Tertiary Entrance Scores: can we do better?

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Abstract

The main measure for predicting students' success at university is their score on the tertiary entrance examinations. In Western Australia this gives equal weight to students' marks in either four or five subjects. Alternative weighting schemes for predicting the academic success of students at the University of Western Australia are considered. While the alternatives examined have better predictive capability than the Tertiary Entrance Score in many instances, the advantages in this regard are minor, and do not seem to match the disadvantages that the alternatives entail.

Introduction

The Australian literature examining academic performance during the first year at university has shown that the main predictor is students' Tertiary Entrance Rank (TER) (see Dobson and Skuja, 2005; Dancer and Fiebig, 2004; Evans and Farley, 1998). For example, Dancer and Fiebig (2004, p.169) state 'TER is widely recognized as a strong predictor of success at University. Our results are consistent with this belief'. Likewise, Evans and Farley (1998, p.4) write 'TER as a general measure of academic ability appeared to have a strong relationship with performance in the more traditional university programs'.

However, this does not mean that the TER is the best predictor of academic performance that can be used. Pascoe *et al.* (1997), for example, are critical of the role of the TER in the Australian university sector, arguing that it is a weak predictor of tertiary academic success. A few Australian studies have reported that when academic performance is examined using students' marks in particular high school subjects in conjunction with their TER, these high school marks are stronger predictors of tertiary academic success than the aggregate measure provided by the TER (see Auyeung and Sands, 1994; Rohde and Kavanagh, 1996; Ramsay and Baines, 1994). This research has concentrated on explaining academic outcomes in business related university courses. Whether the findings carry across to other fields of study at high school and university has been untested to date.

The aim of this study is to examine whether other measures based on high school test results can be used to construct a predictor of first-year academic performance superior to the simple average provided by students' TER.[1] Specifically, it examines whether information on high school performance can be combined in a different way to generate a better predictor of tertiary academic performance than the TER. The study also addresses limitations of the alternatives proposed, with particular emphasis on administrative ease/practicality, and, given the considerable mobility of students across courses of study after they enrol at university, feasibility.

The research is conducted using information on students who commenced studying at the University of Western Australia (UWA) in 2001, having completed high school in Western Australia in 2000. The high school sector in Western Australia is currently undergoing major change, with the curriculum being moved to an outcomes-based approach. While the empirical relationships between student achievement under the new system and academic performance at university will need to be established in the future, the proposed structure for determining a TER under the new system has broad similarities with that used at present.[2] This means the methodology of the current paper will be transferable to analysis of student outcomes following the introduction of the outcomes-based system.

A further issue is the extent to which the findings for UWA, which is one of the more selective universities, in terms of its capacity to attract Year 12 students with high TER scores, will generalise to the tertiary sector as a whole. While this matter cannot be addressed definitively in relation to the specific focus of the current set of analyses without the relevant comparator research, it is noted that findings reported from research into the determinants of first-year marks at UWA are remarkably similar to findings reported for Monash University (Dobson and Skuja, 2005, and the references therein), for another large, comprehensive university in Australia (Birch and Miller, 2005), the analyses of student outcomes for all Australian universities based on the Department of Education, Science and Training's Higher Education Statistics in Birch and Miller (2007b) and also in the British literature (Smith and Naylor, 2005).

The paper is structured as follows. Section II discusses the theoretical model to be employed in the analysis of the determinants of academic success and the findings by previous Australian studies. Section III discusses the data, and the results from the statistical analyses are presented in Sections IV and V. A conclusion is given in Section VI.

Theoretical model and literature

The explanatory variables used in the studies of students' tertiary academic outcomes in Australia by Dobson and Skuja (2005), Dancer and Fiebig (2004) and Birch and Miller (2005), among others, have been largely dictated by the data available rather than by a particular theoretical model. Thus these studies have focussed largely on the role of students' high school results, although information on both the individual student and the high school they attended has been utilised. Despite this generality in approach, it is possible to place the studies in the context of a simple education production function, where a student's university academic performance (AP_i) is modelled as a function of their background characteristics (BC_i), the characteristics of the high school attended (S_i) and their previous academic achievement (PAA_i). The production function for the i^{th} student may be written as:

$$AP_i = f\left(BC_i, S_i, PAA_i\right), \quad i = 1,\ldots n. \qquad (1)$$

A set of background characteristics of the individual (for example, gender, birthplace, English-speaking background) and of the high school attended (for example, school sector), comparable to that of recent research (for example, Dobson and Skuja, 2005; Birch and Miller, 2005) is included in all multivariate analyses presented below. For space considerations, results for these are not reported, though they match reasonably closely those of the comparator studies. Hence, the primary focus in the study is on the links between AP_i and PAA_i.

The most common measurement of students' previous academic achievements (PAA_i) used in Australian studies is the score on university entrance exams (for example, McClelland and Kruger, 1993; Dobson and Skuja, 2005; Dickson *et al.*, 2000). Most studies suggest that there is a strong positive relationship between these scores and marks at university. For example, the review by Birch and Miller (2005) indicates that recent Australian studies show that a one percentage point increase in students' scores on their university entrance exams increases marks at university by three-quarters-to-one percentage point.

