THE IMPORTANCE OF MATHEMATICS BACKGROUND AND STUDENT PERFORMANCE IN A PROPERTY DEGREE

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ABSTRACT

This paper investigates the relative importance of a wide range of academic and personal variables that may impact on student performance in a property degree. In particular, the importance of the property students' mathematics background and prior knowledge is assessed. Using a multi-year data set over 2006-2010, regression analysis (OLS) and quantile regression analysis are used to quantify the marginal learning effects of specific variables, including mathematics background. This issue is assessed at the overall property student performance level (Grade Point Average (GPA) on completion of property degree) and at the individual property subject level (3 valuation subjects). Mathematics background is seen to be an important determinant of success in the property degree; particularly in the more advanced valuation subjects requiring cashflow analysis. The property education implications are also highlighted.

Keywords: Property student performance, mathematics background, GPA, significant factors, OLS regression analysis, quantile regression

INTRODUCTION

Property education has been in the Australian university sector for over 35 years. Most property degrees have a strong property industry focus, meeting the professional accreditation requirements by the API and RICS, as well as valuation registration requirements. However, by 2025, it is expected that the percentage of 25-35 year olds in Australia having obtained a university degree will increase from the current level of 29% to 40% (Commonwealth of Australia, 2009; DEEWR, 2008). This increased participation target will have a significant impact on universities and students, including lower admission standards, concerns over retention rates, need for remedial work (eg: mathematics), increased costs and the need for innovative delivery approaches for effective learning. This clearly impacts the ongoing quality of university property programs and the ability of university property programs to meet professional recognition requirements for the property industry.

A key factor that will also impact on this increased university participation strategy is evidence of declining mathematics ability amongst Australian students. This has seen reduced mathematics ability in recent years, both at an Australian level and benchmarked internationally, with Australia currently ranked only 15th globally compared to 12th in 2006 (OECD, 2010; IAEEA, 2008). This is further supported by a trend by students to select the easier mathematics options in Year 12. This has seen a 25% decline in students selecting intermediate/advanced mathematics options in Year 12 over 1995-2007, and a 30% increase in students selecting the more elementary general mathematics option (Group of Eight, 2009). Similarly, the percentage of students doing mathematics in the Higher School Certificate[1] (HSC) has reduced from 99.7% of the cohort to 87.1% over 2001 – 2009 (NSW BSE, 2010). This raises both quality and quantity issues regarding the mathematics background of students as they undertake property degrees in Australian universities.

This takes on specific significance, given evidence of improved property student perceptions of teaching quality and increased overall satisfaction with their property education at university in recent years (Newell et al, 2010), the increased use of innovative learning strategies in property degrees (Cornish et al, 2009; Yam et al, 2010) and the importance of graduates' professional socialisation (Blake and Susilawati, 2009; Everist et al, 2005; Page, 2008).

The purpose of this paper is to empirically assess the relative importance of a range of academic and personal variables that may impact on student performance in a property degree. In particular, in the context of these declining mathematics standards, the importance of the property students' mathematics background is empirically assessed; both at the overall property degree performance level and at the individual property subject level. The property education implications in the light of the proposed increased Australian university participation processes are also highlighted.

DETERMINANTS OF ACADEMIC SUCCESS

Evaluating potential determinants of students' academic success at university has been researched over the last 25 years. This has largely focused on business, finance and economics students (eg: Birch and Miller, 2006; Chan et al, 1997; Didia and Hasnat, 1998; Ely and Hittle, 1990; Johnson et al, 2002; Mallik and Basu, 2009; Mallik and Lodewijks, 2010; Mallik and Varua, 2008; Sen et al, 1997). Only one study (US) has been done in this area of academic success regarding property students (Allen and Carter, 2007).

[1] The Higher School Certificate is the NSW examinations process conducted at the end of Year 12 and is the primary selection process for university admission.

Typically, these potential determinants of academic success are classified into intellectual and non-intellectual factors. Intellectual factors include academic factors such as academic achievement prior to university (eg: Universities Admission Index (UAI), Australian Tertiary Admission Rank[2] (ATAR), subjects studied such as mathematics, English and economics), while non-intellectual factors include demographic, behavioural, personality and study habits (eg: gender, age, ethnicity, motivation and confidence, time spent in class, exam and assignment preparation, outside work activities). In most cases, these studies used regression-based analyses to isolate the role of specific success factors, and intellectual factors were seen to be more significant than the non-intellectual factors in determining success at university. The importance of intellectual factors was clearly evident in the previous study of US property students' academic success (Allen and Carter, 2007).

