researchers support the view that students would perform better if they spend more time on studying, a recent study done by Oreopolous et al. (2018) reported a different result. They developed an experiment through an intervention to help students to improve their study time. In their experiment, three campuses (fully online Western Governors University and two traditional campuses in the University of Toronto system) were chosen for a case study. They offered coaching and help for students to plan their study time. Although students were significantly engaged, but they did not find any effect on their grades, implying that their intervention did not change student behavior in the way of study. As a result, they concluded that study time is correlated with grades earned, but the amount of time spent on studying has declined significantly.

In addition to the role of study time in students' academic performance, researchers such as Stanca (2006), Dolnicar et al. (2009), Dobkin et al. (2010), Cortright et al. (2011), and Lin (2012 and 2014), focused on the impact of lecture attendance on academic performance.

Stanca (2006) used students in Introductory Microeconomics classes as a case study and employed a large panel data set. His panel estimators indicated that lecture attendance exerted a positive and significant effect on grade performance. His overall conclusion suggested that it is worth to attend the lectures because instructors' lectures provided an important positive effect on students' learning. Dobkin et al. (2010) also used students enrolled in economics classes as a case study, but they implemented a mandatory attendance policy requiring students whose midterm scores below the median to attend class. Their findings suggested that the mandatory attendance policy was significantly associated with the difference in final exam performance. Therefore, they concluded that class attendance significantly improves student performance.

In addition to economics researchers, marketing researchers such as Dolnicar et al. (2009) also investigated this issue. They conducted a survey among students of an Australian university. They found that four primary factors significantly influenced students' attending behavior. These four factors are: (1) the difficulty of the subject, (2) the quality of the lecture as perceived by the student,

(3) the quality of the student as indicate by the student's mark, and (4) the format of the lecture. Their results suggested that improving the quality of lectures is a better idea to achieve better attendance levels and in turn to enhance student performance.

Furthermore, do cumulative missing classes affect later exam performance? Concepts and models taught in earlier lectures could be used in later lectures, thus it is possible that cumulative missing classes may influence the later exam performances, especially on a cumulative (comprehensive) exam. Lin (2012) had a detailed investigation. He found that cumulative missing classes did exert a negative and significance effect on the comprehensive exam performance.

Above all, a number of researchers had broadly studied the topics of study time (preparation level) and lecture attendance in the role of influencing students' academic performance, but none of those previous studies had examined the relationship between the level of preparation and lecture attendance. For that reason, we test the following hypothesis:

Hypothesis 1: Lecture attendance and level of preparation are related and the relationship is complementary.

The literature on class attendance and student performance also investigated the possible role of gender. Cortright et al. (2011) suggested that gender did significantly influence the effect of class attendance on exam performance. However, Lin (2014) had a different result. Lin investigated if missing classes would decelerate student exam "performance progress". (According to Lin (2014) in page 411, "*Performance progress is different from just performance. Performance progress shows a student's development or growth of performance over different periods. That is, performance progress is a dynamic perspective, while performance is a static perspective*.") The empirical evidence from the study by Lin (2014) did not suggest that gender would play an important role in determining whether missing classes hindered students' exam performance progress. Thus, we investigate if gender plays an important role in this issue by testing the following hypothesis:

Hypothesis 2: Gender is a factor in determining whether lecture attendance and level of preparation may be related.

Empirical evidence from Lin (2014) also showed that both missing classes and less study time hampered high-performing students' exam performance progress. Lin's results may imply that the complementary relationship between these two factors may most likely occur in the higher-performing students. Thus, we test the following hypothesis:

Hypothesis 3: The complementary relationship between lecture attendance and level of preparation would most likely occur in the higher-performing students group.

3. Method

3.1. Data Measurement

One hundred and twenty-six (126) business students enrolled in three economics principles classes of a public university in the Midwest in spring 2015 participated in this study. All of these students were at the same level when they enrolled in the class. No one had ever repeated the course. Each class met twice a week. No additional weekly review/tutorial classes were provided by graduate students. Daily attendance was taken, but there was no penalty for skipping classes and no bonus for attending classes. That is, students were given complete freedom to choose whether or not to attend the class. Students' final grades only depended on two midterm exams and one final exam. The exam scores were based on a 100-point-scale. In addition, in order to ensure the same instructional style and teaching materials, only one teacher was chosen which would enable us to better understand how attending behavior differs across students given the same instructor. Moreover, the same exams (midterm and final exams) were created for different sections to ensure that results would be consistent. These two midterm exams and one final exam have all same weights. All exams were collected when students turned in their answers. Therefore, it was not possible for students to get information from different sections.

