Modeling College Graduation GPA Considering Equity in Admissions: Evidence from the University of Puerto Rico

In memory of my beloved son, *Horacio Matos-De Jesús* (March 12, 1983–December 20, 2009)

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Abstract: Over concerns about private school students' advantages in standardized tests, beginning in 1995–96 the University of Puerto Rico (UPR) implemented a new admissions formula that reduced the weight they previously had in the General Admissions Index (GAI), on which its admissions decisions are based. This study seeks to determine the possible effects of the new GAI regarding both its objective of promoting equity in the student body composition and as a measure of academic aptitude capable of predicting student success. With these aims, the study compares the old and new GAI averages of 11 consecutive entering cohorts at the Bayamón campus of the UPR, and models the graduation GPA (GGPA) of 6 of these cohorts. Evidence shows that (a) the new GAI eliminated private school students' advantage over those from public schools and reduced to a minimum the gap between genders; (b) female students obtain significantly higher GGPAs and

exhibit other advantages when compared to males, while public and private school students'
academic outcomes are broadly similar; (c) the probability of accessing a determined boundary in the
GGPA distribution is significantly and nonlinearly related to the GAI; (d) GGPAs exhibit an
uptrend that varies inversely and significantly with the GAI, and (e) the probability of being in the
lower bounds of the GGPA distribution increases to the extent that graduates exceed graduation
required time.
Keywords: college admission; equity; educational opportunities; standardized tests; grade point
average; graduation lags; modeling college graduation GPA; Puerto Rico.

Modelaje del índice académico de graduación en relación con la equidad en el proceso de admisiones: Evidencia de la Universidad de Puerto Rico

Resumen: Preocupada por las ventajas de los estudiantes de escuelas privadas en las pruebas
estandarizadas de admisión, a partir de 1995–96 la Universidad de Puerto Rico (UPR) adoptó una
nueva política que le otorgaba a estas un peso menor en el Índice General del Ingreso (IGS), en el
que se basan sus admisiones. Este estudio busca determinar los efectos posibles del nuevo IGS en
relación con su propósito de promover la equidad en la composición del estudiantado, así como en
cuanto a medida de aptitud para predecir el éxito académico. Con estos objetivos, el estudio
compara los IGS anteriores y nuevos de 11 clases consecutivas de nuevo ingreso en la UPR en
Bayamón, y modela el Índice Académico de Graduación (IAG) de seis de estas clases. La evidencia
demuestra que (a) el nuevo IGS equiparó a los estudiantes procedentes de escuelas privadas con los
de las públicas, y redujo a un mínimo la brecha entre sexos; (b) las estudiantes obtienen un IAG
significativamente mayor y exhiben otras ventajas en relación con los varones, mientras que las
ejecutorias de los estudiantes de escuelas públicas y privadas son básicamente similares; (c) la
probabilidad de acceder a una cota determinada en la distribución del IAG está significativa y no
linealmente relacionada con el IGS; (d) los índices de graduación exhiben una tendencia alcista que
varía de forma inversa y significativa con el IGS; (d) la probabilidad de estar en las cotas inferiores
de la distribución del IAG aumenta en la medida en que los graduados exceden el tiempo requerido
para completar sus grados.
Palabras-clave: admisión universitaria; equidad; oportunidades educativas; pruebas estandarizadas;
índice académico; rezago en tiempo para completar grados; modelaje del índice académico de
graduación; Puerto Rico.

Modelando a classificação da nota média nas universidades considerando equidade nas admissões: Evidências da Universidade de Porto Rico

Resumo: Tendo em conta as vantagens dos alunos de escolas privadas nos testes padrões, no inicio
de 1995–96 a Universidade de Porto Rico (UPR) implementou novas fórmulas que reduzem o peso
que antes era atribuído no Índice Geral de Admissões (GAI, sigla em inglês), no qual se baseava para
se decidir a admissão. Este estudo visa determinar possível efeitos do novo GAI tanto sobre o seu
objectivo de promover a equidade na composição do corpo discente e como uma medida de aptidão
académica capaz de prever sucesso dos alunos. Com estes objectivos, o estudo compara a antiga e a
nova média de GAI de 11 consecutivas coortes que foram admitidas na Faculdade de Bayamón da
UPR, e modela a classificação da GPA, nota média, (GGPA, sigla em inglês) de 6 destes coortes. As
evidências indicam que (a) o novo GAI elimina as vantagens dos alunos das escolas privadas, em
relação às escolas da rede pública e reduza-o para uma diferença mínima entre os géneros; (b) os
alunos do sexo feminino obtiveram GGPAs significativamente maior e apresentam outras vantagens
em relação ao sexo masculino e, enquanto que os resultados académicos de alunos de ambas as
escolas públicas e privadas são muito semelhantes; (c) a probabilidade de aceder a um limite

específico para a distribuição dos GGPA é significativa e não-linear em relação ao GAI; (d) a GGPAs mostra uma tendência ascendente que varia inversamente e é significativa em relação ao GAI, e (e) a probabilidade de estar nos limites inferiores da distribuição das GGPA aumenta à medida que os alunos ultrapassem o tempo necessário para terminar a licenciatura.

Palavras-chave: admissão nas universidade; equidade; oportunidades educacionais; testes padronizados; média; atraso no término da licenciatura; modelagem; classificação da nota média; Porto Rico.

Introduction

In the context of burgeoning demand for admissions during the past decades, one of the most compelling issues faced by colleges and universities has been establishing admission policy criteria that allow them to limit entry to students who are most likely to succeed in attaining their degrees.

The importance of this outcome cannot be underestimated. For some authors (e.g., Zwick, & Sklar, 2005), the best criterion to measure an institution's academic success is, precisely, the proportion of its students that complete their degrees in the allotted time. In this context, low graduation rates have a negative impact on institutions' rankings and, consequently, on their ability to attract students with greater academic potential. Moreover, student attrition represents a fiscal cost to institutions in terms of lost revenues from tuition, room and board, and alumni donations (Schuh, 2005; Raisman, 2013). Attrition also constitutes a problem for society in general, due to reductions in the availability of college-educated workers in the labor market (Bound, Lovenheim, & Turner, 2007). It also has a negative impact in terms of lower tax receipts for federal and state governments (Schneider & Yin, 2011).

In view of these implications, it has been proposed that the task of admissions offices is to predict as accurately as possible which applicants would be most successful if admitted (Rothstein, 2004). To do this, admissions policies have traditionally relied on proxies of academic aptitude, such as high school grades and standardized test scores, whose predictive power in terms of students' potential for success in college – especially as measured by first-year grade point average (GPA) and retention rates – has amply been demonstrated by institutional and scholarly studies.

At the same time, colleges and universities have been trying to modify their admissions policies in reaction to claims, made since the 1960's by progressive movements, demanding greater access to higher education of traditionally underrepresented groups.

Both objectives could be at odds to the extent that certain admissions criteria, especially standardized test scores, have historically correlated to variables such as gender, social class, racial or ethnic group, and parental educational attainment, and thus have tended to calcify inequities regarding access to post-secondary education (see, for example, National Association for College Admission Counseling, 2008; Zwick, 2012; Zwick & Sklar, 2005).

In the context of these claims, during the past years many U.S. institutions, including some large state university systems, started to eliminate standardized tests or de-emphasize their use in their admissions processes.[1] This tendency has kept growing, and by 2014 over 800 colleges and

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[1] The movement to de-emphasize tests started with institutions such as Bowdoin College, which in 1969 adopted a SAT-optional policy, and City University of New York, which in 1970 implemented "open admissions." The movement gained impetus with the publication of Lemann's 1999 book *The big test: The secret history of the American meritocracy*, and President of the University of California R. Atkinson's 2001 speech at the annual meeting of the American Council on Education announcing that the institution no longer required the SAT for admissions (Epstein, 2009).

universities were not using the SAT or ACT to admit substantial numbers of their applicants to bachelor degree programs, including institutions that are "test optional", "test flexible" or otherwise de-emphasize the use of tests (National Center for Fair and Open Testing, 2014).

In 1994 the University of Puerto Rico (UPR) —the country's public university system— had likewise chosen to reduce the weight of standardized tests in the student's General Application Index (GAI), a combination of test scores and high school GPA (HSGPA) on which formal admission decisions to its academic programs are based. The change was motivated by concerns about diminishing enrollment and about the advantages these tests gave to private school students (who have consistently scored better on them) over those from public schools (generally from poorer families).

This study seeks to determine the possible effects of the new GAI regarding both its objective of promoting equity in the student body composition and as a measure of academic aptitude capable of predicting student success. With these aims, the study compares the old and new GAI averages of 11 consecutive entering cohorts at the Bayamón campus of the UPR (UPRB),[2] and models the graduation GPA (GGPA) of the first six of these cohorts in order to analyze the extent to which GGPAs are affected by GAI, gender, high-school of origin (public vs. private), academic program, and time to attain the degrees. Our findings could have important policy implications for other institutions seeking to promote equity without compromising academic standards and student quality.