METHODOLOGY

Student performance

The performance of property degree students at the University of Western Sydney (UWS) over 2006-2010 was assessed in this study. UWS is a major Australian university, having offered property programs for 35 years. The UWS property degree is accredited by the API for membership, meeting Certified Practicing Valuer (CPV) requirements as well as meeting NSW Office of Fair Trading requirements for valuation registration. Specific details regarding UWS and the UWS property degree are given in Table 1.

Overall property degree level performance was assessed using the Grade Point Average (GPA) for 295 property students graduating over 2006-2010. Individual property subject level performance was assessed using the final exam mark[3] for students in the property subjects in the first three semesters of the property degree over 2006-2010; namely:

- Introduction to Property (semester 1): # students = 406
- Principles of Valuation (semester 2): # students = 145
- Commercial Valuation (semester 3): # students = 220.

[2] The Universities Admission Index is the ranking process based on the HSC results for students seeking to enter university. Each university course typically has a minimum UAI required for entry; eg: UAI=70 sees the student in the top 30% of the eligible HSC cohort. In 2009, the UAI was replaced by the ATAR which is an equivalent ranking process for university admission.

[3] Final exam mark for students was used as a purer measure of individual student performance to avoid less individual aspects of assignment work.

Table 1: UWS and property degree profile: 2010

UWS profile

Number of students: 37,400

Number of staff: 2,550

Students from Greater Western Sydney: 62%

Undergraduate students: 76%

Students <25 years old: 66%

International students: 12%

College of Business and Law students: 11,180 (30%)

UWS property degree profile

3-year property degree offered both full-time and external

Property degree located in School of Economics and Finance in College of Business and Law

API accredited property degree

Focus on valuation, as well as property investment, property finance, property development, commercial property management, property law, building; and generic business subjects

Property-specific subjects in degree: 17/24 (71%)

Two hundred (200) students in Year 1

Number of property-specific full-time staff: 6

Significant property industry support

Masters by coursework and PhD programs in property also available

These three subjects were selected as they comprise the sequence of the first three property valuation subjects undertaken and provide the property "building block" for all subsequent property subjects in the property degree, and also reflect increasing mathematical complexity; namely:

- Introduction to Property: non-quantitative; focus on reports
- Principles of Valuation: introduces mathematics of finance concepts
- Commercial Valuation: focus on cashflow analysis and use of discounting procedures.

Survivor bias is always an unavoidable characteristic of this type of student success performance study, as they are inherently based on only those students who complete the subject or degree (Becker and Andrews, 2004). This sees certain students omitted from the analysis and this includes both "censoring" issues (eg: students withdrawing from subject part-way through semester) and "truncating" issues (eg: students withdrawing from degree completely). Censoring occurs where the student's details are available, but no final result in the subject is available. This may come about because of their poor performance in the subject, where they choose to abandon the subject prior to doing all of the assessment, rather than being seen to have failed the subject. Truncating occurs where a student withdraws from the entire degree prior to completion or where they are dismissed from the degree by the university for consistent poor performance. The exclusion of both of these censored or truncated student cohorts from the analysis can lead to potentially biased results. Similarly, this analysis can not be directly replicated across Australian universities due to different property degree structures and multiple ethics committee approval issues.

Potential factors influencing property students' academic success

UWS ethics committee approval was obtained to access full details of the academic records of the property students over 2006-2010; this included UWS performance, their HSC performance and personal demographics.

Specific potential factors (9) influencing the students' academic success in the property degree were identified as:

- UAI (out of 100)
- Gender (71% male)
- HSC lag (years)
- Local or international student
- Full-time or part-time student
- General maths at HSC (55% of cohort)
- Higher level maths at HSC (42% of cohort)
- English (standard) at HSC (45% of cohort)
- Economics at HSC (31% of cohort);

this sees the inclusion of both quantitative factors and qualitative factors (ie yes/no) as potential factors influencing student performance in the property degree.

