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Stevenson, Adam

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The Male-Female Gap in Post-Baccalaureate School Quality*

Adam Stevenson†

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Abstract

Women are less likely than men to earn degrees from high-quality post-baccalaureate programs, and this tendency has been growing over time. I show that, aside from the biomedical sciences, this can not be explained by changes in the type of program where women tend to earn degrees. Instead, sorting by quality within field is the main contributor to the growing gap. Most of this sorting is due to the initial choice in which program type to apply to. No gender differences arise in terms of enrollment or attrition choices, and admissions committees in high-quality post-baccalaureate programs appear to favor women.

JEL classifications: I21, I23, J16
keywords: graduate school, professional school, gender, ability, program quality

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†Department of Economics, University of Michigan

1 Introduction

The number of post-baccalaureate (PB) degrees granted in the U.S. has grown explosively in the last half-century. Since the early 1960s, the number of masters degrees granted annually increased over sixfold while the number of bachelors degrees granted more than tripled. Professional and doctoral degree programs expanded at approximately the same rate as bachelors degree programs. Women have been particularly successful in higher education, and female attainment rates have grown faster than males' at every award level. By 2006, females earned around 361,000 PB degrees, compared to the 236,000 earned by males (Snyder et. al. 2006). The demand for PB education is rising quickly, and many educational institutions see PB programs, particulary masters degree programs, as a lucrative area for expansion (Fairfield 2007).

This relative female success in PB education is not new, but is rather a "homecoming" in the sense that Goldin, Katz and Kuziemko (2006) use the term in the context of bachelors degrees. Over the twentieth century, women's attainment of masters and doctoral degrees peaked in the 1920s, fell through the Great Depression, and then began an unbroken increase in the 1970s. Women's relative attainment rates reached an historic high among doctoral degrees by 1990, and approached the historic high among masters degrees in 2000 (Snyder et al 2006).

This story of women's educational attainment over the last 40 years, as typically told, is entirely positive: higher degrees are generally a gateway to high-status, high-wage professions. There is one dimension of education, however, that has been intensively studied at the undergraduate level and almost entirely ignored at the PB level: program quality. As Hanushek (2004) points out, the discussion of educational policy is almost entirely focused on quality, and not observed quantity, of schooling. At the very least, quality serves a signalling function that is valuable to students (Spence 1973).

The story of female success is more complex and ambiguous than the aggregate statistics suggest. Once educational quality enters the analysis, we must conclude that women's relative gains in PB education are overstated. While women invest to a much greater degree than men in the quantity of education, their average investment in quality is substantially smaller.

At every PB award level (masters, professional, or doctoral), women are less likely than men to earn a degree from a high-quality program, and are much more likely to earn a degree from a low-ranked program. Low-quality programs are the main driver of women's relative gains over the last 20 years while female-intensive fields like education are not, by and large, a substantial contributor to this growth. Most gender sorting by quality at the PB level comes from student choices in where they apply, with a smaller effect arising in admissions.

The disproportionate concentration of women in low-quality programs is little known, it is an important component of U.S. educational growth. In addition, it is a puzzle. Women are over-represented in the top 10% of their high school classes (Goldin, Katz and Kuziemko 2006) and graduate from the top 5% of undergraduate programs in numbers equal to men, with increasingly greater relative numbers below, as seen in figure 2.

Investment in post-baccalaureate education is an under-studied area in economics, particularly with respect to program quality.[1] This study is important, then, because it exposes cracks in what otherwise seems to be a very positive picture of women's relative achievement.

2 The Growing Gender-Quality Gap

The first goal of this paper is to document the levels and changes in the male-female degree achievement gap, and describe how this gap differs by quality. There is a pronounced gender-quality gap, where men are more likely than women to attend high-quality programs, while women are over-represented in low-quality programs. Because of the substantial gender differences in field and occupational choice, I also consider how male and female degree attainment differs by quality across fields. As a rule, female relative attainment growth is faster in masters degree programs, in low-ranked programs, in more "vocational" fields, and is in the biomedical sciences.