A few Australian studies have expanded the measurement of previous academic achievement to include students' marks in high school and enrolment in particular high school subjects as well as their scores on university entrance exams (for example, Auyeung and Sands, 1994; Farley and Ramsay, 1988; Dancer and Fiebig, 2004; Ramsay and Baines, 1994). Some of these studies have found that marks and enrolment in particular high school subjects have a larger impact on performance at university than students' university entrance exams. For example, Ramsay and Baines (1994) report that a one percentage point increase in students' marks in high school accounting was associated with an increase in their marks in first-year university accounting of 1.4 percentage points, whereas a one percentage point increase in their aggregate university entrance score was associated with only a 0.9 percentage point increase in first-year accounting marks.[3] Likewise, Auyeung and Sands (1994) report that, in an examination of the determinants of performance in first-year tertiary business accounting, the estimated coefficient for students' final mark in high school accounting was 0.37 and it was 0.31 for students' score on their tertiary entrance exams.[4]

Data

The key data for estimation of the model outlined above are academic outcomes at university (AP_i) and prior academic achievement (PAA_i). Academic performance at university is measured in these analyses using weighted average first-year marks. While this sums marks in disparate subjects, which may have different means and standard deviations, it is the basis for recent analyses of academic outcomes at university (for example, Dobson and Skuja, 2005; Birch and Miller, 2005), and is being increasingly relied upon in internal university decisions (over prizes and scholarships, for example). Attempts to control for variation in this measure across degree types, due possibly to different marking practices and/or course demands, in the recent analyses by Win and Miller (2005) and Birch and Miller (2007b), indicate that course studied has little incremental explanatory power once university entrance scores are held constant. For example, Win and Miller (2005, p.11) report that '... when course variables were added to the model, few were associated with statistically significant effects, and among those that were, the estimated effects were quite small. Importantly, the underlying results for the remaining variables had no significant changes'. Similarly, using a more extensive set of controls for the course enrolled in, Birch and Miller (2007b) report 'The results from this model indicated that there are small variations in students' weighted average first-year marks according to the type of degree they are enrolled in.... The inclusion of course type in the model of academic performance did not have any major impact on the findings for the other variables in the model.' [5]

Prior academic achievement can be measured using either the Tertiary Entrance Score (TES) that school leaver applicants in Western Australia are generally required to have or the individual subject marks used to form the TES. The TES is an aggregated score of the highest marks that students achieve in their final year of high school. The calculation of the TES depends on the number of Tertiary Entrance Examination (TEE) subjects studied. For the majority of students who study four TEE subjects, the TES is calculated by taking the average of students' best mark[6] in humanities and social science subjects (known as List 1 subjects), their best mark in quantitative science subjects (known as List 2 subjects), and their next two best marks in either List 1 or List 2 subjects. The average mark is then multiplied by 5.1 to give a mark out of 510. If a student has taken more than four TEE subjects, their TES can be calculated by taking the average of their best List 1 subject, best List 2 subject and their next three best subjects and then multiplying this average by 5.1. For these students, their TES is actually the highest score obtained by either using their four best subjects, or by using their five best subjects. Students' entrance to university is achieved by having a Tertiary Entrance Rank (TER) that is equal to or above the minimum rank set by the university. The TER is a rank out of one hundred that orders students' TES as a ranked position relative to other students.

Raw TEE and school marks in Western Australia are subject to statistical moderation, standardisation, and scaling. Moderation ensures that school assessments more fairly reflect the relative standards of achievements of students across schools. Marks on examinations and moderated school assessments are standardised to a benchmark distribution to ensure that students in a particular year are not advantaged or disadvantaged by assessment mechanisms that are easier or more difficult than in previous years. Standardisation of the school assessments and examination results to the same distribution enables their addition into a combined score. Scaling adjusts subject marks to ensure that students are not disadvantaged or advantaged by choosing particular subjects. As the adjusted marks in the various subjects have the same scale, it is valid to combine them into a single index of achievement, which is the TES used in this analysis.[7]

The data for the analyses are from the Student Record Files at the University of Western Australia. These files contain information on students' university characteristics, such as their course type, their demographic characteristics, such as gender, and characteristics of the secondary school attended, such as school type, as well as the students' TERs and their marks for specific TEE subjects. The data sample is comprised of students who commenced university in 2001 and who completed secondary school in 2000. It is restricted to students for whom information is available for four or more List 1 or List 2 high school subjects. The purged sample contains 1,629 students. Further details can be found in Win and Miller (2005) and Birch and Miller (2007a).

Table 1 presents a correlation matrix for four TEE marks and students' TER and TES. The TEE marks are for the required List 1 and List 2 subjects, and the next two best marks. Note that the TER and TES are formed using the marks for the List 1, List 2 and next two best subject marks, and hence high correlation coefficients are expected. What is of more interest in this presentation, however, is the pattern in the correlations across the subject marks included in the table.

All of the correlation coefficients with TER or TES are over 0.6. The variables for highest TEE marks are slightly more correlated with students' TES than with their TER.[8] For example, the correlation between students' TER and their best mark in List 1 subjects (*Hmark1*) is 0.67. It is 0.77 for TER and the best mark in List 2 subjects (*Hmark2*). In comparison, the correlation between students' TES and their best marks in List 1 and List 2 subjects is 0.71 and 0.83, respectively.