Statistical analysis

Regression-based analyses using Ordinary Least Squares (OLS) regression were used to identify the significance of the role of specific factors influencing academic success at both the overall property degree level (GPA) and at the individual property subject level (final exam mark). These OLS regression models included both quantitative factors, as well as qualitative factors via dummy variables to assess the impact of these specific factors on student performance. A number of OLS regressions were run to fully articulate the significance of specific factors. In the individual subject analyses, additional dummy variables were also included to control for potential year differences amongst student cohorts over 2006-2010 and subject differences, with an "aggregated" analysis also conducted by incorporating results from all three property subjects.

Quantile regression was also used to see if the significance of the factor results was consistent across the performance spectrum (eg: top performing students versus low performing students in cohort). Quantile regression generates different regression coefficients at different levels (or quantiles) of the performance spectrum; thus allowing a more complete description of the effects of the various factors on different levels of student performance. Full details concerning the procedure of quantile regression are given in the Koenker (2005) and Koenker and Hallock (2001). This saw separate regression analyses done for each 10% of the student performance cohort. This enabled a comparison of the significance of specific factor regression coefficients across these 10% student performance groupings to assess for significant differences against their overall performance benchmark. In particular, this enabled the relative importance of factors to be assessed and whether factors took on more or less relative importance with specific groups (eg: top 20% student cohort). Quantile regression has been used previously in assessing factors influencing student performance in economics (Birch and Miller, 2006).

RESULTS AND DISCUSSION

Property degree level performance

Table 2 presents the regression analyses for a number of models to assess the significance of specific factors influencing academic success at the overall property degree level based on the GPA of 295 property graduates over 2006-2010. The importance of specific factors influencing overall academic success is reflected in the level of significance of the respective regression coefficients for each factor in the regression model. Model 1 represents a general model at a broad level, without specific HSC subjects included. The importance of UAI as a critical factor in

influencing overall academic success in the property degree is clearly shown, reflected in the significant regression coefficient for UAI (0.013) at the 1% level. Full-time students outperform part-time students, largely reflecting the pressure on part-time students to balance their studies with significant work commitments and often family commitments. HSC lag is also an important factor, reflecting older students being more focused on their property career goals instead of coming direct from the HSC.

Table 2: Overall property degree analysis: regression coefficients

Factors	Model 1 coefficients	Model 2 coefficients	Model 3 coefficients
Constant	3.145	2.867	3.054
UAI	0.013***	0.016	0.017
Full-time	0.232*	0.229	0.215
HSC lag	0.038***	0.029	0.018
Gender	-0.025	0.346	0.303
General maths			-0.203
Maths		0.317*	
Economics		-0.132	
R^2	0.098	0.129	0.093
F-statistic	6.309***	1.054	0.869

*: significant (P<10%) **: significant (P<5%) ***: significant (P<1%)

When the significance of mathematics is included in the models (see models 2 and 3), having done higher level maths in the HSC is clearly an important factor in academic success (significant at 10% level in model 2), while having done general maths in the HSC is not an important factor in academic success (not significant in model 3). This significant role of higher level maths in model 2 replaces to some degree the broad role of the UAI in influencing academic success in the property degree; see non-significant UAI regression coefficient (0.016) in model 2. This reflects the importance of higher level maths in providing the necessary quantitative skills base for academic success in the property degree, and the lesser role of general maths in supporting the quantitative skills base needed in a property degree; particularly concerning financial mathematics and discounting concepts. The models also demonstrate the lack of importance in having done economics in the HSC as a factor in academic success in the property degree, reflected in the non-significance of the economics regression

coefficient (-0.132) in model 2. No significant differences between males and females was seen in being successful in the property degree, as evidenced in all models.

Individual property subject level performance

Table 3 presents the regression analyses to assess the significance of specific factors influencing academic success at the individual property subject level in the first three semesters in the property degree, via Introduction to Property (semester 1), Principles of Valuation (semester 2) and Commercial Valuation (semester 3). An aggregated analysis across all three property subjects is also presented. These analyses were done for student cohorts of 145-406 property students over 2006-2010, with 771 property students assessed in the aggregated subject analysis.