Except students' attendance record and three exam scores, students were required to self-report the frequency of studying for the class (i.e., the level of preparation) outside classroom during each exam period. A few minutes before each exam, a questionnaire was distributed to each student. The questionnaire included the following question:

Overall, approximately how often did you study for the class during this exam period?

1 = I study only 1 day before the test
2 = I study only 2–3 days before the test
3 = I study only 4–5 days before the test
4 = I study one week before the test
5 = I study regularly right after the class.

Since the question was not confidential, we required all students write down their names so that the self-reported data could be matched with the non-self-reported data (i.e., attendance record and three exam scores). It is worthwhile to mention that we did not ask students to write down the number of hours devoted to studying for the class during the exam period because they might not precisely remember the number of hours and might leave it blank, but it could be easier for them to recall how often they studied for the class. We asked students to write down the number of hours devoted to studying for the class during the exam period in an earlier project several years ago, but many students either left it blank or wrote "I don't remember". Therefore, we decided to only ask students the frequency of studying for the class. Moreover, it should be noted that there was an IRB approval to utilize students' exam scores, attendance record, and the survey regarding students' level of preparation for the class in this study.

In addition, Table 1 reports means and standard deviations for the variables used in this study. Moreover, the reliability (i.e., Cronbach's alpha) of exams was measured. Cronbach's alpha was 0.85, which is high and indicates strong internal consistency among these exams. Further, it should be pointed out that the exam scores for each exam used in this study were original scores without curves.

3.2. Econometric Models

To test these hypotheses, a complementarity test is conducted to investigate whether a relationship (i.e., complements or substitutes) exists between lecture attendance and level of preparation. It should be noted that the complementary test has been widely used by economics researchers in the economics literature to examine the relationship between capital and labor (e.g., Lin, 2003). Thus, we applied this formation to investigate the relationship between level of preparation and lecture attendance. The formation done by economics researchers can be described as "output progress" model, because it was taken the first difference. The advantage of using "output progress" as an empirical measure is that it can show a nation's development or growth of economic performance over different periods. Therefore, based upon this idea, we adopt that formation for our study in this particular case. Thus, Model 1 (shown in Equation 1) can be called as "performance progress" model.

In addition to "performance progress" model, we also show "performance" model (Model 2, shown in Equation 2), which was not taken the first difference. The advantage of using "performance" model is that it can avoid the ceiling effect – students with perfect attendance cannot attend more frequently and those in the highest study-sequence cannot attain more. Showing both models enable us to compare which model would serve as a better empirical measure in this particular case. These two econometric models for the complementarity formation are shown below:

Model 1 (Performance Progress):

$$\ln Y_t - \ln Y_{t-1} = C_0 + a_A[\ln A_t - \ln A_{t-1}] + a_S[\ln S_t - \ln S_{t-1}] + a_{AA}\left[(\ln A_t)^2 - (\ln A_{t-1})^2\right]/2 + a_{SS}\left[(\ln S_t)^2 - (\ln S_{t-1})^2\right]/2 + a_{AS}[\ln A_t \ln S_t - \ln A_{t-1}\ln S_{t-1}] + u_t, \quad (1)$$

Model 2 (Performance):

$$\ln Y_t = D_0 + b_A \ln A_t + b_S \ln S_t + b_{AA}(\ln A_t)^2/2 + b_{SS}(\ln S_t)^2/2 + b_{AS}\ln A_t \ln S_t + v_t, \quad (2)$$

where u_t and v_t are stochastic disturbance terms assuming a mean 0 and a variance σ^2. Y_t stands for student performance at testing period *t*, A_t stands for lecture attendance before testing period *t*, and S_t stands for level of preparation before testing period *t, a's, b's, C's* and *D's* stand for parameter estimates. If lecture attendance and level of preparation are substitutes, $a_{AS} < 0$, $b_{AS} < 0$ and the effect should be significant. If $a_{AS} > 0$, $b_{AS} > 0$ and statistically significant, the relationship is complementary and Hypothesis 1 is supported.

In addition, to test Hypotheses 2 and 3, we introduce dummy variables to identify students who were female or higher-performing students, and then interact with $(\ln A_t \ln S_t - \ln A_{t-1}\ln S_{t-1})$ or $(\ln A_t \ln S_t)$. We denote *F* as female students (set *F* = 1 if students are female; wile *F* = 0 if students are male) and *H* as higher-performing students (set *H* = 1 if students received A or B grades for the course; while *H* = 0 if students received C or lower grades for the course).