Table 1
Correlation Matrix of Students' Marks in TEE Subjects, TER and TES

	Hmark1	*Hmark2*	*Hmark3*	*Hmark4*	*TER*	*TES*
Hmark1	1.000					
Hmark2	0.317	1.000				
Hmark3	0.602	0.733	1.000			
Hmark4	0.535	0.745	0.918	1.000		
TER	0.671	0.770	0.890	0.877	1.000	
TES	0.710	0.825	0.945	0.935	0.938	1.000
Mean	72.797	73.616	71.632	67.387	91.788	363.857

Table 1 also shows that the correlation between the separate TEE marks and students' TER or TES is strongest for students' best TEE subject mark other than their highest marks in List 1 and List 2 subjects (*i.e.* for *Hmark3* and *Hmark4*). Hence the correlation coefficient between students' best marks other than their best mark in the required List 1 or List 2 subjects (*Hmark3* and *Hmark4*) and the TER is 0.89 and 0.88, respectively. This is up to 0.2 higher than the correlation coefficients between the marks in the required TEE subjects (*Hmark1* and *Hmark2*) and the TER. This pattern also occurs in the correlation of marks for individual TEE subjects and students' TES. One interpretation of this is that the TER is a measure of depth of knowledge. We return to this theme below.

A final feature of Table 1 is the relatively low correlation between the highest marks in List 1 (humanities and social science subjects) and List 2 (quantitative science subjects). This is only 0.32, compared to the other 'between subject' correlations of 0.54 or higher. *Hmark1* and *Hmark2* are the only marks that are quarantined to a particular subject list. The low correlation is indicating that success in the qualitative science subjects does not imply success in the humanities and social science subjects. Presumably different skills or aptitudes are required for success in these subjects.

The relatively high correlation coefficients between pairs of high school subject marks in Table 1 indicates that, when examining their potential for predicting academic success at university, the independent information of each high school subject may be modest. This has a major bearing on the results of the analyses presented below. Nevertheless, the correlation coefficients are less than one, indicating that each subject mark contains independent information. In other words, the use of more than one high school subject mark when modelling academic outcomes at university should lead to better predictions than where only such mark is employed. This is why past studies have generally used the TES. The research question addressed in the next section is whether the TES uses this information in the most effective way.

University-wide analyses

In Section II it was proposed that university academic performance (AP_i) could be explained within a multivariate regression framework using the background characteristics of students (BC_i), the characteristics of the high school they attended (S_i) and their previous academic achievement (PAA_i), namely:

$$AP_i = f(BC_i, S_i, PAA_i). \tag{1}$$

As noted above, while variables for the background characteristics of students and for the high school they attended are included in the model, they are not the central focus of this analysis, and the results for them are not reported here.[9] Interested readers are referred to Birch and Miller (2005 and 2007a) and Win and Miller (2005). Instead, the model of students' first-year academic performance considered in this section focuses on measures of students' prior academic achievements (PAA_i). The first specification is the most general that could be considered. It includes the final marks for students' best List 1 subject (*Hmark1*), final marks for their best List 2 subject (*Hmark2*) and final marks in their next best two subjects from either List 1 or List 2 (*Hmark3* and *Hmark4*, respectively) in the estimating equation.[10] The second model replaces these four individual subject marks by students' TES (*TES*).[11] As the *TES* gives equal weighting to each high school subject, this specification is essentially saying that the links between the marks in each of the high school subjects used to compute the *TES* and university academic outcomes are the same.

That is, the first model is:

$$AP_i = \alpha_0 + \alpha_1 Hmark1_i + \alpha_2 Hmark2_i + \alpha_3 Hmark3_i + \alpha_4 Hmark4_i + \ldots \quad (2)$$

If $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$, then this equation can be written as:

$$AP_i = \alpha_0 + \alpha_1 (Hmark1_i + Hmark2_i + Hmark3_i + Hmark4_i) + \ldots \quad (3)$$

$$AP_i = \alpha_0 + 4\alpha_1 (0.25 Hmark1_i + 0.25 Hmark2_i + 0.25 Hmark3_i + 0.25 Hma \quad (4)$$

$$AP_i = \alpha_0 + 4\alpha_1 (TES_i) + \ldots \quad (5)$$

Where $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4$, equation (3) will not be valid. However, as the estimating equation may be written as:

$$AP_i = \alpha_0 + \alpha_1 (Hmark1_i + \frac{\alpha_2}{\alpha_1} Hmark2_i + \frac{\alpha_3}{\alpha_1} Hmark3_i + \frac{\alpha_4}{\alpha_1} Hmark4_i) + . \quad (6)$$

it is possible to construct a valid aggregate index of students' high school subject marks by using the estimated regression coefficients from the most general model of equation (2). This is the basis for the other specifications of the model of university outcomes that are developed, and discussed below. Essentially, by placing more weight on any individual subject mark that has a relatively high partial effect on university academic outcomes, the covariance of the constructed index with university academic outcomes should be enhanced and hence a stronger model obtained. The gains in terms of proportion of the variation in university academic outcomes explained will be bounded by that obtained with the single subject mark having the smallest partial effect on university academic outcomes (*Hmark1* which is associated with an R^2 of 0.169[12]) and that in the most flexible model of equation (2), which is shown below to be associated with an R^2 of 0.310.