With these aims, the rest of the paper is organized as follows. The second section presents the objectives, dataset and methodology; the third section analyses the data and discusses the results; and the fourth uses three different econometric approaches to model GGPA and evaluate the data's robustness. The article ends with a summary and conclusions.

Objectives, Dataset, and Methodology

This paper addresses the following questions: (a) To what extent does the new GAI promote equity in admissions to the UPRB among genders and among public and private school students? (b) What is the correlation between the new GAI and students' GGPA? (c) To what extent is the GGPA affected by other variables, including students' gender, high-school type, and academic program? (d) What are the effects on the GGPA of exceeding the minimum time required for graduation? (e) To what extent variations over the temporal trend in the relationship between GAIs and GGPAs point to the possibility of grade inflation in the GGPA distribution?

To determine the effects of the new GAI on both the general UPRB student body composition and that of its specific academic programs in terms of gender and high school type, the study considered 11 cohorts admitted to the institution in an eleven-year period, from 1995–96 (when the new GAI formula was implemented) to 2005–2006. The total sample consists of over 13,000 full-time (12 or more credits per semester) students. Since detailed UPRB admissions data prior to 1995–96 are unavailable, it is not possible to directly compare average GAIs before and

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[2] The UPRB is one of the UPR's 11 autonomous units. Accredited by the Middle States Association of Colleges and Secondary Schools, the institution offers associate and bachelor's degrees, as well as articulated transfer programs to the Río Piedras, Mayagüez and Medical Sciences campuses of the UPR. From 1995-96 to 2005-06, each incoming class consisted of some 1,300 students, of which approximately 99% were Puerto Rican.

after the change. To overcome this limitation, averages for the old GAI were computed using the relative weights it gave to each proxy for academic potential.

To develop the model to address the remaining questions regarding the determinants of the GGPA, the original sample had to be truncated to allow students enough time to complete all graduation requirements. The criterion used was that at least 12 semesters (150% of the time required to complete a bachelor's degree) had passed since the last class to be studied was admitted to the UPRB. Thus, each of the 8,258 incoming students admitted to the institution between 1995–96 and 2000–2001 was tracked until the end of the 2005–2006 academic year. Of these students, 420 graduated with an associate degree, 1,912 graduated with a bachelor's degree, and 75 obtained both degrees. Consequently, the final sample of this part of our study consists of 2,407 observations.

For each of the admitted students, the following data are available: HSGPA, scores of the verbal and mathematical aptitude tests administered by the Puerto Rico (PR) and Latin America Office of the College Entrance Examination Board (CEEB), GAI, high school code, gender, academic program to which she/he was admitted, academic program from which he/she graduated, and the UPRB GGPA. To identify the temporal trend (T_T) of the six classes considered in this study, six dummies, whose reference group is the first cohort (1995–96), are defined. Also defined is a time variable measuring the graduation lag in terms of the semesters exceeding the minimum time required for graduation $\left(-1 \leq t_t \leq 14\right)$. The academic programs are identified with eleven dummies, whose reference group is: Other Programs.[3] Dummies also identify the graduate's gender and school of origin; the respective reference groups are male and public. Appendix Table 1 describes the variables utilized in the study.

To evaluate the robustness of the data, we modeled the GGPA using three different econometric approaches. The first two use linear models (ordinary least squares (*OLS*) and quantile regression) to estimate, respectively, Models 1 and 2, reported in Appendix Table 2, and the five models included in Appendix Table 3. The third approach uses a maximum likelihood model to compute the probability with which a student may obtain access to a determined bound of the GGPA distribution, including the possibility of graduating with honors (Model 3, Appendix Table 2).

The first part of this study contributes to the literature by using a large sample to evaluate the possible effects on student body composition of decreasing the weight of tests in admission policies. This analysis is important to the extent that tests have consistently given advantages to male and private high school/wealthier students, and thus their use and effects should be subject to scrutiny when considering questions regarding equity in admissions.

The contributions of the second part include (1) utilizing a rich dataset that describes in detail each of the UPRB graduate from six consecutive cohorts; (2) combining historical data with results from three different econometric models that allow evaluating the findings' robustness; (3) focusing on the GGPA, an academic outcome which has received scant attention in the literature[4] in

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[3] This cluster comprises graduates from different programs who originally were admitted to Social Sciences, Engineering Transfer and Health Sciences programs, which do not confer degrees.

[4] Traditionally, most studies have focused on the validity of measures used to predict first-year GPA (since it has the advantage of avoiding the problem of non-random attrition from the university) and first- to second-year retention. Important exceptions are studies by Shaw, Kobrin, Patterson, and Mattern (2012), on the SAT's ability to predict cumulative GPA by college major, and by Mattern and Patterson (2011), on that test's validity in predicting fourth-year grade point average and cumulative GPA. Unlike our paper, however, these studies do not necessarily consider GGPA, as completion of graduation requirements might take more than 4

spite of the fact that it combines two measures of student success: cumulative GPA and attainment of degrees; (4) analyzing the correlation of the GAI, gender, high school type and academic program with the GGPA; (5) including a new variable related to the graduation lag or time required to complete degree requirements;[5] and (6) analyzing the possibility of grade inflation in the GGPA distribution.

The analysis of the correlation between students' new GAIs and their GGPAs is important in the context of ongoing debates over the predictive value of different proxies of students' academic potential. This analysis, and that of the correlation between other variables and the GGPA, is also relevant given that only 28.24 % of all incoming students considered in this study reached the expected goal of graduation.[6] Findings should shed light on areas that require institutional interventions aimed at increasing graduation rates.

Data Results and Discussion

Effects of UPR Admissions Policy Changes on UPRB Student Body Composition

As stated earlier, in 1994 the UPR decided to change its admission formula over concerns about decreasing enrollment and about the advantages of private school students over those from public schools (generally from poorer families)[7] in the standardized tests used as part of its GAI,[8] on which admissions to the different academic programs of each UPR campus are based.[9]

In the previous admissions formula, implemented by the PR Council of Higher Education (CHE) since 1979–80, scores on the CEEB verbal and mathematical aptitude tests contributed one-third each to the GAI, while the remaining third corresponded to the student's HSGPA.[10] Under the new formula, used since the 1995–96 academic year, each test score represents 25% of the GAI, while HSGPA accounts for the remaining 50 percent (Menéndez Raymat, 1995). To obtain the highest possible GAI (398), a student must have a 4.0/4.0 HSGPA and perfect scores (800) in each CEEB test.

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years. On the other hand, some studies have analyzed the correlation between GGPA and gender (Cohn, Cohn, Balch, & Bradley, 2004) and high school type (Horowitz & Spector, 2005; Smith & Naylor, 2005).

[5] The variable is defined as follows: t_t = semester to graduation – minimum degree required time. The minimum required time or thresholds are defined as 6 semesters for the associate degree and 12 semesters for the bachelor degree, respectively.

[6] At the end of the 2005-06 academic year, the graduation rates of the six UPRB classes studied were, respectively: 28.50%, 25.14%, 30.10%, 29.94%, 30.81%, and 25.62%.

[7] According to the 2000 census (whose data roughly correspond to the period under study), 66.8% of PR households with students in public schools lived below the poverty level, and had an average income of $4,170 (Ladd & Rivera-Batiz, 2005, pp. 202-203).

[8] In the 1994-1996 tests, the difference in average scores between public and private high school students were, respectively, 453 and 520 in the verbal and 470 and 550 in the mathematics test; in 2002-2003, they were, 444 and 526 in the first and 466 and 549 in the second one (Ladd & Rivera-Batiz, p. 201).

[9] Admission decisions to each program are based exclusively on GAI scores except for a small number of cases of students with special abilities in areas such as sports and the arts, whose scores may be up to 20 points lower than the minimum required by a program (UPR, Portal de Estudiantes, 2014).

[10] It should be noted that although the CHE certification that created the formula clearly established its "experimental" character and required the UPR to conduct empirical studies to determine its adequacy (Menéndez Raymat, 1995), none were performed in the fifteen years in which it was in use. Moreover, few studies about the determinants of academic outcomes have been conducted in Puerto Rico, with the exception of those by the PR CEEB on the validity of its tests to predict first-year GPA.

Every year, each of the UPR's eleven campuses establishes the minimum GAI required by its different academic programs in response to trends in enrollment demand and the programs' capacity. At the UPRB, for example, this minimum now ranges from 335 (B.S. in Mechanical Engineering transfer program) to 235 (associate degree in Civil Engineering Technology), while at the Utuado campus (UPRU) it ranges from 290 (transfer program in Nursing) to 165 (various associate degrees in Agricultural Technologies). In the case of a program offered by different campus, the minimum sometimes is also different: for the B.A. in Office Systems Program, it is 250 at the UPRB and 203 at the UPRU.

