Intertemporal Consistency of Predictors of Student Performance: Evidence From a Business Administration Program

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ABSTRACT. In this article, the author analyzes the intertemporal consistency of high school grades as predictors of the academic performance of business administration students over a 2-year period by using data from a university in Germany. This study shows how students' average high school grades and a range of other factors are regressed on the students' grade performance at regular half-year intervals during their participation in the program. The author applies a bootstrapping procedure to analyze changes in the regression estimators over time and finds that the magnitude of the coefficients on high school grades decreases over the 2-year period, and this decline is statistically significant. Nevertheless, high-school grades remain the most important predictors of the students' performance throughout the period studied here.

Key words: business administration programs, grades, performance prediction, student performance

Educators and administrators in academic institutions, such as business schools, have an acute interest in making predictions about the performance of the students who enroll in their programs. The existing literature shows that high-school grades are reasonably good, yet incomplete predictors of the grade performance of students in university level business administration programs and similar courses of study. However, few studies have researched the intertemporal consistency of high school grades as predictors of students' performance (for an exception see Bartlett, Peel, & Pendlebury, 1993). I seek to fill this research gap addressing the question of whether high school grades and a range of other factors predict students' performance during their academic studies over an extended period of time.

The question of whether high-school grades predict the performance of students consistently well over an extended period of time, or which alternative measures can be used for this purpose, is of particular importance for those who make admission decisions. For example, if high school grades predict the performance of students in the fourth term of their course of study as well as in the first term, students selected initially on the basis of their high-school grades are likely to do well throughout the program. In that case, universities and similar institutions should focus on assessing applicants' profiles as rigorously as possible to admit those who are most likely to fit the requirements.

If the predictive power of high-school grades with respect to the grade performance of university students diminishes quickly as performance is measured at progressively higher levels, then universities should not rely on high-school grades beyond the admission decision. Rather, they should use the regular testing throughout the course of study.

Review and Hypotheses

In the extant literature, high-school grades are reasonably good, but nevertheless incomplete, predictors of the grade performance of students in university-level education. Ransdell (2001) reports results according to which high school grade point averages (GPAs) account for up to 20% of the variance in first-year college GPA (see also Linn, 1989). Most studies in the area of psychological and general educational research show that high-school GPA tends to be a slightly better predictor of college GPA than scores from the Scholastic Aptitude Test (SAT, Anderson, 2001; Wolfe & Johnson, 1995).

With respect to the performance of students of economics and business-related subjects (e.g., accounting, finance, marketing), most studies confirm that high-school grades and standardized tests of educational achievement have the greatest predictive power with respect to the academic performance of students in university education, when compared with other factors (Anderson, Benjamin, & Fuss, 1994; Borde, 1998; Borg & Shapiro, 1996; Borg & Stranahan, 2002; Brasfield, Harrison, & McCoy, 1993; Devadoss & Foltz, 1996; Didia & Hasnat, 1998; Filbeck & Smith, 1996; Gist, Goedde, & Ward., 1996; Johnson, Joyce, & Sen, 2002; Williams, Waldauer, & Duggal, 1992; Ziegert, 2000). However, a few studies come to different conclusions. In a study of 39 students in an undergraduate accounting program in the UK, Bartlett et al. (1993) found that A-level scores are not significantly related to accounting exam results at the beginning of the program, after 1, and after 3 years of study. Their result may be driven by the relatively small size of the sample they use. In a study of 1,286 university students in the United States, Laband and Piette (1995) did not find evidence of significant effects of the scores in the verbal and the math portion of the SAT taken prior to entry on average GPAs in upper-level economics courses. This finding may be partly explained by the fact that the authors include the GPA in economics principles courses among the independent variables, which is likely to capture some of the abilities measured by the SAT score. Also, as a test that measures the performance of students at one particular point in time only, the SAT score result should be expected to have less predictive power than appropriately weighted and aggregated high school grades, which reflect the students' performance potential across a variety of dimensions and over an extended period of time.

In conformance with the majority of studies, one could expect high-school grades to predict the performance of business administration students reasonably well.

> H_1: High-school grade performance is positively and significantly related to the performance of students in a business administration program.

Few authors have investigated the intertemporal consistency of high-school grades and similar measures as predictors of students' performance in university-level education, House (1994) being an exception. The predictive power of high-school grades should decline over time as students acquire new skills during their studies and the nature of the performance challenges they face changes. The speed of this decline is contingent on several factors, such as the rate at which the nature of the tasks asked of a student changes over time. Therefore, one should assume that comprehensive measures of educational achievement stand a better chance of remaining relevant for a longer period of time than more narrow measures, unless the nature of the task requirements during academic studies are very specific. This approach is consistent with that of Bartlett et al. (1993) who found that the advantage preuniversity qualifications confer to students of accounting erodes rather quickly as the task requirements during the program of study become more idiosyncratic.