Column (*i*) of Table 2 presents the results from the estimation of the determinants of academic success when the model includes information on students' marks in each of their best four TEE subjects (see equation (2) above). The main aim of this exercise is to establish whether the four subjects have the same associations with first-year academic performance, as the method of constructing the *TES*, which assigns equal weight to the four marks, implies. A second aim is to obtain the weights for the alternative aggregate index outlined in equation (6). The R^2 in this model is 0.310, indicating that only around three-tenths of the variation in first-year university marks can be accounted for by the variables in the model (see footnote 9). Similar R^2 values have been reported in the comparator research, and the remaining seven-tenths of the variation is presumably due to study habits, market work commitments, motivation, luck and related factors.

Each of the separate TEE subject marks variables has a positive coefficient in the model of first-year academic performance. In particular, a one percentage point increase in *Hmark1* is associated with a 0.15 of a percentage point increase in the weighted average first-year mark at university. One percentage point increases in *Hmark2*, *Hmark3* and *Hmark4* are associated with increases in the weighted average first-year mark of 0.22, 0.16 and 0.24, respectively. Hence, this preliminary assessment of the data seems to indicate that subjects taken in the TEE are not all associated with the same change in the weighted average first-year mark at university. Moreover, the fact that the greatest partial effect is associated with *Hmark4* introduces the importance of breadth of knowledge as a key to success at university.[13] Tests showed, however, that the coefficients of the four separate TEE marks on performance at university do not differ statistically.[14] Nevertheless, the variation apparent in their coefficients in Table 2 may provide the basis for the construction of a better aggregate predictor of success at university.

Column (*ii*) of Table 2 presents the results from the model estimated with the inclusion of students' *TES* as the measure of prior academic success. The *TES* is a strong predictor of their marks in first year university, with a one percentage point increase in students' *TES* resulting in a 0.8 percentage point increase in their average first-year marks at university. As discussed above, this nearly one-to-one relationship is consistent with the findings in many recent Australian studies on the determinants of academic performance. The R^2 in this model, at 0.308, is only slightly less than that of the more general model of column (*i*). The adjusted R^2, which takes account of the number of explanatory variables in the model, is the same as for the column (*i*) specification. In other words, as expected given the equality of the regression coefficients on the separate TEE subject variables, the *TES* variable is an effective summary indicator of prior academic achievement.

Table 2

Results for Prior Academic Achievement Variables in Models of First-Year Academic Performance

	Column (i)[a]	Column (*ii*)	Column (*iii*)
TES: *TES*	(b)	0.780 (23.07)***	(b)
Marks in TEE Subjects: *Hmark1*	0.151 (4.47)***	(b)	(b)
Hmark2	0.221 (5.98)***	(b)	(b)
Hmark3	0.156 (2.14)**	(b)	(b)
Hmark4	0.241 (3.74)***	(b)	(b)
Weighted Marks in TEE Subjects: *ATES*	(b)	(b)	0.769 (23.18)***
	Mean Mark = 63.429 R^2 = 0.310 Adjusted R^2 = 0.305 *F*-test = 72.54 Sample Size = 1,629	Mean Mark = 63.429 R^2 = 0.308 Adjusted R^2 = 0.305 *F*-test = 102.99 Sample Size = 1,629	Mean Mark = 63.429 R^2 = 0.310 Adjusted R^2 = 0.307 *F*-test = 103.82 Sample Size = 1,629

Notes: [a] The absolute t-statistics are in parentheses. The symbols *** and ** represent significant at the 1 percent and 5 percent level. [b] Not included in the model.

Column (*iii*) lists results obtained using the alternative weighted average of *Hmark1*, *Hmark2*, *Hmark3* and *Hmark4*, with the weights being given by the relative contributions of each mark to first-year performance at university (*i.e.* the coefficients on these variables in Table 2, column (*i*)).[15] Because more weight is given to subject marks that are more closely linked to first-year university outcomes under *ATES* than under *TES*, the covariance between the former measure of tertiary entrance success and first-year university outcomes will be higher than is the case with the latter measure of tertiary entrance examination success. However, as the statistical test could not reject the hypothesis that the estimated coefficients in the more general model of column (*i*) were the same, the potential for gains in this instance are slight.

The R^2 in the model of column (*iii*) is, by construction, the same as that for column (*i*). The adjusted R^2 is, reflecting the three fewer explanatory variables, slightly higher. It is also slightly higher than that of the model based on the *TES*. However, as the difference is very minor, a reasonable conclusion is that the explanatory power of this new specification does not differ appreciably from that based on *TES* as the measure of previous academic achievement. Moreover, the partial effects of the alternative measures of prior academic achievement are similar, and there does not appear to be any heterogeneity in student performance that is being averaged out inappropriately in the simple average provided by the *TES*: the correlation between the predicted values from the models based on, respectively, *TES* and *ATES*, is 0.999.

At the aggregate level, therefore, it is possible to construct a variable (*ATES*) that is statistically superior to the *TES* (or TER).[16] However, and again at the aggregate level, this statistically superior variable does not appear to offer any practical advantages, at least from the perspective of predicting academic outcomes during the first year at university.

Course-level analyses

While the *TES* (TER) appears to be a very useful measure at the aggregate level, it is possible that the components used to construct it could vary in their impacts when separate university courses are considered. This is because the relationship among the achievements in the four subjects used to compile the *TES* varies appreciably by type of course studied. This is shown by correlation matrices compiled for the separate groups of students studying Arts, Economics/Commerce, Law, Science and Engineering, as reported in Table 3.