Table 3: Individual property subject analysis: regression coefficients

Factor	Introduction to Property coefficients	Principles of Valuation coefficients	Commercial Valuation coefficients	Aggregated subjects coefficients
Constant	23.357	-1.905	-7.930	12.859
UAI	0.199***	0.368**	0.303***	0.259***
HSC lag	0.064	-0.758	-1.002	-0.230
Gender	0.506	3.419	3.536**	1.902**
General maths	0.011	4.378	1.791	1.988
Maths	-0.516	8.051*	6.882***	3.389***
English	1.250*	0.769	1.306	-0.117
Economics	1.304	2.576	-1.298	0.410
R^2	0.130	0.308	0.183	0.262
F-statistic	5.35***	6.670***	4.247***	20.644***

*: significant (P<10%) **: significant (P<5%) ***: significant (P<1%)

For Introduction to Property, the key factors associated with academic success in this property subject (as reflected in significant regression coefficients) are UAI and having done standard English at the HSC, with neither level of maths in the HSC being a key factor in this subject. This reflects Introduction to Property, as a first semester subject, being a non-quantitative subject; more focused on developing an understanding of the property industry and property report writing.

Principles of Valuation contains details of mathematics of finance and its property application in discounting. Whilst UAI remains a key factor in student success in this subject (significant at 5% level), having done higher level maths in the HSC is now also a key success factor (significant at 10% level), but having done general maths is not a significant success factor; with standard English at the HSC now not being a significant success factor in this more quantitative property subject.

For Commercial Valuation, which sees students carrying out detailed DCF analyses, UAI continues to remain as a key success factor (significant at 1% level), as does having done higher level maths in the HSC (significant at 1% level). Again, neither having done standard English or general maths were significant success factors. Unlike other subjects previously, gender was significant, with males performing better than females (significant at 5% level).

When aggregated across these three property subjects, UAI and having done higher level maths in the HSC dominate as the critical success factors (significant at 1% level), with gender also significant (at 5% level). Having done standard English, general maths or economics in the HSC were not seen as significant success factors.

Overall, across these three property subjects which increase in quantitative complexity, the following general trends emerge from these regression analyses; particularly in relation to the level of significance attached to the various success factors in the property degree:

- UAI is a significant success factor in all three subjects
- Having done higher level maths in the HSC takes on increased significance as a key success factor as the subjects become more quantitative
- Having done general maths in the HSC is not a significant success factor in any instance, although there was a marginal increase in its importance as the subjects became more quantitative
- Having done standard English in the HSC took on less importance as the subjects become more quantitative; only in the non-quantitative Introduction to Property was English level seen as a key success factor
- Having done economics in the HSC was not significant and took on less importance as the subjects become more quantitative
- Apart from Commercial Valuation, gender was not significant as a success factor; particularly at the overall property degree level (GPA)

- Intellectual factors are clearly the most important success factors (compared to demographic factors etc); this is consistent with previous research for business students regarding performance success factors.

Consistency of success factors across performance spectrum

To assess whether the impact of specific factors in influencing academic success was consistent across the performance spectrum, quantile regression was used and 10% performance sub-sector analyses (from low performers to high performers) carried out[4]. The respective regression coefficients for UAI and having done higher level maths in the HSC are calculated for these 10% performance sub-sectors and benchmarked against overall performance for the full cohort in each of these three property subjects.