In this article, I used average high-school grades as predictors of the grades during the first 2 years (four semesters) of a business administration program at a university in Germany. The German high school (*Abitur*) grade, which most of the students earned, is widely considered to be a fairly comprehensive measure because it reflects performance of high school students over a 2-year period across a broad array of subjects. Student choice with respect to these subjects exists, but is restricted to the weighting of individual subjects and to trade-offs within particular subject groups (Steedman et al., 1997). Because of this comprehensiveness, the intertemporal consistency of high-school grades as predictors of student performance in business-administration programs can be expected to remain high for an extended period of time:

> H_2: The predictive power of high school grades with respect to the grade performance of students during their business administration program declines, but remains significant over an extended period of time.

METHOD

I regressed average high school grades and a battery of other factors on the students' grade performance at four half-year intervals during their participation in a business administration program. I applied a bootstrapping procedure to analyze the coefficients on the independent variables, as well as the total explanatory power of the regressions, as students progress. *Bootstrapping* produces estimates of the distribution of the regressions' estimators, which are used to assess the significance of the changes in these estimators over time. The results show that the predictive power of high-school grades declines significantly as students progress. Despite this decline, high-school grades remain the most important predictors of the grade performance of business-administration students.

I obtained the data used in this study from a cohort of undergraduate students of business administration in the late 1990s. I collected the data from three sources at a university in Germany (i.e., the admissions office, the student registry, and the examinations office). The data set covers information from students' applications, which include high school grades and self-assessment reports, and the performance history of each student while enrolled in the program. The data set also contains a large number of biographical variables (e.g., vocational training and number of internships before the beginning of study).

Of the total of over 200 students who started the program in the given year, I used information from 160 students. This group forms the sample. Analysis of variance (ANOVA) conducted on selected variables revealed no significant differences between those students for whom complete data were available and those for whom this was not the case.

Students' average grade across all subjects taken in the first four semesters (half-year terms) of their business administration program was the dependent variable. Among the independent variables were the average high-school grades and other factors reflecting the students' demographic and biographic characteristics (see Table 1).

I used an ordinary least squares (OLS) regression to determine the predictors of student performance. The regression function estimated was

TABLE 1. Variable Definitions and Descriptive Statistics

Variable	*M*	*SD*	Range	Variable Description
Demographics and biographic				
AGE	20.28	1.14	17–25	Age of the student at the beginning of the program
GENDER	0.36	0.48	[0; 1]	1 if the student is female; 0 otherwise
POB	0.04	0.20	[0; 1]	1 if the student's place of birth is outside of Germany; 0 otherwise
COS	0.76	0.42	[0; 1]	1 if the student is taking foreign languages as his or her area of specialization; 0 if information systems
Schooling				
HSGRADE	1.99	0.51	1.0–3.3	Average high school grade
MATH	0.39	0.49	[0; 1]	1 if the student took math as a high school major; 0 otherwise
ENG	0.64	0.48	[0; 1]	1 if the student took English as a high school major; 0 otherwise
SOCIAL	0.19	0.40	[0; 1]	1 if the student took social studies or economics as a high school major; 0 otherwise
Academic Social Performance				
$ACGRADE_{t1}$	2.45	0.51	1.2–3.5	Average grade across all subjects, 1st semester
$ACGRADE_{t2}$	2.48	0.53	1.2–3.6	Average grade across all subjects, 2nd semester
$ACGRADE_{t3}$	2.52	0.49	1.3–3.5	Average grade across all subjects, 3rd semester
$ACGRADE_{t4}$	2.54	0.46	1.4–3.4	Average grade across all subjects, 4th semester

Note. $N = 160$. All varaibles except dummies represent grades on the basis of the standard German grading scale, ranging from 1 (*very good*) to 5 (*failing*).

$$ACGRADE_{t1\text{-}t4} = \beta_0 + \beta_1 HSGRADE + \beta_2 (HSGRADE)^2 + \beta_3 MATH + \beta_4 ENG + \beta_5 SOCIAL + \beta_6 AGE + \beta_7 GENDER + \beta_8 POB + \beta COS + e$$

with e denoting the error term. Average grades in semesters one to four were the dependent performance variables. The quadratic term $(HSGRADE)^2$ is included in the regression to avoid specification problems. Previous versions of the regression model included additional independent variables, such as the number of internships taken by students prior to their academic studies. Because these variables proved to be insignificant, I excluded them from the regressions, in order to achieve greater model parsimony. Ramsey regression specification error tests (1969) confirmed that the regression model is well specified. The Cook and Weisberg (1983) test yielded no evidence of heteroscedasticity. Inspection of the correlation matrix did not indicate any multicollinearity problems.