These correlation coefficients have the main features of the aggregate-level correlations presented in Table 1. Thus, the correlation between *Hmark1* and *Hmark2* is relatively low (between 0.16 and 0.38). The correlation between *Hmark3* and *Hmark4* is very high within each course (between 0.85 and 0.95). Furthermore, the correlations between

TES and *Hmark3* and *Hmark4* are higher than the correlations between *TES* and the 'required marks' in the List 1 and List 2 subjects (*i.e.* *Hmark1* and *Hmark2*).

Despite these broad similarities, there are several striking differences across the marks in the subjects that were used to form the *TES*. First, the correlations between the highest mark in a List 2 subject (*Hmark2*) and the highest two marks in subjects other than the best marks in List 1 and List 2 subjects vary by course type. These correlations are particularly high for Science and Engineering students – presumably because of a preponderance of quantitative subjects in the non-required units.[17]

Second, the correlations between *Hmark1* and *Hmark3* and *Hmark4* also vary by course of study. These correlations are much higher for Arts degree students than for those enrolled in other courses. This pattern is presumably because of a preponderance of humanities and social science subjects among the non-required units for students selecting into the Arts degree.[18] Related to this is the higher correlation between *Hmark1* and TES for the Arts degree than for the other courses.

The different patterns evident among the correlation coefficients presented in Table 3 suggest that the amount of independent information contained in each of the 'highest marks' variables varies by type of course. The extent to which these variables can be used to predict academic outcomes during the first year at university could also differ across the courses. This possibility is explored below.

The models presented in Table 2 were estimated for the separate degree types identified in Table 3. Selected results are presented in Table 4.

Table 3 - *Correlation Matrix of Students' Marks in TEE Subjects, TER, TES and ATES, by Selected Courses*

Arts Degrees (Sample Size[a] = 343)

	Hmark1	*Hmark2*	*Hmark3*	*Hmark4*	*TER*	*TES*	*ATES*
Hmark1	1.000						
Hmark2	0.375	1.000					
Hmark3	0.800	0.526	1.000				
Hmark4	0.680	0.568	0.859	1.000			
TER	0.762	0.717	0.853	0.847	1.000		
TES	0.828	0.723	0.927	0.909	0.934	1.000	
ATES	0.667	0.930	0.761	0.786	0.884	0.932	1.000
Mean	76.596	68.626	71.520	66.272	91.532	360.845	70.123

Economics/Commerce Degrees (Sample Size = 477)

	Hmark1	*Hmark2*	*Hmark3*	*Hmark4*	*TER*	*TES*	*ATES*
Hmark1	1.000						
Hmark2	0.347	1.000					
Hmark3	0.632	0.725	1.000				
Hmark4	0.596	0.700	0.859	1.000			
TER	0.707	0.763	0.886	0.869	1.000		
TES	0.743	0.818	0.994	0.928	0.940	1.000	
ATES	0.692	0.882	0.888	0.912	0.924	0.985	1.000
Mean	74.553	74.837	72.684	68.557	93.147	370.487	72.578

Law Degrees (Sample Size = 122)

	Hmark1	*Hmark2*	*Hmark3*	*Hmark4*	*TER*	*TES*	*ATES*
Hmark1	1.000						
Hmark2	0.155	1.000					
Hmark3	0.597	0.571	1.000				
Hmark4	0.497	0.650	0.848	1.000			
TER	0.600	0.654	0.817	0.761	1.000		
TES	0.668	0.761	0.914	0.914	0.869	1.000	
ATES	0.478	0.937	0.770	0.783	0.810	0.929	1.000
Mean	85.771	81.293	83.169	78.829	97.973	419.218	82.692

Science Degrees (Sample Size = 599)

	Hmark1	*Hmark2*	*Hmark3*	*Hmark4*	*TER*	*TES*	*ATES*
Hmark1	1.000						
Hmark2	0.366	1.000					
Hmark3	0.499	0.834	1.000				
Hmark4	0.463	0.829	0.941	1.000			
TER	0.654	0.828	0.903	0.885	1.000		
TES	0.668	0.882	0.951	0.940	0.950	1.000	
ATES	0.609	0.893	0.953	0.968	0.941	0.994	1.000
Mean	70.155	74.405	70.481	66.468	91.009	358.864	69.539

Engineering Degrees (Sample Size = 280)

	Hmark1	*Hmark2*	*Hmark3*	*Hmark4*	*TER*	*TES*	*ATES*
Hmark1	1.000						
Hmark2	0.364	1.000					
Hmark3	0.397	0.898	1.000				
Hmark4	0.377	0.858	0.948	1.000			
TER	0.663	0.814	0.861	0.836	1.000		
TES	0.664	0.898	0.933	0.915	0.921	1.000	
ATES	0.410	0.901	0.977	0.992	0.865	0.945	1.000
Mean	72.575	81.893	78.104	75.298	96.063	392.575	76.603

Notes: (a) The sample sizes do not sum to the total in the sample (1,629 students) as students can study more than one type of degree and not all courses, such as Medicine and Music, have been examined due to small sample sizes.