The fact that the GAI required for each program is made public every year has led, from its inception, to a self-inclusion/exclusion process by which students themselves decide whether to apply to the UPR (and a particular UPR program), based on their GAI and the minimum established by the program. To a large extent, this policy led to a progressive and significant decrease in the number of applicants to the UPR (and especially those from public schools) since the implementation of the GAI, from 31,234 in 1979–80 to 13,719 in 1993–94 (-56.08%) (Menéndez Raymat, 1995, pp. 26-31).[11]

Our analysis of the 11 cohorts admitted to the UPRB from 1995–96 to 2005–2006 shows that, at the same time that all GAIs increased with the new formula, the change had the effect of reducing males' advantage over females[12] in the new GAI (GAI2) to only one point (286 vs. 285), and abolished the difference between private and public school students.[13] Given the greater weight that CEEB tests had in the previous formula (GAI1), male students' average score would have been seven points higher than that of females (274 vs. 267, respectively), while that of private school students would have been six point higher than that of public school ones (274 vs. 268), as shown in Table 1. Since the same GAI formula is used in the UPR's eleven units, these results could be generalized to the whole UPR.

Moreover, since the GAI is used to determine admissions to specific academic programs in each UPR campus, the new formula also reduced the advantages that males and private school students previously had in admissions to several more selective programs, usually associated with males and with more prestigious and higher-paying jobs, as shown in Table 2.

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[11] At the same time, the number of applicants and of students enrolled in the country's less-selective private nonprofit or for-profit post-secondary institutions had been steadily growing. In 1949, 12,497 students were enrolled in public institutions (which include, besides the UPR, some specialized schools like the Conservatory of Music, the School of Fine Arts, and several technological institutes), while only 1,149 (9.2%) attended private ones. Some 20 years later (1970-71), enrollment in private institutions had grown to 20,577 (32.5% of the total population) and, by the middle of that decade, overtook enrollment in the public sector. In 1990–91 (shortly before the UPR changed the GAI formula), 55,691 students were enrolled in public institutions, while the number of those in private ones had grown to 98,374 (63.9%) (Ladd & Rivera-Batiz, 2005, p. 192).

[12] Although the UPR was concerned with equity among students from private and public high schools, rather than with gender equity, its decision to apply equal weights to high-school grades and admission test scores increased the standing of female applicants to UPR relative to the previous admissions policy, since their test scores were also lower than males'.

[13] Previous studies by Matos-Díaz (2008) and by Ragan, Li, & Matos-Díaz (2011) had already demonstrated the leveling effect of the new GAI on the general UPRB student body composition.

Table 1
Proxies for College Academic Potential by Type of School and Gender 1995–96 to 2005–2006 UPRB Incoming Classes

Type of school	GAI1	GAI2	Verbal	Math	HSGPA
Private	274	286	586	555	3.24
Public	268	286	550	540	3.40
Gender					
Male	274	286	602	551	3.22
Female	267	285	549	544	3.40
Percent of sample:	Private: 44%		Public: 56%		
	Male: 45%		Female: 55%		

Table 2
Differences between Mean GAI1 and GAI2 by High School Type and Gender in Selected Academic Programs 1995–96 to 2005–2006 Incoming Classes

	Private	Public	Male	Female
	Accounting			
GAI1	293.39	293.18	293.04	293.41
GAI2	307.54	310.17	304.74	310.98
	Business			
GAI1	272.68	271.81	271.95	272.48
GAI2	285.63	290.10	283.75	289.89
	Electronics			
GAI1	273.41	273.93	273.72	274.01
GAI2	284.32	288.37	286.59	290.69
	Computer Sciences			
GAI1	288.07	288.80	288.94	266.92
GAI2	296.58	302.44	296.58	302.95
	Materials Management			
GAI1	258.62	256.44	256.98	258.93
GAI2	270.34	273.02	268.98	276.85

GAI, GGPA, and Time Lag by Gender and Academic Programs

As stated earlier, 8,258 incoming students from six cohorts enrolled full-time at the UPRB from 1995–96 to 2000–2001. Of these, 59% were female and 41% were male. By the end of the 2005–2006 academic year, 1518 (63.07%) of the females and 889 (36.93%) of the males had completed their associate or bachelor's degrees. This increase of some four points in the proportion of female graduates vs. cohort enrollment tends to support the conclusion that student quality was not compromised by changes in the GAI benefitting females.

Table 3 compares graduates' performance by academic programs and gender. Using GAI scores as proxy for student quality, the table shows that compared to females, male graduates started college with an advantage of one point (288 vs. 287). However, this advantage disappears when graduates are compared along academic programs. Females started college with higher GAIs than males in eight out of eleven programs. Females' greater advantage was in Electronics (25 points), a program traditionally associated with males (only 9 females graduated from it, compared to 189 males). Other traditionally male programs in which females' GAI is greater than that of males include Accounting and Business (in which they outnumbered males), as well as Computer Science,

Engineering Technologies and Materials Management. They also have an advantage in Education, a program usually associated with women in Puerto Rico, and in which they vastly outnumbered males. Males exhibit advantages in three programs only: Physical Education (3 points), Other Programs (3 points), and Office Systems (16 points), but only one male graduated from this program, vs. 279 females, which makes the difference unimportant.

The females' advantage increases while in college, and they graduate with GPAs greater than those of males. Overall, females' GGPA is 0.16 points greater than that obtained by males (*p*-value < 0.0000). Their advantage is even greater when compared among academic programs since they exhibit greater GGPAs in ten out of eleven programs. These advantages range from 0.04 in Other Programs to as high as 0.23 in Electronics and 0.40 in Education. Only in Biology is their advantage reversed, but the difference that favors males is merely 0.01 (3.13 vs. 3.12), the smallest of all differences in GGPA between genders.

Table 3

GAI, GGPA and graduation lags by gender and academic program 1995–96 to 2000–2001 Incoming Classes

Academic Programs	Females				Males			
	GAI	GGPA	$\overline{t_t}$	*n*	GAI	GGPA	$\overline{t_t}$	*n*
All Programs	287	3.11	2.94	1518	288	2.95	3.43	889
Accounting	307	3.28	2.93	187	306	3.17	2.86	91
Business	289	3.05	2.81	370	283	2.91	3.48	189
Computer Science	307	3.20	2.59	54	301	3.06	3.2	166
Education	277	3.17	3.19	265	267	2.77	7.75	4
Physical Education	250	3.01	2.88	64	253	2.96	2.93	61
Electronics	314	3.07	2.78	9	289	2.84	3.81	189
Engineering Technologies	284	2.77	4.54	13	265	2.68	3.65	55
Materials Management	282	2.87	3.35	26	270	2.77	4.55	44
Biology	306	3.12	2.67	165	301	3.13	2.67	55
Office Systems	268	2.99	2.87	279	284	2.90	3	1
Other Programs	296	3.21	3.37	86	299	3.17	3.35	34

Notes: *n* = sample size, $\overline{t_t}$ average graduation lag (semesters).

Figure 1 provides added perspective on gender by showing student differences at the beginning of college, as well as at the time of graduation. The figure plots the kernel density functions of HSGPA and GGPA separately for males and females. The females' advantage is clearly depicted in both distributions. According to prior studies of U.S. student performance (Bridgeman, McCamley-Jenkins, & Ervin, 2000; Cohn et al., 2004; Rothstein, 2004), females tend to earn higher grades in high school, whereas males tend to do better on admission tests. On the other hand, various studies have found that females tend to earn higher grades than males in college (see, for example, Betts & Morell, 1999; Grove & Wasserman, 2004; Leppel, 1984; Mau & Lynn, 2001). Our findings confirm those results: UPRB females performed better than males on HSGPA, GAI, and GGPA, while males only performed better on tests.

Finally, compared to males, females also exhibit advantages in terms of graduation lags. Overall, their average lag is 2.94 semesters, while males' value is 3.43 semesters, a difference of 0.49 semesters. Moreover, females perform better than males in eight out of eleven programs, and in two of them their lag is substantially smaller than males: Education (3.19 vs. 7.75, a difference of 4.56 semesters) and Materials Management (3.35 vs. 4.55, a difference of 1.2). Only in Accounting, Other Programs and Engineering Technologies is their lag greater than males'. In the first two, the lag is

relatively small (0.07 and 0.2 semesters, respectively), but in the third it is more significant (4.54 vs. 3.65, i.e., 0.89 semesters). Therefore, females start college with higher GAI scores, graduate from college with better grades and complete their degrees faster than males. These findings strongly support the conclusion that student quality was not compromised by changes in the GAI benefitting females.
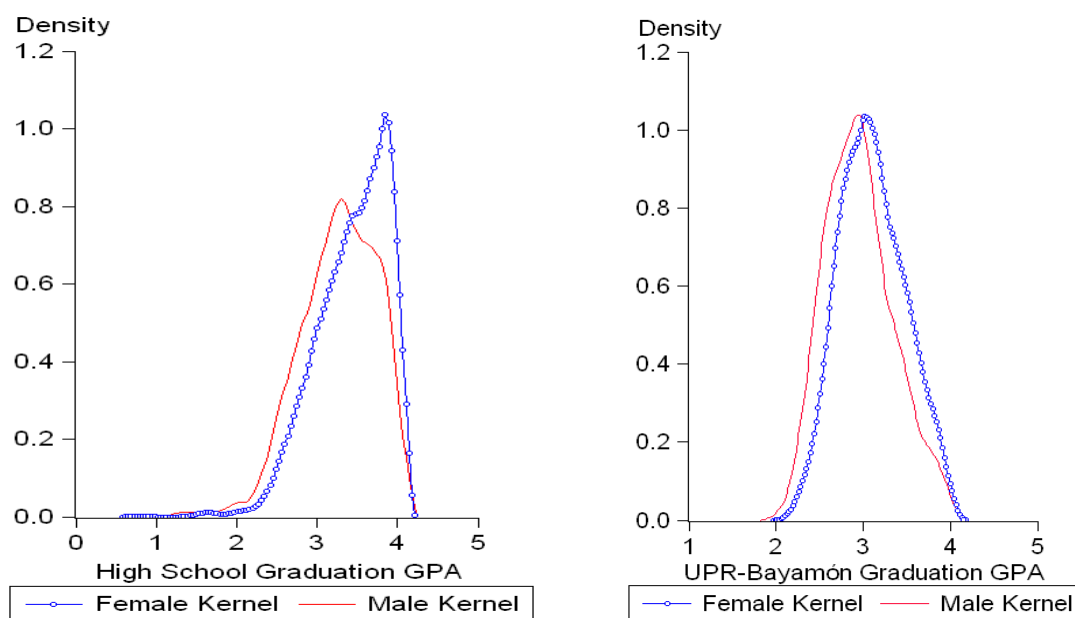