Figure 1: Principles of Valuation analysis: quantile regression coefficients

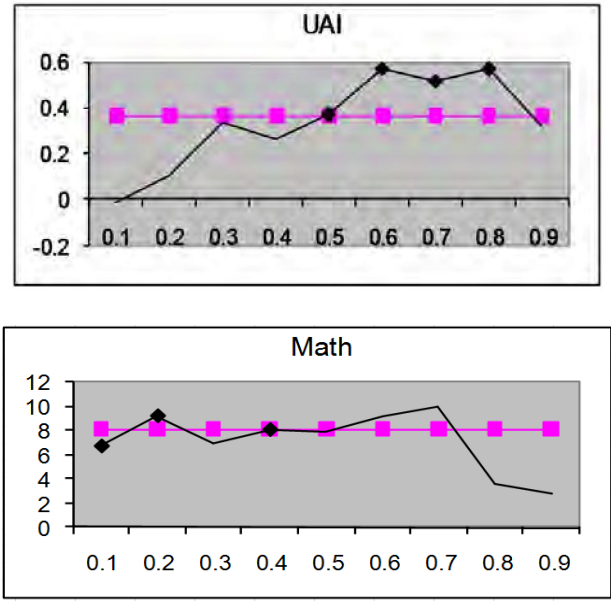


Figure 1 presents these quantile regression coefficients for each 10% performance cohort for the significance of UAI and having done higher level maths in the HSC for Principles of Valuation. For UAI, benchmarked against the overall UAI performance

[4] Quantile regression was not carried out for Introduction to Property as the level of maths done in the HSC was not significant for this subject.

coefficient of 0.37 (see Table 3), UAI takes on increased relative importance for achieving better results in Principles of Valuation. This is reflected in the increasing regression coefficients for UAI as the cohort's performance improves; see Figure 1. However, in the top 10% cohort, with a reduced regression coefficient, there is evidence of other factors playing an important role in the success of this top 10% cohort. Whilst not explicitly assessed, these are potentially the non-quantifiable "other" factors characterised by top performers, including lecture and tutorial attendance, and strong motivation, commitment and good study habits. Similarly, for having done higher level maths in the HSC, the relative importance of this factor was seen to be relatively consistent throughout, compared to the benchmark overall performance coefficient of 8.05 (see Table 3). This is reflected in the relatively stable regression coefficients for higher level maths as the cohort's performance improved; see Figure 1. Again, as with the relative role of UAI in this subject, other factors were seen to take on increased importance with the top 20% cohort; reflected in the reduced regression coefficients. The magnitude of the contribution by these other factors for the top cohort was more evident for the impact of the higher level of maths than for the impact of UAI.

Figure 2: Commercial Valuation analysis: quantile regression coefficients

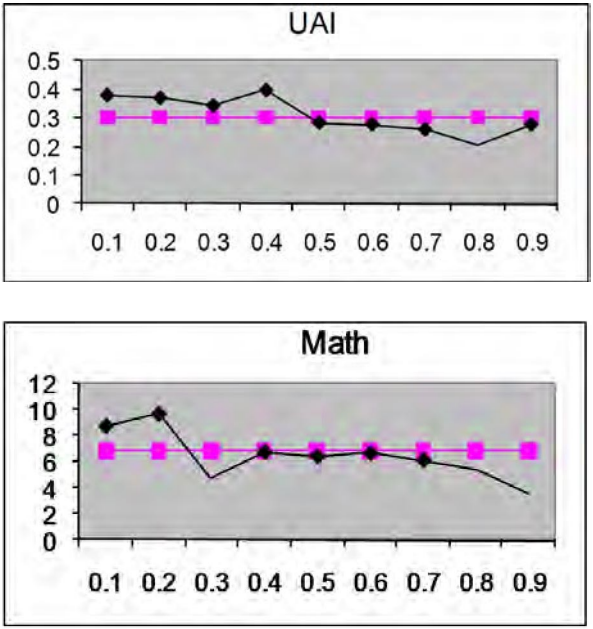
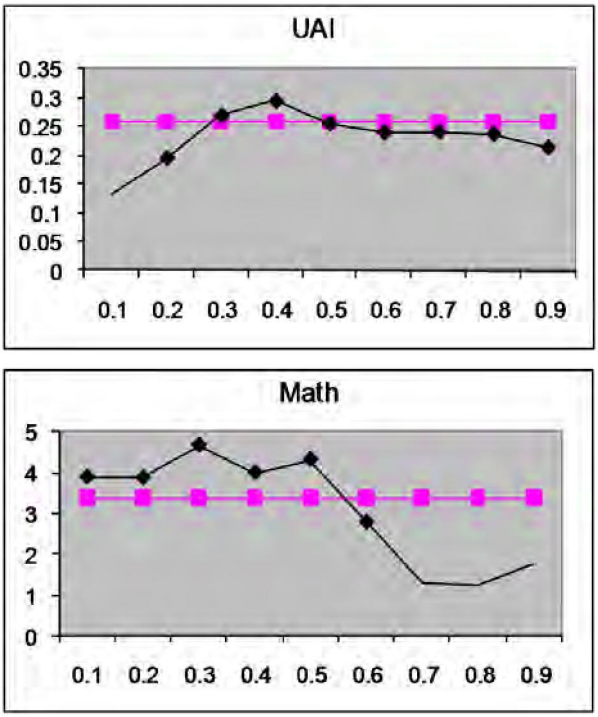