Table 4
Results for Prior Academic Achievement Variables in Models of First-Year Academic Performance by Course Studied, Selected Courses

Measure of Prior Academic Performance	Arts[a]	Economics/ Commerce	Law	Science	Engineering
TES: *TES*	0.626 (6.40)***	1.023 (14.36)***	0.737 (8.80)***	0.970 (14.43)***	1.166 (11.76)***
Marks in TEE Subjects: *Hmark1*	0.157 (1.36)	0.265 (4.03)***	0.170 (1.93)*	0.174 (3.25)***	0.022 (0.35)
Hmark2	0.385 (4.91)***	0.429 (6.39)***	0.431 (5.85)***	0.233 (2.91)***	0.111 (0.72)
Hmark3	0.005 (0.03)	-0.048 (0.37)	0.109 (0.75)	0.104 (0.74)	0.299 (1.17)
Hmark4	0.116 (0.85)	0.370 (3.25)***	-0.007 (0.05)	0.436 (3.38)***	0.726 (3.29)***
Weighted Marks in TEE Subjects: *ATES*	0.662 (7.21)***	1.016 (14.89)***	0.704 (9.99)***	0.947 (14.57)***	1.158 (13.45)***
R^2 for model with TES	0.169	0.395	0.443	0.374	0.421
R^2 for model with high school marks	0.192	0.408	0.500	0.377	0.476
R^2 for model with ATES	0.192	0.408	0.500	0.377	0.476
Adjusted R^2 for model with TES	0.151	0.386	0.413	0.366	0.406
Adjusted R^2 for model with high school marks	0.168	0.396	0.460	0.366	0.456
Adjusted R^2 for model with ATES	0.175	0.400	0.474	0.369	0.462
F-test for model with TES	9.71	43.73	15.21	50.38	28.27
F-test for model with high school marks	7.90	32.18	12.46	35.56	24.41
F-test for model with ATES	11.39	46.27	19.20	51.06	35.26
	Sample Size = 343	Sample Size = 477	Sample Size = 122	Sample Size = 599	Sample Size = 280

Notes: [a] The absolute t-statistics are in parentheses. The symbols *** and * represent significant at the 1 percent and 10 percent level.

The coefficients on the measures for students' prior academic achievements (*i.e. TES, Hmark1, Hmark2, Hmark3, Hmark4* and *ATES*) in the model of first-year university marks differ across the courses examined. As shown in Table 4, students' *TES* has a considerably larger association with academic performance in Engineering degrees (estimated coefficient of 1.2) than it has in Arts degrees (estimated coefficient of 0.63). There is no obvious pattern (other than the name of the degree!) in the magnitude of the coefficients on the *TES* variable. For example, the mean *TES* in Arts, Economics and Commerce and Science degrees is between 360 and 370 (see Table 3) and yet the estimated coefficient on the *TES* variable ranges from 0.63 to 1.03 for these courses. Law and Engineering have the two highest mean *TES*, yet they have the highest (Engineering, at 1.17) and second lowest (Law, at 0.74) coefficients on the *TES* variable in the model of first-year university outcomes. A reasonable conclusion is that the link between first-year university results and the *TES* is course specific.

Table 4 also shows that the four separate TEE marks variables considered are associated with larger estimated coefficients for some courses than for other courses. A useful way of discussing the findings is to focus separately on the required marks in List 1 and List 2 subjects, and the marks in the remaining TEE subjects. For the required List 1 and List 2 subjects (*Hmark1* and *Hmark2*), the partial effects are greater in Economics and Commerce, Law, Science and, to a lesser extent, Arts than in Engineering. For the non-required subjects, *Hmark3* is consistently insignificant, and *Hmark4* is a strong predictor of first-year academic achievements in Engineering, Science and Economics and Commerce courses but not in Law or Arts courses. Unlike the situation in the aggregate-level analysis above, the hypothesis that the coefficients on the four separate TEE subject marks are the same is rejected in this course-level analysis in the case of each course other than for Science.

This statistically significant variation in the impacts of *Hmark1*, *Hmark2*, *Hmark3* and *Hmark4* within four of the five courses examined suggests that the information content of students' performance in the specific TEE subjects for predicting academic outcomes at university may be able to be exploited to provide a university entrance score superior to the TES. While this alternative university entrance score would, by construction be course-specific, the results of Table 4 (where the impacts of each subject mark and of the TES typically differ across the five courses) clearly suggest that a single selection mechanism might not be the most useful approach for university admission. This is already recognised, to some extent, by the use of alternative admission tests for Medicine, Dentistry and Music.[19]

The ex post encompassing measure of TEE success, *ATES*, was formed for each course using the coefficients on the four 'Hmark' variables from Table 4. In some instances, (for example, *Hmark3* for Arts) this gives a weight that is effectively zero to a component that has a weight of 0.25 in the *TES*. In other cases (*Hmark3* for Economics and Commerce, *Hmark4* for Law) a negative weight is called for.[20]

In the case of the Science course, where the estimated impacts of the subject marks were the same, there is no gain from pursing this alternative TES. This is shown in the miniscule change in the R^2

between the models based on the *TES* and *ATES*. For the other four courses there are changes in the R^2 of between 0.023 (Arts) and 0.055 (Law and Engineering). Given the low values of the R^2 in the first place, these apparently small gains in explanatory power should not be dismissed too quickly. However, the predictions using the *ATES* variable are highly correlated with the predictions using the *TES* variable for each of the courses, with the correlation coefficient between these predictions ranging from 0.936 (Arts) to 0.993 (Science). As with the aggregate-level analysis, the ex post (*ATES*) measure does not appear to offer any advantages over the ex ante (*TES*) measure.