Figure 1. High School and UPRB GGPA by gender

GAI, GGPA and Time Lag by Type of High School and Academic Programs

Of the 8,258 students enrolled full-time in the UPRB in the six cohorts, 54% were from public and 46% from private schools. By the end of the 2005–2006 academic year, 1,302 public school students (54.09%) and 1,105 from private schools (45.91%) had completed their associate or bachelor's degrees, which corresponds to the general proportion of incoming students. The fact that the proportion of public school students that graduated is the same as that of the incoming classes tends to support the conclusion that student quality was not compromised by changes in the GAI.

Table 4 shows that on average students from private schools started college with a GAI two points higher than that of public schools students (288 vs. 286). Nevertheless, in seven out of eleven programs, public school students' GAI scores were two to seven points higher than those of private school ones. Only in Accounting, Electronics, Engineering Technologies and Materials Management were their GAIs lower (by two points in the first two and by four points in the last). It must be noted, however, that most of these programs are associated with more prestigious and higher-paying jobs, in contrast to programs such as Education, Physical Education and Office Systems, in which graduates from public schools' GAIs were higher (by seven, three, and two points, respectively).

In five of the seven programs in which their GAI is higher, public school students' GGPAs are greater than those obtained by their counterparts from private schools, while graduates from private schools' GGPAs are higher in six programs. Differences in the GGPA between both groups usually range between 0.03 and 0.05, except in the case of Office Systems and Physical Education (in

which public school graduates have an advantage of 0.14 and 0.09 points, respectively), and Materials Management (in which graduates from private schools' GGPA is 0.08 points higher). In spite of these differences, the GGPA of both groups of graduates is the same: 3.05, which also suggests that student quality was not affected by GAI changes benefitting public school students.

On the other hand, private school students perform better than students from public schools in terms of the graduation lag. On average, their lag is 2.89 semesters while that of public school students is 3.31 semesters, a difference of 0.42 semesters. In terms of specific programs, UPRB graduates from public schools lags range from 1.26 and 0.93 semesters (in Electronics and Materials Management, respectively) to 0.29 semesters (in Other Programs). Public school students exhibit shorter graduation lags in only three programs (Education, Physical Education and Office Systems), in which their advantages are, respectively, 0.14, 0.21, and 0.27 semesters. Although the explanation for these differences is beyond the scope of this paper, it has been proposed that the increase in time-to-degree could be associated with increased hours of employment among students (Bound et al., 2007), which would possibly be more common among public school students, generally from lower-income families.

Table 4

GAI, GGPA and graduation lags by high-school type and academic program 1995–96 to 2000–2001 Incoming Classes

Academic Programs	Public High School				Private High School			
	GAI	GGPA	$\bar{t}_t$	*n*	GAI	GGPA	$\bar{t}_t$	*n*
All Programs	286	3.05	3.31	1302	288	3.05	2.89	1105
Accounting	305	3.23	3.25	134	307	3.27	2.59	144
Business	288	3.03	3.36	236	286	2.99	2.8	323
Computer Science	304	3.08	3.19	125	301	3.12	2.87	95
Education	280	3.19	3.2	161	273	3.14	3.34	108
Physical Education	253	3.03	2.81	67	250	2.94	3.02	58
Electronics	290	2.83	4.14	140	292	2.88	2.88	58
Engineering Technologies	267	2.68	4.0	39	271	2.71	3.59	29
Materials Management	273	2.78	4.5	40	277	2.86	3.57	30
Biology	307	3.10	3.01	93	304	3.14	2.42	127
Office Systems	268	3.02	2.8	206	266	2.88	3.07	74
Other Programs	299	3.21	3.51	61	296	3.18	3.22	59

Notes: *n* = sample size, $\bar{t}_t$ average graduation lag (semesters).

Effects on GGPA of Exceeding the Minimum Time Required for Graduation

As stated in the Introduction, one of our study's aims was to determine the consequences on the GGPA of exceeding the minimum time required for graduation, which at the UPRB is two years for the associate degree and four years for the bachelor's. These graduation lags have important consequences for students, in terms of deferral of the higher wages associated with college completion and lowering the rate of return to college education, as well as to society in general, due to reductions in the availability of college-educated workers in the labor market (Bound et al., 2007, p. 4), which has important implications for long-run economic growth (DeLong, Goldin, & Katz, 2003, cited in Bound et al., 2007, p. 4).

Table 5 compares the GGPA by academic programs at different points and intervals of the graduation lags distribution. A total of 237 (9.85%) students completed the graduation requirements

in or before the allotted time $(-1 \leq t_t \leq 0)$. A second cluster of 303 (12.59%) and 657 (27.3%) students exhibits graduation lags of one and two semesters, respectively. As expected, these three groups of graduates obtained the highest GGPAs. On the other hand, a total of 825 (34.28%) students exhibit graduation lags of three to five semesters, inclusive. Finally, 329 (13.67%) and 56 (2.33%) graduates needed six to eight, and nine or more semesters in order to complete their degrees, respectively. Graduates belonging to these last three clusters obtained the lowest GGPAs.

Table 5
GGPA by academic programs and graduation lags 1995–96 to 2000–2001 Incoming Classes

Program	$-1 \leq t_t \leq 0$	$t_t = 1$	$t_t = 2$	$3 \leq t_t \leq 5$	$6 \leq t_t \leq 8$	$t_t \geq 9$
Accounting	3.50 (41)	3.32 (55)	3.23 (58)	3.14 (77)	3.20 (38)	2.90 (9)
Business	3.28 (92)	3.06 (83)	3.00 (108)	2.95 (164)	2.84 (100)	2.67 (12)
Computer Science	3.49 (13)	3.41 (33)	3.16 (75)	2.93 (71)	2.81 (22)	2.82 (6)
Education	3.45 (8)	3.31 (32)	3.26 (75)	3.12 (125)	2.92 (23)	2.70 (6)
Physical Education	3.38 (4)	3.30 (8)	3.10 (48)	2.89 (56)	2.71 (9)	N/A
Electronics	3.41 (13)	3.11 (14)	2.88 (61)	2.72 (54)	2.76 (49)	2.57 (7)
Engineering Technologies	3.43 (1)	2.56 (1)	2.73 (26)	2.62 (28)	2.71 (8)	2.66 (4)
Materials Management	3.09 (3)	3.50 (3)	2.93 (20)	2.69 (25)	2.73 (15)	2.57 (4)
Biology	3.37 (39)	3.37 (14)	3.22 (68)	2.97 (77)	2.83 (20)	2.90 (2)
Office Systems	3.41 (8)	3.19 (46)	3.08 (99)	2.82 (102)	2.75 (22)	2.68 (3)
Other Programs	3.57 (15)	3.29 (14)	3.47 (19)	3.13 (46)	2.88 (23)	2.63 (3)
Total	237	303	657	825	329	56
Females	72%	66%	62%	66%	52%	48%
Males	28%	34%	38%	34%	48%	52%
Private	64%	51%	44%	43%	42%	34%
Public	36%	49%	56%	57%	58%	66%

Note: Sample sizes are in parentheses.

As already explained, females exhibit several advantages in terms of graduation lags, including an average lag 0.49 semesters smaller than that of males. Females also constitute the great majority of the graduates who finish their degrees in the allotted time (72%) and of those whose graduation lags are of only one (66%) or two semesters (62%). Private school students also exhibit advantages in terms of graduation lags, with an average lag 0.42 semesters smaller than that of public school ones. Moreover, private school students complete their degrees in the allotted time in a higher proportion than public school students (64% vs. 36%), but this difference substantially narrows when considering those with a graduation lag of one semester (51% vs. 49%) and the proportion is reversed in the case of those with a lag of only two semesters (44% vs. 56%).

Thus, three important findings come from Table 5: (a) GGPAs vary inversely with graduation lags, (b) the existence of graduation lags is obvious and persistent across all the programs, but its incidence is significantly lower among females, and (c) private school students show marked advantages only regarding completion of degrees in the allotted time.