Figure 2 presents the quantile regression coefficients for each 10% performance cohort for the significance of UAI and having done higher level maths in the HSC for Commercial Valuation. Benchmarked against the overall UAI performance coefficient of 0.30 (see Table 3), UAI is important throughout but takes on marginally less relative importance for the top 30% cohort, reflected in the reduced regression coefficients. Again, this is potentially attributable to other factors such as the personal motivation and study habit factors for this top 30% cohort. A similar trend and inferences about the top 30% cohort also applies concerning the relative importance of having done higher level maths in the HSC for Commercial Valuation, benchmarked against the overall performance coefficient of 6.88 (see Table 3). The impact on this top 30% cohort was more evident concerning maths than UAI, reflected in the reduced regression coefficients.

Figure 3: Aggregated property subject analysis: quantile regression coefficients



The quantile regression coefficients for each 10% performance cohort for the aggregation of these three property subjects is given in Figure 3 for the significance of UAI and having done higher level maths in the HSC. As per Commercial Valuation,

both UAI and having done higher level maths in the HSC are important, relative to their overall performance coefficients of 0.26 and 3.39 respectively (see Table 3). However, other factors contribute more significantly for the top 30% cohort; again, these are expected to constitute the other factors of personal motivation and study habit factors. Again, maths is more impacted for this top 30% cohort than UAI, reflected in the more significantly reduced regression coefficients.

Overall, this quantile regression analysis has clearly demonstrated the relative contribution that UAI and having done higher maths in the HSC have on the performance of different cohorts in these property subjects. Both factors are seen to play a relative increasing role against their overall performance benchmark; however other factors such as motivation and study habits are likely to play an increasingly important role for the top-performing cohorts.

The clear inference that can be drawn from this quantile regression analysis is that UAI and having done higher level maths in the HSC are important in doing well in these property subjects. However, to be in the top-achieving cohort, other factors play an increasing role. Whilst not being explicitly assessed in this study, other potential factors for this top 30% cohort would be expected to include students being motivated and utilising good study habits relating to attendance and assessment tasks.

PROPERTY EDUCATION IMPLICATIONS

These analyses of the potential factors influencing student performance in a property degree and individual property subjects have clearly highlighted the significance of UAI and doing higher level mathematics in HSC as the key factors in academic success in the property degree. This has significant implications, given the expected increased university participation rates (and lower UAI/ATAR entry) and the evidence of generally declining levels of mathematics ability amongst HSC students. These implications are at both the university level and property industry level.

At the university level, larger cohorts in property degrees with lower UAI/ATAR and lesser maths backgrounds will become evident. These lower admission standards will impact on property student retention rates in first year and highlight the need for remedial work (eg: mathematics) to address deficiencies in student learning prior to entering university and to improve university retention rates. This has additional cost implications for universities, as well as for implementing effective learning delivery systems to enhance student retention, student performance and student motivation; particularly in the early stages of the property degree.

Whilst innovation in learning strategies (eg: use of new technology, use of problem-based learning) has recently been evident in property programs in Australia (Cornish et al, 2009; Yam and Rossini, 2010), this research has also highlighted the potential

key role of the non-quantifiable features such as student motivation and study habits (eg: class attendance, assignment and exam preparation, study/work balance). As seen in the quantile regression analysis in this research, this is particularly the case for property students seeking to be in the top performing cohorts in their property degree. With most universities moving towards an increased emphasis on use of the internet in property subject delivery, it further highlights the need for effective delivery systems to enhance property student learning opportunities.