For testing Hypothesis 2, Equations (1) and (2) can be rewritten as Equations (3) and (4), respectively:

$$\ln Y_t - \ln Y_{t-1} = C_1 + \alpha_A[\ln A_t - \ln A_{t-1}] + \alpha_S[\ln S_t - \ln S_{t-1}] + \alpha_{AA}\left[(\ln A_t)^2 - (\ln A_{t-1})^2\right]/2 + \alpha_{SS}\left[(\ln S_t)^2 - (\ln S_{t-1})^2\right]/2 + \alpha_{AS}[\ln A_t \ln S_t - \ln A_{t-1}\ln S_{t-1}] \times F + u_t, \quad (3)$$

$$\ln Y_t = D_1 + \beta_A \ln A_t + \beta_S \ln S_t + \beta_{AA}(\ln A_t)^2/2 + \beta_{SS}(\ln S_t)^2/2 + \beta_{AS}(\ln A_t \ln S_t) \times F + v_t. \quad (4)$$

If $\alpha_{AS} > 0$, $\beta_{AS} > 0$ and statistically significant, then Hypothesis 2 is supported.

For testing Hypothesis 3, Equations (1) and (2) can be rewritten as Equations (5) and (6), respectively:

$$\ln Y_t - \ln Y_{t-1} = C_2 + \gamma_A[\ln A_t - \ln A_{t-1}] + \gamma_S[\ln S_t - \ln S_{t-1}] + \gamma_{AA}\left[(\ln A_t)^2 - (\ln A_{t-1})^2\right]/2 + \gamma_{SS}\left[(\ln S_t)^2 - (\ln S_{t-1})^2\right]/2 + \gamma_{AS}[\ln A_t \ln S_t - \ln A_{t-1}\ln S_{t-1}] \times H + u_t, \quad (5)$$

$$\ln Y_t = D_2 + \delta_A \ln A_t + \delta_S \ln S_t + \delta_{AA}(\ln A_t)^2/2 + \delta_{SS}(\ln S_t)^2/2 + \delta_{AS}(\ln A_t \ln S_t) \times H + v_t. \quad (6)$$

If $\gamma_{AS} > 0$, $\delta_{AS} > 0$ and statistically significant, then Hypothesis 3 is supported.

4. Results

Hypothesis 1

The results for Equations (1) and (2) are reported in Table 2. As shown in Table 2, both coefficients a_{AS} and b_{AS} are positive, and are statistically and significantly different from zero at the 1% level in both models. These results imply that lecture attendance and level of preparation are significantly related and the relationship is complementary.

Therefore, Hypothesis 1 is supported. To better perform in a course, students are required to attend classes frequently and study the course materials outside the classroom regularly.

Hypothesis 2

The results for Equations (3) and (4) are presented in Table 3. As displayed in Table 3, both coefficients α_{AS} and β_{AS} are not statistically and significantly different from zero at the 1%, 5%, or 10% levels in both models.

As a result, empirical evidence does not support Hypothesis 2, which suggests that gender cannot be a significant factor in determining whether lecture attendance and level of preparation may be related.

Hypothesis 3

The results for Equations (5) and (6) are reported in Table 4. As demonstrated in Table 4, in Model 1 (performance progress model), the coefficient γ_{AS} is not statistically and significantly different from zero at the 1%, 5%, or 10% levels. However, in Model 2 (performance model), the coefficient δ_{AS} is positive, and is statistically and significantly different from zero at the 1% level.

The empirical evidence from both models is not consistent. The result from Model 1 (performance progress model) does not support Hypothesis 3; while the result from Model 2 (Performance model) supports Hypothesis 3. This leaves us for further discussion. Therefore, we provide our discussion in the following section – whether or not Hypothesis 3 should be supported.

5. Discussion

In this section, we discuss why the empirical evidence from Model 1 cannot support Hypothesis 3; while the empirical evidence from Model 2 can support Hypothesis 3. The result from Model 1 for higher-performing students may puzzle readers, because we expected a complementary relationship between lecture attendance and level of preparation – students' performance in a course is the best when they attend classes regularly as well as study the course material outside the classroom.

A possible explanation for the insignificant effect in Model 1 (performance progress model) would be the ceiling effect—students with perfect attendance cannot attend more frequently and those in the highest study-sequence cannot attain more. Many higher-performing students had both perfect attendance and highest study-sequence, implying that they could not do any better. That is, their efforts would be commensurate with earlier efforts. Consequently, after differentiating the data, the relationship between lecture attendance and level of preparation cannot be significantly displayed.