Statistical Models' Results and Discussion

Results of Linear Models

We used OLS regression to estimate Models 1 and 2, reported in Appendix Table 2 and quantile regression for the five models included in Appendix Table 3. In Appendix Table 2, Model 1 uses a dummy variable to identify the high school of origin (private = 1) while Model 2 uses 223 dummies to identify each of the UPRB graduates' specific high school of origin. The equation to be estimated in both models was specified as follows:

$$(1) \qquad \text{GGPA}_i = \begin{cases} \alpha + \delta(\text{Female}) + \rho(\text{PHS}) + \lambda(\text{Associate}) + \gamma \text{GAI}_i + \sum_{j=1}^{10} \left(\theta_j \cdot \text{AP}_j \right) \\ + \sum_{t=1}^{9} \left(\phi_t \cdot t_t \right) + \sum_{T=2}^{6} \left\{ \psi_T \cdot T_T + \beta_T \left(\text{GAI}_i \cdot T_T \right) \right\} \end{cases} + \mu_i$$

It is assumed that the disturbance term $\left(\mu_i \right)$ is random and normally distributed.

It must be noted that the linear nature of Models 1 and 2 imply that the marginal effect of explanatory variables (such as school of origin, student quality (GAI) and gender) is uniform throughout the distribution of the GGPAs, independently of the bounds where it is evaluated. This aspect will be discussed when we explain results using a maximum likelihood model, and analyzed in light of the highly nonlinear ordered probability model, which allows for capturing the effect of all these considerations.

OLS Models

The first of the three columns to the right of Appendix Table 2 displays the estimated regression coefficients of Model 1 according to academic programs. The reference group is Other Programs. Graduates from the Engineering Technologies, Electronics, and Materials Management are at disadvantage. Other things being equal, the GGPA expected by a graduate from one of these programs is, respectively, 0.44, 0.29, and 0.25 points less than the one expected by a graduate from the reference group. These penalties may be associated with the academic rigor displayed by these programs' faculty or with the inherent difficulty of the curricula, which require specific mathematical skills. Graduates from all other programs exhibit smaller disadvantages (ranging from –0.19 in Business and -0.15 in Biology to -0.11 in Computer Science and -0.03 in Accounting). Graduates of only two programs, Education and Physical Education, exhibit very slight advantages over the reference group's graduates (+0.06 and + 0.003, respectively).

Likewise, the bachelor's degree graduates' expected GGPA is 0.14 points less than the one expected from the associate's degree graduates. This is a relatively high penalty, but the inherent difficulty of these programs' curricula is significantly greater than that of the associate programs. Everything else being equal, females' expected GGPA is significantly greater than that expected from males. The difference varies between 0.0664 points in Model 1 and 0.0753 points in Model 2.

According to Model 1, the GGPA expected from private school graduates is 0.02 points less than the one expected by public school ones. This result is in accordance with Horowitz and Spector (2005), who reported an insignificant private high school coefficient in the GPA determinants at Ball

State University.[14] They do, however, find a significant religious school coefficient of 0.055, but its effect disappears through time in college.

In Model 2, the effect that the 223 specific schools of origin have on UPRB graduates' GGPA is emphasized even more when it is controlled for each of them, for it is found that all 223 are statistically significant. Such a result implies that the inclusion of each school incorporates into the analysis other elements of valuable information about the socio-economic conditions of graduates' immediate environment. The evidence suggests that their effect on academic performance both in high school and in college is significant and long lasting, even many years after admissions to the UPRB.

Relationship between the GAI and GGPA

It was conjectured that, given the weight of the GAI in the admission process, it should play a significant role as a predictor of graduates' academic success in terms of the GGPA. To shed light on the matter, the coefficient of elasticity of the GGPA with respect to the GAI is computed. Its equation is included in the expression (2):

$$(2) \quad \varepsilon_{\text{GGPA}_i \to \text{GAI}_i} = \frac{\% \, \Delta \text{ in GGPA}}{\% \, \Delta \text{ in GAI}} = \frac{\partial(\text{GGPA}_i)}{\partial(\text{GAI}_i)} \frac{\overline{\text{GAI}}}{\overline{\text{GGPA}}} = \left\{ \hat{\gamma} + \sum_{T=2}^{6} \left(\hat{\beta}_T \cdot T_T \right) \right\} \frac{\overline{\text{GAI}}}{\overline{\text{GGPA}}} \sigma_{\text{GAI}}^{-1}$$

The main effect $\left(\hat{\gamma} = 0.1847 \right)$ is positive and significant, which is consistent with the prior conjecture. Other things being equal, an increment of 1 standard deviation in GAI will increase the expected GGPA by 0.18 points. Thus, the GAI can be considered a strong predictor of academic success. These findings confirm those of a previous study using the same data base (Ragan et al., 2011), which found that the new GAI produces the least mean squared error for predicting first-, second-, third- and fourth- year GPA, compared to other measures of academic potential such as the old GAI, HSGPA, and CEEB mathematics and verbal aptitude tests.

However, the interaction coefficients $\left(\hat{\beta}_T \right)$ are all negative, implying that their relative importance as predictors tends to decrease throughout the temporal trend of entering cohorts.[15] This progressive decrease of the GAI's predictive value could be associated with an inflationary trend in GGPAs.

The exercise described above lacks the limitations inherent to the linear nature of Models 1 and 2. According to Model 1, increases of 1 standard deviation in the GAI are associated with increases of 0.18 points in the expected GGPA, whether the prediction is made starting from the lower or higher bounds of the distribution. It is assumed that the marginal effect of the variable is the same throughout the entire distribution. Such a condition could be very restrictive and questionable.

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[14] Although the institutions are different in several important aspects, the similarity of both studies' findings suggests that there is an insignificant private high school coefficient in the GPA.

[15] In Model 1, 2 of the estimated interaction coefficients $\left(\hat{\beta}_T \right)$ are insignificant. Nevertheless, a Wald test rejects the null hypothesis, which states that the five coefficients are simultaneously equal to zero, at any specified confidence level.

Quantile Models

The estimated quantile regression[16] coefficients reported in Appendix Table 3 shed light on the issue of nonlinearities. In order to compare the coefficients of models 1 and 2 (Appendix Table 2) and models 1-5 (Appendix Table 3), all seven models were estimated using the same set of covariates. Appendix Table 3 reports the quantile regression coefficients estimated at different percentile points: 0.15, 0.25, 0.5, 0.75, and 0.85. For space limitations, only a few of the covariates included in Appendix Table 2 are reported in Appendix Table 3. The private high school variable is significant only in the neighborhood of the 75 and 85 percentiles. Its signs and estimated coefficient values are consistent with prior results reported in Appendix Table 2. On the other hand, female and GAI covariates are highly significant and nonlinear. Other things being equal, the GGPA expected by females is significantly greater than that expected by males. The difference varies from 0.052 to 0.077, depending on the percentile utilized as reference. Once again, the estimated coefficients are very similar to those reported in Appendix Table 2; however, they allow for capturing the nonlinearities of the variable throughout the grades' distribution.

At the 15 percentile and for the first cohort's graduates, an increment of 1 standard deviation in GAI will increase the expected GGPA by 0.14 points. The value of the estimated coefficient changes along the distribution depending on the percentile of reference and reaches its maximum (0.203) at the 75 percentile. A high proportion (88%) of the estimated interaction coefficients $\left(\hat{\beta}_T\right)$ is negative, which implies that the effect of GAI on GGPA tends to decrease across time. Nevertheless, only 32% of them are significantly different from zero.

Results Using a Maximum Likelihood Model

To overcome the linear models' limitations, this section re-evaluates the results of some of the relations discussed utilizing a maximum likelihood (ordered probit) model to compute the probability with which a student may obtain access to a determined bound of the GGPA distribution, including the possibility of graduating with honors (Model 3, Appendix Table 2). For this purpose, a partition of the GGPA is made and five different rankings are defined, three of which are closely related to the institutional criteria used when granting honors at graduation. Let us consider the dummies of expression (3):

$$(3) \quad \begin{cases} y_0 = 1 & \text{if } \text{GGPA} \leq 2.49, \\ y_1 = 1 & \text{if } 2.50 \leq \text{GGPA} \leq 2.99, \\ y_2 = 1 & \text{if } 3.00 \leq \text{GGPA} \leq 3.32, \\ y_3 = 1 & \text{if } 3.33 \leq \text{GGPA} \leq 3.74, \\ y_4 = 1 & \text{if } \text{GGPA} \geq 3.75, \end{cases}$$

According to the UPRB Academic Senate Certification No. 11 (1988–89), *Cum Laude*, *Magna Cum Laude*, and *Summa Cum Laude* are granted to graduates whose GGPA are 3.00-3.32, 3.33-3.99, and 4.00 points, respectively. Therefore, y_0 and y_1 define the inferior bounds of the GGPA distribution for which there are no academic honors. Furthermore, y_2 corresponds with *Cum Laude*, while y_3 and y_4 define the higher bounds of the distribution and coincide with *Magna Cum Laude*.