Various extensions of this approach were considered, and detailed results are available from the authors. The first involved analysis where achievement in TEE English and mathematics was linked to first-year university marks separately from the marks in other TEE subjects. The second involved the use of information on high school performance in specific subjects that were closely related to the field of university study (for example, economics for a Commerce degree). These extensions did not lead to any material improvement in the ability of the model to predict tertiary outcomes. Thus, no matter how high school marks are entered into the specification, the general conclusions appears to be the same – one based on the *TES* is just as good as the next such model. In other words, while the covariance between the measure of tertiary entrance examination success and first-year university outcomes can be enhanced though placing more weight on subjects that appear to have stronger links, as established through partial regression coefficients, with first-year academic outcomes, the gains from this are limited by the correlations between the separate TEE subject marks.

Summary and conclusion

The *TES* is an aggregate indicator of success in high school. It gives an equal weight to four or five different subjects, at least one of which must be in the humanities and social sciences and one must be in the quantitative sciences. There are some indications that the *TES* provides an indicator of breadth of knowledge.

In the first year of study at university, students typically enrol in eight units, often across a wide range of subject areas. There are positive relationships between students' academic performance in these subjects and their *TES*. These relationships, however, vary according to the subjects studied in high school. Nevertheless, it appears that recombining the marks achieved in individual TEE subjects in an (ex post) optimal way, or indeed focussing only on specific TEE subjects, does not offer any practical advantages over the use of the *TES* (or equivalently the TER) in university admission decisions in the university-wide analyses presented in this study. Can we do better than the use of Tertiary Entrance Scores in university admission decisions? The answer on the basis of the analyses presented above is no.

It was established, however, that there was scope to improve the predictive capability of the aggregate indicator of TEE success for specific courses of university study by recombining the marks achieved in individual TEE subjects in an (ex post) optimal way. While the superiority of the *ATES* variable was established for four courses (Arts, Law, Economics and Commerce, Engineering), the predictions obtained from the model were very similar to those obtained with the usual *TES* variable. Thus, the gains from the use of this alternative measure are more apparent than real. Moreover, there are a number of additional arguments against attempting to exploit the empirical relationships established in this paper. The first concerns student mobility across faculties. Once students arrive at university they often attempt to transfer between courses, or even change institutions. From this perspective, having multiple entrance mechanisms has the potential to be counterproductive. The second chief concern is the administrative burden associated with multiple entrance scores, particularly in a setting where they appear to offer minimal advantages in terms of predicting student potential for academic success at university. So, in answer to the question of whether we can do better than the use of the *TES* in university admission decisions, a more appropriate answer is an empathic no.

The results presented above are, of course, limited by the information currently available on the student record systems. Research could extend the current study to include other measures of prior academic achievements, such as scores on aptitude tests, and to examine the merits of the range of issues noted in Footnote 1.

The analyses in this study are also limited by the fact that they are based only on one Group-of-Eight (Go8) university in Western Australia. It was argued in Section I that findings on the determinants of first-year marks at the University of Western Australia have been remarkably similar to findings reported for other universities, including Monash University (Dobson and Skuja, 2005 and Evans and Farley, 1998). Monash University is sometimes described as a 'microcosm of the higher education sector in Australia' (Evans and Farley, 1998, p. 2). Research should, however, be undertaken for a wide set of universities to ensure that the findings reported here are not institution specific.[21]

APPENDIX

Table 5
Description of the Variables Used in Models of the Determinants of Students' First-Year Academic Performance

Variable/ Code	Description	Mean	Std Dev.
Dependent Variable			
Mark	The average first-year mark for each unit of study, weighted by the relative contribution of the unit in the students' course. It is a continuous variable measured as a mark out of one hundred.	63.549	11.568
Independent Variables			
Gender:			
Female	Dummy variable for female students (male students form the omitted category).	0.519	0.500
Locality:			
Noncity	Dummy variable for students from outside the capital city of Western Australia (students from the capital city form the omitted category).	0.131	0.338
Socioeconomic Status:			
Index	A continuous variable for the socioeconomic status of students' home neighbourhoods derived from the Australian Bureau of Statistics' *Index of Economic Resources.*	1048.825	75.830
School Type:			
Catholic	Dummy variable for students who attended a Catholic secondary school (students who attended Government secondary schools form the omitted category).	0.242	0.428
Independent	Dummy variable for students who attended an Independent secondary school (students who attended Government secondary schools form the omitted category).	0.356	0.480
Degree Type:			
Double	Dummy variable for students who are studying a double degree (students who are studying a single degree form the omitted category).	0.300	0.458
TER			
TER	Continuous variable for students' TER.	91.788	8.389
Marks in TEE Subjects:			
Hmark1	Continuous variable for the final mark in students' best List 1 subject in high school.	72.797	9.528
Hmark2	Continuous variable for the final mark in students' best List 2 subject in high school.	73.616	10.233
Hmark3	Continuous variable for the final mark in students' best subject in high school other than their best List 1 or best List 2 subject.	71.632	9.062
Hmark4	Continuous variable for the final mark in students' second best subject in high school other than their best List 1 or best List 2 subject.	67.387	9.765
Weighted Marks in TEE Subjects:			
ATES	A derived variable of students' final marks in high school. It is a continuous variable that is the average of *Hmark1, Hmark2, Hmark3* and *Hmark4*, scaled by the relatively contribution of each mark to first-year academic performance.	71.093	5.820