These issues also have significant implications for the property industry at a professional accreditation level by the API and RICS. In particular, professional accreditation requires students to have key competencies in specific core property and business areas. Increasingly, these competencies are in the areas of quantitative property financial analysis (eg: DCF) which requires a strong understanding of financial mathematics concepts. Similarly, the inclusion of remedial work (eg: maths) and a general movement to broader more generic business programs (versus profession-specific programs) at the degree level by several Australian universities will see increased pressure on the ability to include sufficient property-specific subjects in these property programs. The API and RICS may need to focus on these aspects more fully in future accreditations to ensure property students are meeting the necessary standards of property knowledge and skills for professional accreditation.

Overall, this research has provided significant insights regarding potential factors influencing academic success by property degree students in Australia. It has also identified significant future challenges, both for universities, professional accrediting bodies and the property industry, to ensure the maintaining of the high standards for professional practice in the property industry required for future property graduates.

REFERENCES

Allen, M. and C. Carter (2007), Academic success determinants for undergraduate real estate students. Journal of Real Estate Practice and Education, 10:149-160.

Becker, W. and M. Andrews (2004), The Scholarship of Teaching and Learning in Higher Education. Indian University Press: Bloomington.

Birch, E. and P. Miller (2006), Student outcomes at university in Australia: a quantile regression approach. Australian Economic Papers, 45:1-17.

Blake, A. and C. Susilawati (2009), An evaluation of how well undergraduate property students are prepared for commencing their careers. Pacific Rim Property Research Journal, 15: 204-224.

Chan, K., Shum, C. and D. Wright (1997), Class attendance and student performance in Principles of Finance. Financial Practice and Education, Fall: 58-65.

Cornish, S., Reed, R. and S. Wilkinson (2009), Incorporating new technology into the delivery of property education. Pacific Rim Property Research Journal, 15: 303-320.

Commonwealth of Australia (2009), Transforming Australia's Higher Education System. CA.

DEEWR (2008), Review of Australian Higher Education. DEEWR.

Didia, D. and B. Hasnat (1998), The determinants of performance in the university introductory finance course. Financial Practice and Education, Spring: 102-107.

Ely, D. and L. Hittle (1990), The impact of math background on performance in managerial economics and basic finance courses. Journal of Financial Education, 19: 59-61.

Everist, L., Francis, V. and L. Armitage (2005), Student preferences for career mentoring in property and construction. Pacific Rim Property Research Journal, 11: 337-354.

Group of Eight (2009), Review of Education in Mathematics, Data Science and Quantitative Disciplines. Group of Eight: Canberra.

International Association for the Evaluation of Educational Achievement (2008), TIMSS 2007 International Mathematics Report. IEA: Boston.

Johnson, D., Joyce, P. and S. Sen (2002), An analysis of student effort and performance in the finance principles course. Journal of Applied Finance, Fall: 67-72.

Koenker, R. (2005), Quantile Regression. Cambridge University Press: Cambridge.

Koenker, R. and K. Hallock (2001), Quantile regression. Journal of Economic Perspectives, 15: 143-156.

Mallik, G. and P. Basu (2009), Does high school mathematics improve student learning in economics in university? The International Journal of Learning, 16:15-20.

Mallik, G. and J. Lodewijks (2010), Student performance in a large first year economics subject: which variables are significant? Economics Papers, 29: 80-86.

Mallik, G. and M. Varua (2008), HSC mathematics results and tertiary success in quantitative units: an Australian experience. Australian Journal of Economic Education, 5: 1-10.

National Committee for the Mathematical Sciences (2009), A National Strategy for Mathematical Sciences in Australia. NCMS: Melbourne.

Newell, G., Susilawati, C. and S. Yam (2010), Student perceptions of the quality of property education in Australia: 1994-2009. Pacific Rim Property Research Journal, 16: 400-422.

NSW Board of School Education (2010), NSW HSC Participation Statistics (from NSWBSE website).

OECD Programme For International Student Assessment (2010), PISA 2009 Results: What Students Know and Can Do. OECD: Paris.

Page, G. (2008), Australian graduates' perspective on their professional socialization. Australian and New Zealand Property Journal, 1: 561–570.

Sen, S., Joyce, P., Farrell, K. and J. Toutant (1997), Performance in principles of finance courses by students with different specialisations. Financial Practice and Education, Fall: 66-73.

Yam, S. and P. Rossini (2010), Effectiveness of project-based learning as a strategy for property education. Pacific Rim Property Research Journal, 16: 291-313.

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