I used a nonparametric bootstrap procedure to test H_2 regarding the intertemporal consistency of the coefficients estimated by the regression and of the explanatory power of the regression model as a whole. In bootstrapping, "the variability of an estimator is investigated by repeating an estimation with a subsample of the data" (Hardin & Hilbe, 2001, p. 32). The estimators of interest are reestimated a large number of times (replications) on the basis of the sample in use by resampling the original observations with replacement. The implementation of the resampling scheme depends on the null hypothesis. The model is estimated for each resample. In this way, bootstrapping produces an asymptotically valid estimate of the distribution of the model's estimators, using the sample instead of the true population whose distribution is unknown. The researcher uses this asymptotic result to calculate a measure of precision on the basis of a finite sample.

I investigated whether the significant coefficients and the adjusted R^2 values for the OLS regression specified above stay the same or diminish significantly when using average academic grades at the end of each of the four semesters ($ACGRADE_{t1}$, $ACGRADE_{t2}$, $ACGRADE_{t3}$ and $ACGRADE_{t4}$) as dependent variables. To test whether the estimates for the early semesters differ significantly from the estimates for the later semesters, the null hypothesis was that the estimates for the four semesters remain unchanged. This null hypothesis requires defining the 160 observations for the independent variables in the sample as the x matrix and the 160 observations for $ACGRADE_{t1}$, $ACGRADE_{t2}$, $ACGRADE_{t3}$ and $ACGRADE_{t4}$ as the y matrix in one overall dataset with observations and 4 times the same x variables. This setup is chosen because the null hypothesis assumes the four data sets to be representative subsets of a single data set. The pooled data set is used to calculate the residual values. A vector of residual values is resampled with replacement to produce a new vector of dependent variables. This procedure generates four new data sets under the null hypothesis that are then used for bootstrapping the coefficients and the adjusted R^2 values. The resampling of residual values from a pooled data set is necessary to test the null hypothesis of the equality of estimators. If the prediction about a gradual decline in the magnitude of the estimators over time holds true, the hypothesis of equality is disconfirmed, thus establishing a statistically significant decline of the coefficients.

To extract several factors about the distribution simultaneously, one must produce a large number of replications (2,000). The bootstrap estimates thus generated are approximately normally distributed (as shown by applying the Shapiro-Wilk *W* and Shapiro-Francia *W* tests for normality) so that the standard normal and the percentile intervals nearly agree. Differences between the bootstrap estimates for the relevant coefficients, respectively for the adjusted R^2 values, can then be calculated. Thereafter, one realizes the resulting distributions of the differences between matched pairs of estimates. If a difference of zero is in a 90% confidence interval, the null hypothesis cannot be disconfirmed, but a *p* value of less than 10% falsifies the null hypothesis (for the use of confidence intervals in the context of bootstrapping see Davison & Hinkley, 1997, and Efron & Tibshirani, 1993).

The bootstrap method is superior to alternative approaches that can be used to address the issue of intertemporal consistency. For example, House (1994) uses Fisher's *z*-transformation procedure in order to compare correlation coefficients between dependent and independent variables. With this procedure, however, only bivariate correlations can be analyzed. Resampling methods of the bootstrap family are, in contrast, based on the multivariate regression model exactly as specified by the researcher.

RESULTS

Table 1 provides an overview of the key demographic and biographic characteristics of the group of students included in the data set, as well as their schooling and academic grade performance.

These data show that, because the study participants were from a German university, the sample characteristics differ from those typically found in English-speaking countries. For example, the average age of students entering university is approximately 20 years, reflecting the fact that high-school education in Germany is longer compared with international standards, and that national military or social service is mandatory for most male students after finishing high school.

Table 2 shows the pairwise correlation coefficients between the dependent and nonbinary independent variables and their significance levels. These statistics suggest that average high-school grades are closely correlated with students' average grades during their business administration program. The values of the correlation coefficients decrease slightly over time. These findings provide some tentative support for H_1 and H_2.

Table 3 shows the results from the regressions, with average grades in

TABLE 2. Correlation Coefficients and Significance Levels Among Continuous Variables

Variable	HSGRADE	AGE
AGE	0.24**	1.00
$ACGRADE_{t1}$	0.56***	0.05
$ACGRADE_{t2}$	0.55***	0.13+
$ACGRADE_{t3}$	0.53***	0.18*
$ACGRADE_{t4}$	0.52***	0.14+