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NOTES

1. While several Australian researchers have recommended that students' TER score should be used in conjunction with other criteria, such as high school aptitude tests (Everett and Robins, 1991), school type (Dobson and Skuja, 2005), work experience (West and Slamowicz, 1976), interviews and school reports (Pascoe *et al.*, 1997; Levy and Murray, 2005) to predict potential for university study, these more extensive issues are not explored in the current paper.
2. There are a number of differences, such as the elimination of the List 1 and List 2 requirements, and changes in acceptable course combinations. However, the overall structure will be similar to that used at present, and described below.
3. The model used in this study contained a dichotomous variable for whether the student took high school accounting, their final mark in high school accounting, their university entrance score and an interaction term between whether they took high school accounting and their university entrance score.
4. In this study, the mark for high school accounting is a continuous variable derived from grades in high school accounting, where the grade 'very high achievement' is given a mark of 5, 'high achievement' is given a mark of 4, 'sound achievement' is given a mark of 3, 'low achievement' is given a mark of 2 and 'very low achievement' is given a mark of 1. Students who did not take accounting in high school are given a mark of zero. The model estimated included both the mark in high school accounting and the university entrance score.
5. In the Birch and Miller (2007a) study, students enrolled in the degrees of Arts, Arts/Education, Arts/Music, Fine Arts, Horticulture, Landscape Architecture and Social Work had slightly higher first-year marks than the reference group of students enrolled in Science degrees. Students studying Arts/Commerce, Commerce, Computer and Mathematical Science, Health Science, Engineering, Law, Medicine, Science/Economics and a residual group of all other courses had lower marks than Science students. Students enrolled in Agriculture, Music, Natural Resource Management, Arts/Economics, Computer and Mathematical Science/Science, Animal Science and Economics had first-year marks similar to that of their counterparts studying Science.
6. Students' marks are comprised of two components: (i) their final mark in school assessments of the high school subject and (ii) the mark obtained in the external assessment (known as the TEE) of the high school subject. Each component is given an equal weight.

7. Note that these remarks are best viewed as 'in principle' comments. There has been healthy debate over whether the scaled marks in various subjects are comparable. Further details can be obtained from the Curriculum Council of Western Australia: http://www.curriculum.wa.edu.au.
8. This is expected, as the TER compresses the upper-tail of the TES.
9. All models used to estimate the determinants of academic success include variables for gender, locality, socioeconomic status of the students' home neighbourhoods, school type, and for double degree students. The results for these variables are available from the authors.
10. Descriptions, and the means and standard deviations, of all the variables used in the model of tertiary academic performance are presented in Table 5 in the Appendix.
11. Student's TES is entered in the model as a normalised TES, where their actual score is divided by 5.1, to give a mark out of one hundred.
12. This would arise in the extreme case where all weight in the aggregate index was placed on *Hmark1* and no weight on any of the other three subject marks.
13. Note that if only *Hmark1* is included in the estimating equation then the R2 is 0.169. If only *Hmark2* is used the R2 is 0.237, and it is 0.278 when only *Hmark3* is used and 0.279 in the case where the focus in only on *Hmark4* (results not reported here, but available from the authors). Hence, this shows that (i) the information content for predicting academic success at university varies across the four high school subject marks; (ii) there is advantage to using the information from more than one subject mark when attempting to account for success at university; and (iii) due to the correlations between the subject marks, the incremental gain in explanatory power from using more than one high school mark is not always huge. The model that does not contain any information on TEE results has an R2 of 0.08.
14. The test used was a F test of the null H0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$ in equation (2).
15. Note that the weights are scaled to sum to one, to mirror the weights in the construction of the *TES*.
16. It is possible to form a nested model that includes both the *TES* and *ATES* variables. Given the method of construction, this should show a preference for the *ATES*, and this is what is revealed by such an approach with the university-wide data.
17. Approximately 70 percent of Science students' and 94 percent of Engineering students' *Hmark3* and *Hmark4* were from mathematics and science subjects.
18. Around four-fifths of students studying Arts used scores from humanity or social science subjects for their '*Hmark3*' and around two-thirds used these subjects for their '*Hmark4*'.
19. At the University, entry to Music degrees is obtained by successfully auditioning for the course, combined with achieving a TER score above the minimum cut-off rank. The selection criteria used in Medicine and Dentistry includes a relevant TER score, a relevant score on national admission tests to study medicine and dentistry, and an interview process.
20. It is recognised that a negative weight would be difficult to present publicly, and in practice a zero weight might be used. The negative weights are used here to present the strongest possible case for the alternative TES measure.

21. Findings reported by Birch and Miller (2007b), based on data from the Department of Education, Science and Training's Higher Education Statistics collection, suggests that the determinants of students' performance in the first year of university for all first year students in Australia are similar to those for students at specific institutions reported in the existing Australian literature.