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[16] The standard reference in this field is Koenker (2005).

Using the expression (3), the ordered variable y_i^G, where superscript '*G*' stands for graduated, is defined in expression (4):[17]

(4) $y_i^G = \{0 \text{ if } y_0 = 1; \; 1 \text{ if } y_1 = 1; \; 2 \text{ if } y_2 = 1; \; 3 \text{ if } y_3 = 1; \; 4 \text{ if } y_4 = 1\}$

The observed value y_i^G is modeled through the latent unobservable variable y_i^{G*}, which is assumed linearly dependent on the same vector of covariates utilized in Models 1 and 2.[18] The model to be estimated is specified in the expression (5):

(5) $y_i^{G*} = \mathbf{X}_i^T \boldsymbol{\beta} + \varepsilon_i$

The disturbance terms $\left(\varepsilon_i\right)$ are assumed to be normally distributed (zero mean and unit variance), with cumulative and density distributions denoted by $\Phi(\cdot)$ and $\phi(\cdot)$, respectively.[19] The fact that female graduates exhibit higher GGPAs than those obtained by males and that private and public school graduates have similar ones was previously documented. Econometrics results from *OLS*, quantile and probit models demonstrate the robustness of such empirical findings. Nevertheless, based only on these statistical results, their adequacy could be questioned. For example, one could conjecture the existence of a self-sorting process by gender, school of origin, the quality of students (GAI) and the inherent difficulty of their academic program's curricula. If it were the case that higher (lower) quality males (females) from private (public) schools applied mainly for admission in more (less) competitive programs and of greater (less) inherent difficulty, such as Biology, Electronics, Computer Science or Accounting, then the most probable results would be those reported by the statistical models.

The estimated coefficients of Model 3 (Appendix Table 2) provide a simple mechanism for verifying this self-sorting conjecture's adequacy. It should be emphasized that the marginal effect of dummy variables (gender, high school type, and academic programs) over the probability that the GGPA will lie in any of the five rankings of the distribution should be estimated through simulations since their qualitative character lessens the validity of the computation of partial derivatives. Using the coefficients of Model 3 in said table and the sub-routine "Make a Model"

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[17] The variable is operationally defined as follows: $y_i^G = \sum\limits_{k=0}^{4}\left(\mathbf{y}_k \cdot k\right)$.

[18] The observed values of y_i^G are determined from y_i^{G*} according to the rule described in EViews 7, User Guide II, (2009): pp. 267-273.

[19] The estimated coefficients $\left(\hat{\beta}_j\right)$ of this model should be carefully analyzed since, in contrast to the linear model cases, they do not correspond to the marginal effects of the covariates. Nevertheless, at the ends of the ranking the direction of the marginal effects of a variable is determined by the sign of its coefficient $\left(\hat{\beta}_j\right)$. Hence, $P\left(y_i^G = 0\right)$ varies inversely, while $P\left(y_i^G = 4\right)$ varies directly with the sign of $\hat{\beta}_j$. In the other rankings it is not possible to determine the sign of the marginal effect a priori. It is solely determinable through computations of the corresponding partial derivatives or by simulations. See Greene (2012), for details.

supported by EViews package, the expected GGPA was computed using different scenarios. Each scenario considers the effect of gender, high school type, academic programs, and GAI. These simulations show that the probability of performance in the upper bounds of the GGPA distribution demonstrated by females, as well as that by public school graduates is greater than that demonstrated by males and graduates from private schools, respectively.[20] The estimated differences by gender and by school of origin are significant, ranging upwards of seven to nine percentage points (pp). When simulating the effects of the different academic programs and for the different values of the GAI, it is demonstrated that the results are robust and invariant to the inherent difficulty of the curricular content of the academic program of graduation, as well as to the quality of the graduates. Also, the differences by gender are invariant to the nature of the school of origin and vice versa.[21] These results are at odds with the prior self-sorting conjecture.[22]

The simulations mechanism was used to isolate the quality of the graduates based on their probability of performance in the different bounds of the GGPA distribution. The results of the simulations are reported in Appendix Table 4. In this exercise, graduates are assumed to have completed their bachelor's degree in the allotted time $(t_t < 1)$ and belong to the first class of the studied period (T_1), while all other variables were evaluated at their reference group or mean values. An increase of 1 standard deviation in the GAI will increase the probability of the expected performance in the higher bounds of the grade distribution (GGPA $\geq$ 3.75) by 25 pp, while decreases of equal magnitude will reduce this probability by 12 pp. Meanwhile, increases of 2 standard deviations will increase this probability by 45 pp, while decreases of equal magnitude would reduce it to practically zero. The probability of the GGPAs of the other four rankings varies inversely in relation to the quality of the graduates. Thus, the probability of performance in the lower bounds of the GGPAs distribution (GGPA $\leq$ 2.49) is reduced to 50% (from 0.02 to 0.01) if the quality of graduates increases in 1 standard deviation, while a decrease of such magnitude would have the effect of increasing this probability by 100% (from 0.02 to 0.04). Therefore, the magnitude and direction of the GGPA responses to the changes in the quality of graduates would depend on the relative position in the GGPA distribution where it is evaluated. The specificity of these results cannot be obtained with the linear models that were previously discussed.

GGPA Behavior over the Temporal Trends

The three estimated models reported in Appendix Table 2 allow for the study of the GGPA's evolution on the two temporal tendencies used in the study: T_T and t_t. Models 1 and 2 allow for examining whether or not the evidence is consistent with the presence of inflation in the GGPAs distribution (for details refer to Jewel, McPherson, & Tieslau, 2013; Matos-Díaz, 2014). Such a phenomenon would exist if the GGPA would tend to increase throughout time without a concomitant increase in the quality of graduates, as measured by the GAI.[23] Hence, it was required that the partial derivative of expression (6) be positive:

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[20] In Model 3, Table 5, private school coefficient variable is not statistically different from zero.

[21] The simulations of the effect of the changes in the quality of the graduates using deviants of one and two standard deviations from the mean of the GAI were done simultaneously in each of the academic programs considered.

[22] The simulation results are not reported, but they are available upon request.

[23] For a literature review refer to Hu (2005), Johnes (2004), and Johnson (2003).

(6) $$\frac{\partial(\text{GGPA}_i)}{\partial(T_T)} = \left(\hat{\psi}_T + \hat{\beta}_T \cdot \text{GAI}_i\right) > 0$$

The estimated coefficients $\hat{\psi}_T$ are positive and significant (except $\hat{\psi}_2$), while all the interaction coefficients $\left(\hat{\beta}_T\right)$ are negative. The pattern of signs of the $\hat{\psi}_T$ coefficients is consistent with GGPA inflation, since they tend to increase over the temporal trend of the new incoming classes even after controlling for the graduates' quality (GAI). This conclusion is reinforced given that the GAI variable is standardized. Therefore, GGPA inflation increases within the subset of graduates whose quality (GAI) is less than the mean. Thus, the GGPAs of students with lower GAIs tend to increase faster than that of those with higher GAIs. If, with the aim of recruiting, retaining and/or graduating more students, the academic programs make the academic standards more flexible, then the most probable result would be GGPA inflation, particularly among graduates with lower GAIs.

It is a different story when the temporal reference corresponds to the semesters in excess of the time required to complete the degree (t_t = graduation lag). In the case of the linear Models 1 and 2 (Appendix Table 2), all the estimated coefficients $\left(\hat{\phi}_t\right)$ are negative and significant. This result implies that prolonging studies at the UPRB does not benefit students, as the GGPA tends to decrease as they exceed the minimum time required for graduation. It is unclear if the GGPA tends to diminish because graduates exceed the minimum time required for graduation or if they delay the graduation date because they have not satisfied the minimum academic requirements necessary for graduation. To shed light on this point, the expected GGPA value was simulated in each of the rankings in Model 3 (Appendix Table 2) and the results are included in the graphs displayed in Appendix Figure 1. It is evident that only the probability of the GGPA of the lower bounds of the distribution tends to increase as the graduates exceed the time required for graduation. Therefore, graduation candidates will fall into the lower bounds of the GGPA distribution to the extent they exceed the minimum time required. These results come from Model 3 (Appendix Table 2), a highly nonlinear one.

Summary and Conclusions

The main objectives of this study were determining the extent to which a 1994 change in the UPR admissions formula promoted equity among genders and among public and private school students, and the degree to which outcomes related to the GGPA are affected by students' GAI, gender, high-school type, and academic program. Related research questions address the effects on the GGPA of exceeding the minimum required time for graduation, and GGPA variations in relation to the graduates' quality (as proxied by the GAI) over the temporal trend of new incoming classes.

With these aims, the study compared the GAI scores of 11 cohorts admitted to the institution from 1995–96 to 2005–2006 with those that they would have had using the old GAI formula. The study also modeled the GGPA of the UPRB graduates belonging to six classes admitted from 1995–96 to 2000–01 and tracked to the end of the 2005–2006 academic year.