+$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

TABLE 3. Regression Results

	Academic performance[a]							
	(1) $ACGRADE_{t1}$		(2) $ACGRADE_{t2}$		(3) $ACGRADE_{t3}$		(4) $ACGRADE_{t4}$	
Independent variable	*B*	*t*	*B*	*t*	*B*	*t*	*B*	*t*
CONSTANT	0.65	0.73	0.16	0.22	0.09	0.12	0.96	1.39
HSGRADE	1.94***	4.83	1.93***	4.63	1.63***	4.03	1.35***	3.54
$(HSGRADE)^2$	–0.34***	–3.46	–3.34***	–3.36	–0.28***	–2.83	–0.22*	–2.37
MATH	–0.05	–0.75	–0.12	–1.60	0.07	1.01	0.10	1.50
ENG	0.06	0.94	0.03	0.38	–0.05	–0.67	0.01	0.25
SOCIAL	0.02	0.30	0.07	0.85	0.07	0.80	0.09	1.19
AGE	–0.03	–1.00	0.00	–0.04	0.02	0.67	0.00	–0.25
GENDER	0.12	1.64	0.05	0.70	0.00	–0.08	–0.08	–1.20
POB	0.27+	1.67	0.27	1.63	0.09	0.55	0.20	1.31
COS	–0.10	–1.18	–0.07	–0.84	–0.07	–0.87	–0.08	–1.05
$R^2/(adj.\ R^2)$	0.40	0.36	0.38	0.35	0.34	0.30	0.33	0.29
F (9, 150)	10.90***		10.41***		8.44***		8.44***	

[a]Dependent variables.
+$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

semesters one to four as dependent variables. The model displays good fit. As indicated by the R^2 values, the model explains between 33% and 40% of the variance in students' grade performance, which corresponds with the findings of other authors (e.g., Anderson et al., 1994; Borde, 1998; Didia & Hasnat, 1998; Gist et al., 1996; Gul & Chun Cheong Fong, 1993; Johnson et al., 2002).

As the regression results show, the most important predictor of the students' academic performance in all four semesters is their grade achievement in high school. This finding provides support for H_1. As students progress from semester one to four, the magnitude of the coefficient on the high-school grade decreases by more than 30%, but high-school performance remains the most powerful predictor of student performance. The fact that the coefficient on the square of the high school grade (*HSGRADE*) variable is significant and negative suggests that academic performance is concave in high school performance. Again, the magnitude of this effect appears to diminish over time. The other variables in the model turn out to be insignificant at a 95% significance level.

Table 4 contains the *p* values of the differences in the adjusted R^2 values between the relevant bootstrap estimates for the early and the more advanced semesters. The bootstrap results presented in Table 4 show whether the observed decline in the adjusted R^2 values of regressions 1 to 4 is statistically significant. This decline is shown to be relatively weak, approaching statistical significance only when comparing the regression with respect to performance in the first semester with the regression for the fourth semester of study. These results imply that the overall explanatory model employed here provides relatively consistent predictive power over time.

However, the development of the coefficients on the *HSGRADE* variable is more relevant to H_2. Table 5 provides the *p* values of the differences in the coefficients on the *HSGRADE* variable between the first and the subsequent semesters.

TABLE 4. *p* Values for the Hypothesis That the Differences in the Adjusted R^2 Values of Regressions (1) – (4) Are Zero

Semester	2	3	4
1	0.25	0.11	0.07⁺
2	—	0.25	0.18
3	—	—	0.42

⁺$p < .10$.

TABLE 5. *p* Values for the Hypothesis That the Differences in the Coefficients of the Average High School Grade (HSGRADE) Variable of Regressions (1) – (4) Are Zero

Semester	2	3	4
1	0.13	0.02*	0.01**
2	—	0.15	0.08⁺
3	—	—	0.25

⁺$p < .10$. *$p < .05$. **$p < .01$.

The results presented in Table 5 suggest that the individual semester-after-semester changes in the coefficients on the *HSGRADE* variable reach significance as students progress into later semesters. Comparing average high-school grades as predictors of students' grade performance at half-year intervals, the results suggest that half a year does not make a significant difference to their predictive power, but two or more half-year steps do. Nevertheless, among the factors included in the analysis, high school grades remain the most important predictors of the performance of students of business administration. These findings confirm H_2.

DISCUSSION

In this study, I examined high-school grades as predictors of the academic grade performance of students enrolled in a business-administration program at a German university. The particular focus of the study was the intertemporal consistency of these predictors. Results show that, among the factors taken into account, high-school grades are the most important predictors of the performance of business administration students. The magnitude of the coefficients on high school grades decreases notably over the 2-year period analyzed here. However, high-school grades continue to be the most important predictors of the students' performance in their academic studies.

Administrators can draw policy recommendations with respect to the use of high-school grades as admission criteria from the study. Educators and administrators should have confidence in using high-school grades in the context of admission decisions. In contrast, the predictive power of some of the alternative methods on which universities and other academic institutions often rely for their admissions decisions, such as interviews, tends to be limited. Interviews and other admission tests are a means for selecting candidates, and serve as public relations instruments and also send out signals to candidates encouraging them to self-select. For these reasons, admission procedures should be multidimensional in design. However, the results of this study suggest that, if high-school grades were disregarded entirely, a valuable predictor of future performance would be lost.

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