However, why can the evidence from Model 2 support Hypothesis 3? This is because Model 2 uses "performance" rather than "performance progress" as an empirical measure in this particular case. In the performance model (Model 2), we do not take the first difference. That is, we do not need to differentiate data. Without differentiating data, the ceiling effect will not exist. For that reason, the complementary relationship between lecture attendance and level of preparation can be significantly displayed.

Based upon the discussion above, we are able to suggest that Hypothesis 3 should be supported. Hence, the complementary relationship between lecture attendance and level of preparation most likely occur in the higher-performing students group.

In addition, according to our discussion, it seems that "performance progress" may not be the appropriate measure in the case of Hypothesis 3 due to the existence of the ceiling effect. Comparing these two models (performance progress model and performance model), unfortunately, "performance progress" may not be better than "performance" as an empirical measure in this particular issue (Hypothesis 3), even though performance progress can demonstrate a student's development or growth of performance over different periods.

Furthermore, our discussion of the empirical results solely emphasizes on the complementary relationship between lecture attendance and level of preparation. We have not discussed the individual impacts of these two variables on performance. Let's take a quick look at the coefficients of $(\ln A_t - \ln A_{t-1})$, $(\ln A_t)$, $(\ln S_t - \ln S_{t-1})$, and $(\ln S_t)$ in Tables 2 – 4. Unfortunately, they do not exactly show all what we expected (we expected a positive and significant effect on performance progress or performance). A positive and significant effect on performance progress only displays in Model 1 in Tables 3 and 4. We believe the reason of insignificant evidence is that these two models were designed to verify the complementary relationship between attendance and preparation rather than to verify the impacts of these two variables on performance or performance progress. If we want to verify the individual impacts of these two variables on performance, we need to re-design a new model which emphasizes that issue. Indeed, a number of previous studies had broadly investigated and discussed that issue, such as Stinebrickner and Stinebrickener (2008), Cortright et al. (2011), and Lin (2012 and 2014). Therefore, we are not going to continue discussing that issue in this paper.

Finally, it should be noted that our results are not casual, which would undermine our empirical analysis, because we have no other control variables except lecture attendance and preparation. That is, our empirical results reveal partial correlations rather than casual relations, and we need to use more controls to obtain clear-cut partial correlations, such as students' GPA, background, or similar controls. This, we believe, indicates the direction of a future study.

6. Conclusion

In this paper, we used a complementarity test to investigate whether a relationship (i.e., complementary or substitute) exists between lecture attendance and level of preparation. One hundred and twenty-six students in three economics principles classes in spring 2015 participated in this case study. Our study results offer sufficient empirical evidence to support that the relationship between lecture attendance and level of preparation will be complementary and this complementary relationship is more prevalent for higher-performing students. In other words, to better perform in a course, students should attend classes frequently and study the course material outside the classroom regularly.

In short, this study offers an important contribution to the higher education literature. Our study is perhaps the first to use complementarity test to investigate the relationship between lecture attendance and level of preparation. Our findings will benefit both students as well as instructors. Students, particularly the lower-performing students, should attend as many classes as possible along with additional hours of preparation. This will increase their chances to perform in course examinations. Instructors should also implement innovative and interesting class exercises to motivate students to attend more classes.

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Table 1
Means and Standard Deviations of Variables

	All Students		**Male Students**		**Female Students**	
Variables	M	SD	M	SD	M	SD
Scores for exam I (Max=100)	74.5	17.99	74.93	17.56	72.88	18.80
Scores for exam II (Max=100)	83.13	16.54	82.08	15.75	84.83	17.79
Scores for exam III (Max=100)	51.66	14.93	51.27	13.88	52.30	16.62
Frequency of studying for 1st exam	2.52	1.27	2.47	1.28	2.60	1.27
Frequency of studying for 2nd exam	2.69	1.19	2.65	1.24	2.75	1.12
Frequency of studying for 3rd exam	2.74	1.17	2.65	1.17	2.89	1.15
Attendance in the 1st exam period (Max=10)	9.18	1.15	9.14	1.14	9.33	1.17
Attendance in the 2nd exam period (Max=10)	8.72	1.70	8.81	1.67	8.58	1.77
Attendance in the 3rd exam period (Max=10)	8.57	1.87	8.67	1.83	8.42	1.93

Note: M = mean; SD = standard deviation.