The change in the admissions formula eliminated the advantage students from private schools had over those from public schools and reduced to a minimum the advantage males had over females. In terms of the proportion of public high school students in the composition of the

UPR, this change potentially helped reduce the wide gap in their representation in the public university system, in which private school students traditionally have accounted for close to 55% of matriculants, in spite of the fact that they represent only 25% of PR's high school graduates each year. The case of females is different, as they have been more than adequately represented in both our public and (to a somewhat lesser extent) private higher education institutions during the past decades. However, as the UPR uses the GAI to determine admissions to specific academic programs, the new formula also reduced the advantages that male and private high school students previously had in admissions to more selective programs, usually associated with more prestigious and higher-paying jobs.

On the other hand, the fact that the proportion of public school students that graduated is the same as that of the incoming classes, and that the proportion of females is even greater than that of the cohorts, tends to support the conclusion that student quality was not compromised by changes in the GAI.

This conclusion is also supported by our findings that the GGPA expected by females is significantly greater than that expected by males. This result is invariant with respect to the inherent difficulty of the academic program of graduation, the high school of origin, or the GAI. Females also exhibit advantages in terms of graduation lags, with an average lag of 0.49 semesters lower than males'. These findings confirm those of numerous other studies regarding the advantages that females exhibit over males in terms of different college and university academic outcomes. An explanation for this phenomenon is beyond the scope of this study. However, there is a growing literature in the fields of sociology and psychology, which deals with such important issues (Buchmann & DiPrete, 2006; Furnham, Nuygards, & Chamorro-Premuzic, 2013; Sackett et al., 2009).

Although private schools started college with a GAI two points higher than that of public schools students, the GGPA of both groups was the same, 3.05, which also suggests that student quality was not affected by GAI changes. However, public school students' lag is 0.42 semesters greater than that of their private school counterparts, which may be explained by increased hours of employment by these students, which generally come from lower-income families.

The empirical evidence likewise demonstrates that the GGPA is directly, significantly and highly nonlinearly related to the GAI, which thus constitutes the best proxy of the graduates' quality. This finding confirms those of a previous study using the same database (Ragan et al., 2011), which found that the new GAI is an accurate proxy for predicting student success. In this context, the UPR's new GAI formula might serve as a model for similar moderately selective institutions interested in de-emphasizing the use of tests in order to promote greater equity without comprising standards of academic excellence. Nevertheless, the nonlinear nature of the relationship implies that the effect of the GAI would depend on the distribution bounds of the GGPAs where they are evaluated. Therefore, it would be impossible to detect using linear models, as has been the norm in this type of study.

Evidence also shows that GGPAs vary inversely with graduation lags. Groups that graduated in or before the allotted time or with graduation lags of only one or two semesters obtained the highest GGPAs. The study also shows that the existence of graduation lags is obvious and persistent across all UPRB programs, but its incidence is lower among females and, to a lesser extent, males. The persistence of lags across all programs could be explained both by reductions in collegiate resources per student in public colleges outside the most selective universities and, as already explained, by increased hours of employment by students, as has been suggested by Bound et al. (2007). In any case, these findings point to the need of institutional interventions to address the problem, which has economic consequences for both students and the institution.

Finally, upon analyzing the behavior of the GGPA on the two temporal references used in the study, the results obtained tend to complement each other. The GGPA exhibits an upward and significant tendency over the temporal trend of the new incoming classes consistent with the grade inflation phenomenon. However, the GGPA varies inversely with the graduate's quality (GAI). Such a result points to the possibility of reductions in the academic standards by the programs and departments with the aim of recruiting, retaining and graduating more students (Matos-Díaz, 2012). Evidence also points to the conclusion that the probability of grades in the lower bounds of the GGPAs distribution increases to the extent that graduates exceed the time required for graduation.

In view of the fact of wide divergences among different post-secondary institutions, these findings and method are not easily generalizable. Potentially, findings could differ for elite, highly selective colleges and for colleges with relatively less demanding admissions standards. As is the case with many other similar studies, each of our conclusions must be tempered according to each institution's specific characteristics, including its mission and vision, size, demand for admission, and retention policies and programs, among others.

We do hope, however, that our findings might provide some guidance to similar institutions now reflecting on the complex issues involved in attempts to balance equity considerations with those regarding institutional efficiency and the maintenance of standards regarding student quality and academic excellence.

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Appendix

Table A1
Description of Variables

Variable	Description	$\bar{X}$	σ	Max.	Min.
Accounting	1, if Accounting	0.1235	0.3291	1	0
Business	1, if Business	0.2328	0.4227	1	0
Computer Sc.	1, if Computer Science	0.0919	0.2889	1	0
Education	1, if Education	0.1120	0.3155	1	0
Electronics	1, if Electronics	0.0856	0.2798	1	0
Engineering	1, if Engineering Technologies	0.0292	0.1685	1	0
Material Mg.	1, if Materials Management	0.0261	0.1594	1	0
Biology	1, if Biology	0.0870	0.2819	1	0
Physical Ed.	1, Physical Education	0.0539	0.2259	1	0
Office Systems	1, if Office Systems	0.1082	0.3107	1	0
Other Programs	1, if Other Programs	0.0418	0.2001	1	0
Gender	1, if Female	0.6193	0.4856	1	0
High School	1, if Private HS	0.5383	0.4986	1	0
Bachelor	1, if Bachelor Degree	0.1698	0.3755	1	0
T_T	Temporal trend	3.358	1.6696	11	1
T_1	1, if cohort is 1995–96	0.1795	0.3839	1	0
T_2	1, if cohort is 1996–97	0.1785	0.383	1	0
T_3	1, if cohort is 1997–98	0.1740	0.3792	1	0
T_4	1, if cohort is 1998–99	0.1740	0.3792	1	0
T_5	1, if cohort is 1999–00	0.1604	0.367	1	0
T_6	1, if cohort is 2000–01	0.1336	0.3402	1	0
GAI	UPR General Application Index	287.13	36.104	385	110
GGPA	Graduation Grade Point Average	3.06	0.3901	4.00	2.04
HSGPA	High School GPA	3.37	0.4617	4.00	0.29
y_i^G	$\sum_{k=0}^{4}\left(\mathbf{y}_k \cdot k\right)$	1.74	1.01	4	0
t_t	Graduation lag (semesters)	3.11	2.29	14	-1
t_0	1, if lag ≤ 0	0.0994	0.2993	1	0
t_1	1, if lag $= 1$	0.1257	0.3316	1	0
t_2	1, if lag $= 2$	0.2716	0.4449	1	0
t_3	1, if lag $= 3$	0.1216	0.3269	1	0
t_4	1, if lag $= 4$	0.1664	0.3725	1	0

Table A1 (cont.d)
Description of Variables

Variable	Description	$\bar{X}$	σ	Max.	Min.
t_5	1, if lag = 5	0.0567	0.2313	1	0
t_6	1, if lag = 6	0.0813	0.2734	1	0
t_7	1, if lag = 7	0.0279	0.1648	1	0
t_8	1, if lag = 8	0.0263	0.16	1	0
t_9	1, if lag ≥ 9	0.023	0.15	1	0

Notes: $\bar{X}$ = arithmetic mean; σ = standard deviation; Max. = maximum; Min. = minimum.

Table A2
Determinants of GGPA

Variables	Model 1	Model 2	Model 3
Constant	3.49**		
	(0.0421)		
Biology	-0.1452**	-0.1251**	-0.4854**
	(0.0338)	(0.0363)	(0.1203)
Electronics	-0.2909**	-0.2749**	-1.0194**
	(0.0382)	(0.0422)	(0.1381)
Computer Science	-0.1107**	-0.1035**	-0.4137**
	(0.0361)	(0.0383)	(0.1274)
Accounting	-0.0310	-0.0261	-0.1395
	(0.0352)	(0.0376)	(0.1227)
Business	-0.1873**	-0.1787**	-0.6384**
	(0.0320)	(0.0344)	(0.1110)
Materials Management	-0.2475**	-0.2488**	-0.7630**
	(0.0434)	(0.0454)	(0.1639)
Engineering Technologies	-0.4395**	-0.4100**	-1.3713**
	(0.0529)	(0.0548)	(0.1877)
Education	0.0559†	0.0620†	0.0596
	(0.0334)	(0.0355)	(0.122)
Physical Education	0.0025	0.0203	-0.0813
	(0.0388)	(0.0425)	(0.14)
Office Systems	-0.1365**	-0.1343**	-0.4211**
	(0.0354)	(0.0383)	(0.1234)
Baccalaureate	-0.1424**	-0.1333**	-0.4082**
	(0.0234)	(0.0243)	(0.0845)
Female	0.0664**	0.0753**	0.1733**
	(0.0158)	(0.0174)	(0.0566)
Private High School (PHS)	-0.0214†		-0.0427
	(0.0127)		(0.0471)
GAI	0.1847**	0.1776**	0.6119**
	(0.0151)	(0.0165)	(0.0604)
t_1	-0.1230**	-0.1285**	-0.3906**
	(0.0277)	(0.0289)	(0.1028)

Table A2 (cont.d)
Determinants of GGPA

Variables	Model 1	Model 2	Model 3
t_2	-0.2112**	-0.2178**	-0.6518**
	(0.0246)	(0.0255)	(0.0947)
t_3	-0.3113**	-0.3165**	-0.9850**
	(0.0282)	(0.0294)	(0.1105)
t_4	-0.3614**	-0.3600**	-1.1856**
	(0.0265)	(0.0279)	(0.1042)
t_5	-0.3949**	-0.3845**	-1.242**
	(0.0334)	(0.0345)	(0.1296)
t_6	-0.4165**	-0.4128**	-1.3969**
	(0.0318)	(0.0338)	(0.1215)
t_7	-0.5258**	-0.5407**	-1.8481**
	(0.0393)	(0.0413)	(0.1572)
t_8	-0.4899**	-0.4815**	-1.5151**
	(0.0442)	(0.0452)	(0.1812)
t_9	-0.5500**	-0.5346**	-1.7727**
	(0.0468)	(0.0501)	(0.187)
T_2	-0.0098	0.0008	0.0434
	(0.0227)	(0.0242)	(0.0829)
T_3	0.0482*	0.0512*	0.1644*
	(0.0214)	(0.0224)	(0.078)
T_4	0.0511*	0.0586**	0.2212**
	(0.0212)	(0.0230)	(0.079)
T_5	0.0502*	0.0531*	0.1557*
	(0.0211)	(0.0228)	(0.0772)
T_6	0.0328	0.0435†	0.1604*
	(0.0223)	(0.0243)	(0.0830)
$GAI \cdot T_2$	-0.1302**	-0.1177**	-0.4415**
	(0.0208)	(0.0224)	(0.0784)
$GAI \cdot T_3$	-0.0195	-0.0072	-0.0797
	(0.0212)	(0.0222)	(0.0808)
$GAI \cdot T_4$	-0.0434*	-0.0320	-0.2048*
	(0.0219)	(0.0235)	(0.0867)
$GAI \cdot T_5$	-0.0204	-0.0072	-0.0506
	(0.0197)	(0.0210)	(0.0746)
$GAI \cdot T_6$	-0.0407†	-0.0195	-0.1832*
	(0.0210)	(0.0224)	(0.0804)

Table A2 (cont.d)
Determinants of GGPA

Variables	Model 1	Model 2	Model 3
Limit points			
μ_1			-3.2466**
			(0.1874)
μ_2			-1.4882**
			(0.1759)
μ_3			-0.5024**
			(0.1728)
μ_4			0.7479**
			(0.1718)
$\bar{R}^2$	0.41	0.43	
Pseudo *R*-square			0.16
log likelihood			-2,791
Sample sizes	2,407	2,407	2,407

Notes: †, *, ** = Statistically significant at the 10, 5 and 1 percent levels, respectively. Standard errors are in parentheses. Models 1 and 2 use White heteroskedasticity-consistent standard errors and covariances. Model 3 uses QML (Huber/White) standard errors and covariances. GAI variable is standardized. Model 2 also controls for the unobservable effects of 223 high schools of origin.

Table A3
Determinants of GGPA: Quantile regression

Variable	Model 1 ($\tau = 0.15$)	Model 2 ($\tau = 0.25$)	Model 3 (Median)	Model 4 ($\tau = 0.75$)	Model 5 ($\tau = 0.85$)
Constant	3.05*	3.15**	3.34**	3.60**	3.74**
	(0.065)	(0.052)	(0.055)	(0.062)	(0.07)
Female	0.059*	0.077**	0.067**	0.059**	0.052*
	(0.023)	(0.023)	(0.019)	(0.023)	(0.024)
PHS	0.006	-0.009	-0.012	-0.045**	-0.036*
	(0.019)	(0.017)	(0.017)	(0.017)	(0.017)
GAI	0.14*	0.147**	0.168**	0.203**	0.20**
	(0.036)	(0.024)	(0.017)	(0.023)	(0.021)
$\text{GAI} \cdot T_2$	-0.118*	-0.118**	-0.119**	-0.138**	-0.134**
	(0.042)	(0.031)	(0.026)	(0.028)	(0.028)
$\text{GAI} \cdot T_3$	-0.021	-0.015	-0.025	-0.008	0.029
	(0.039)	(0.03)	(0.025)	(0.029)	(0.024)
$\text{GAI} \cdot T_4$	-0.029	-0.022	-0.025	-0.056†	-0.037
	(0.041)	(0.037)	(0.028)	(0.03)	(0.031)
$\text{GAI} \cdot T_5$	0.004	0.001	-0.019	-0.038	-0.018
	(0.044)	(0.034)	(0.025)	(0.028)	(0.026)
$\text{GAI} \cdot T_6$	-0.015	-0.02	-0.024	-0.049†	-0.066**
	(0.05)	(0.034)	(0.025)	(0.03)	(0.027)
Pseudo R-squared	0.22	0.22	0.25	0.28	0.29
Sample sizes	2407	2407	2407	2407	2407

Notes: †, *, ** = Statistically significant at the 10, 5 and 1 percent levels, respectively. Standard errors are in parentheses. GAI variable is standardized. Models also control for academic programs, graduation lags, bachelor's degree, and temporal trend.

Table A4

GGPA's response to changes in graduate's quality (GAI)

Standard deviations from the mean	Expected GGPA					
	GGPA1	GGPA2	GGPA3	GGPA4	GGPA5	Total
$\Delta\sigma_{(GAI)} = -3$	0.141181	0.664838	0.182852	0.011127	0.000015	1
$\Delta\sigma_{(GAI)} = -2$	0.076180	0.498038	0.329639	0.095212	0.000931	1
$\Delta\sigma_{(GAI)} = -1$	0.040414	0.318458	0.345682	0.269025	0.026421	1
$\Delta\sigma_{(GAI)} = 0$	**0.021249**	**0.185356**	**0.263347**	**0.379241**	**0.150808**	**1**
$\Delta\sigma_{(GAI)} = 1$	0.011120	0.102395	0.167912	0.345096	0.373478	1
$\Delta\sigma_{(GAI)} = 2$	0.005805	0.054999	0.097268	0.243090	0.598838	1
$\Delta\sigma_{(GAI)} = 3$	0.003026	0.029106	0.053553	0.148611	0.765704	1

Notes: GGPA1 ≤ 2.49, 2.50 ≤ GGPA2 ≤ 2.99, 3.00 ≤ GGPA3 ≤ 3.32, 3.33 ≤ GGPA4 ≤ 3.74, GGPA5 ≥ 3.75 Simulations come from model 3, Table 2, and were performed under the assumption that $T_1 = 1$ and $t_t \le 0$, while all other variables were evaluated at their mean values.
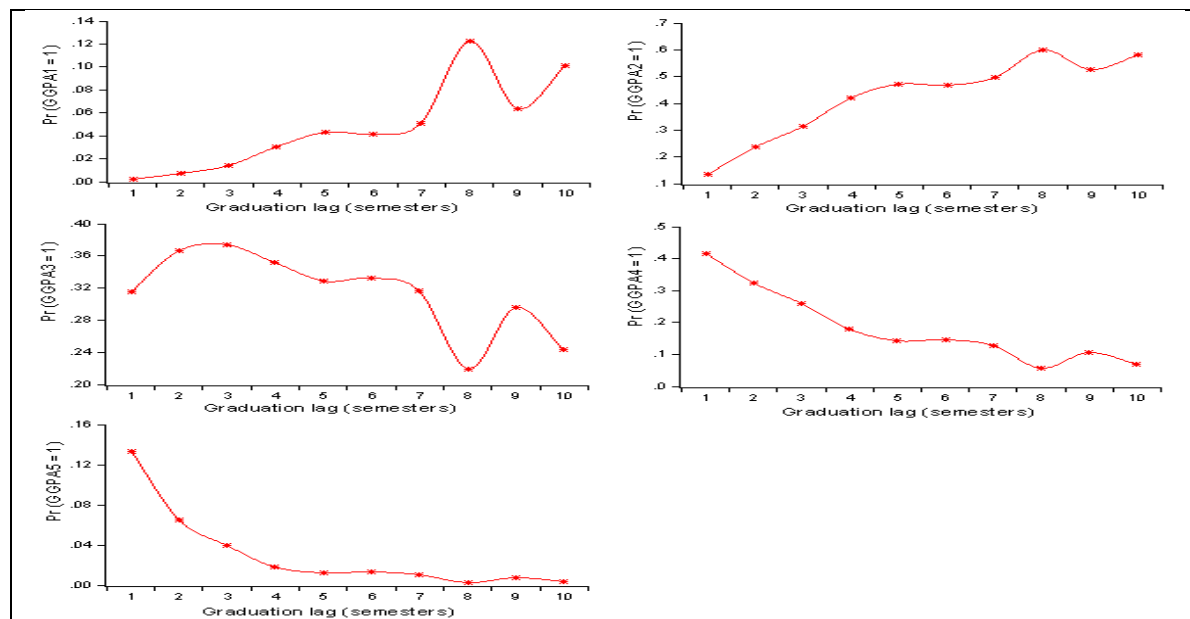
Figure A1. Relationship between expected GGPA and graduation lag

Notes: Simulations come from Model 3, Table 4, and are based on the first cohort $\left(T_1\right)$, while all other variables are evaluated at their mean values.

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