Table 2
Parameter Estimates
Results for Hypothesis 1 – All Students

Explanatory Variables	Explained Variable: $\ln Y_t - \ln Y_{t-1}$ (1)	Explained Variable: $\ln Y_t$ (2)
Constant	-0.189*** (-7.75)	4.157*** (15.83)
$\ln A_t - \ln A_{t-1}$	0.305 (0.98)	
$\ln A_t$		-0.133 (-0.58)
$\ln S_t - \ln S_{t-1}$	-0.716*** (-2.57)	
$\ln S_t$		-0.696*** (-2.67)
$\frac{(\ln A_t)^2 - (\ln A_{t-1})^2}{2}$	-0.370* (-1.84)	
$\frac{(\ln A_t)^2}{2}$		0.148 (1.05)
$\frac{(\ln S_t)^2 - (\ln S_{t-1})^2}{2}$	-0.164** (-2.04)	
$\frac{(\ln S_t)^2}{2}$		-0.050 (-0.70)
$\ln A_t \ln S_t - \ln A_{t-1} \ln S_{t-1}$	0.881*** (3.48)	
$\ln A_t \ln S_t$		0.322*** (2.70)
R^2	8.4%	10.9%
$\bar{R}^2$	6.6%	9.7%
F-Statistics	4.52	9.08
Observations	252	378

Note: Number in parentheses is t-value; *$p<.1$; **$p<.05$; ***$p<.01$. A = lecture attendance; S = level of preparation.

Table 3
Parameter Estimates
Results for Hypothesis 2 – Female Students

Explanatory Variables	Explained Variable: $\ln Y_t - \ln Y_{t-1}$ (1)	Explained Variable: $\ln Y_t$ (2)
Constant	-0.184***	3.671***
	(-7.81)	(19.45)
$\ln A_t - \ln A_{t-1}$	0.514*	
	(1.64)	
$\ln A_t$		0.021
		(0.09)
$\ln S_t - \ln S_{t-1}$	0.206**	
	(2.33)	
$\ln S_t$		-0.023
		(-0.31)
$\frac{(\ln A_t)^2 - (\ln A_{t-1})^2}{2}$	-0.284	
	(-1.37)	
$\frac{(\ln A_t)^2}{2}$		0.214
		(1.54)
$\frac{(\ln S_t)^2 - (\ln S_{t-1})^2}{2}$	-0.159*	
	(-1.74)	
$\frac{(\ln S_t)^2}{2}$		-0.047
		(-0.64)
$(\ln A_t \ln S_t - \ln A_{t-1} \ln S_{t-1}) \times F$	0.076	
	(0.76)	
$(\ln A_t \ln S_t) \times F$		0.021
		(1.31)
R^2	4.1%	9.5%
$\overline{R}^2$	2.2%	8.3%
F-Statistics	2.11	7.85
Observations	252	378

Note: Number in parentheses is t-value; *p<.1; **p<.05; ***p< .01. A = lecture attendance; S = level of preparation; F = female students (dummy variable).

Table 4
Parameter Estimates
Results for Hypothesis 3 – Higher Performing Students

Explanatory Variables	Explained Variable: $\ln Y_t - \ln Y_{t-1}$ (1)	Explained Variable: $\ln Y_t$ (2)
Constant	-0.192***	3.739***
	(-7.69)	(22.08)
$\ln A_t - \ln A_{t-1}$	0.567*	
	(1.84)	
$\ln A_t$		0.216
		(1.08)
$\ln S_t - \ln S_{t-1}$	0.178*	
	(1.82)	
$\ln S_t$		-0.204***
		(-2.96)
$\frac{(\ln A_t)^2 - (\ln A_{t-1})^2}{2}$	-0.312	
	(-1.52)	
$\frac{(\ln A_t)^2}{2}$		0.012
		(0.09)
$\frac{(\ln S_t)^2 - (\ln S_{t-1})^2}{2}$	-0.122	
	(-1.48)	
$\frac{(\ln S_t)^2}{2}$		0.055
		(0.85)
$(\ln A_t \ln S_t - \ln A_{t-1} \ln S_{t-1}) \times H$	0.067	
	(0.71)	
$(\ln A_t \ln S_t) \times H$		0.140***
		(9.59)
R^2	4.1%	27.2%
$\bar{R}^2$	2.1%	26.2%
F-Statistics	2.10	27.74
Observations	252	378

Note: Number in parentheses is t-value; *p<.1; ***p< .01. A = lecture attendance; S = level of preparation; H = higher-performing students (dummy variable).