Program quality is a major dimension of differentiation among higher educational programs, and it is a critical dimension of gender differences at the PB level. The two papers that most directly consider PB quality are Zhang (2005a), which proxies quality with Carnegie classification, and Borjas (2004), which uses per-student expenditures to

[1] Most academic work in this area focuses on the PhD, as in Groen and Rizzo (2004), the most similar existing work to this paper. See also Ehrenberg (1992) and its references.

measure quality.[2] In the latter, graduate and undergraduate quality are conflated, and in both, measured quality varies only at the institutional level. PB education is, however, differentiated by major as well as degree, so that quality can vary substantially within an institution.

2.1 Institutional Data

My primary source of institutional data is the Integrated Postsecondary Education Data System (IPEDS), the census of institutions of higher education in the U.S. I use only the IPEDS degree completions module, which is available from 1980-2006. The IPEDS has regularly counted the number of degrees granted to each gender separately since 1985, so this is the starting point for my panel data. The data includes the entire population of individuals earning a degree in a given year, including imputed data.[3]

I classify academic programs by either award level a, or by sixteen broad "degree programs" d.[4] The traditional academic divisions of the humanities, social science, and natural science are a useful baseline for classification. At the doctoral level, I use these categories, breaking up the natural sciences into biomedical and "hard" science fields. At the masters level, each of these academic divisions has a relatively applied portion where the masters is typically terminal, and a relatively academic portion where the masters is not typically terminal. I split the majors in each academic division at the masters level accordingly, and I list each degree program with its primary component majors in the appendix.

I exclude all students of certification programs (such as the CPA), and I also exclude non-citizens under temporary permission to be in the country (typically an educational visa) who do not intend to remain in the country.[5]

[2]The Carnegie classification is a categorization of schools according to their highest degree offered and the scope of the fields offered. More detail on this quality measure may be found at the foundation's website, http://www.carnegiefoundation.org/classifications/.

[3]In most years, imputed data accounts for less than 5% of observed degrees.

[4] I use the term "degree program" to define these overall major groupings (for example "law programs"), and I use the word "program" to refer to specific institution and degree program combinations (for example, "Harvard law"). I generally use the terms "field" and "degree program" interchangeably.

[5]I exclude these individuals primarily for expositional and analytical clarity. It is not obvious how to calculate an attainment rate for these students. PB degree completions by foreigners in the U.S. have changed so greatly in the last two decades that they merit an independent analysis. For example, the share of bachelors and professional degrees granted to foreign students has remained essentially constant over the last two decades while the share of masters and doctoral degrees granted to foreign students has

The IPEDS collects information on the 25^{th} and 75^{th} percentile of ACT and SAT test scores for those schools where at least 60% of their enrolled students submit the results of that specific test. I use the 75^{th} percentile SAT score from 1993 as my measure of undergraduate program quality, since this is the year that the students in my individual level data earned their bachelors degrees. [6]

I use the National Research Council's (NRC) Study of Research Doctorate Programs (SRDP) data (Goldberger et. al. 1995) to measure the quality of masters and doctoral programs in arts and sciences. For each institution offering a PhD in each of the 41 included majors, the SRDP surveyed faculty within that major to rank every program that they are familiar with on a scale from zero ("scholarly quality is insufficient for work at the graduate level") to five ("scholarly quality is distinguished beyond that of peer institutions"). This reputational measure covers 90% of students in the surveyed fields and 50% of all U.S. PhDs granted annually. I also impute this quality data to masters degree programs in the same major at the same institution. This is reasonable because the classes offered often overlap with PhD programs, have similar (relative) student cohorts and are often taught by the same faculty. Masters degrees in the arts and sciences account for less than a quarter of all masters degrees granted annually, and this method generates quality data for approximately one third of these programs.

For quality data in non-arts-and-sciences PB programs, I use a recent edition of the U.S. News and World Report's "America's Best Graduate Schools" survey (USNWR 2005). The 2004 survey has the greatest scope in terms of both the number of schools and the number of fields surveyed (and subsequently published). The USNWR universe is almost entirely complementary to the SRDP. USNWR focuses on professional and service-based fields such as law, medicine, business, education, social work, public administration, and nursing. The ranking system they use varies by degree program, generally using average student test scores for larger fields like law, medicine, business and education while using the reputational scale (which is for all intents and purposes identical to the SRDP's) in most other fields. Where available, I used the more objective test score

increased by approximately 50%. Borjas (2004) and Zhang (2005b) discuss the causal effect of degrees granted to foreign students on domestic completion rates.

[6] Since I only use one measurement of quality per undergraduate and PB program, we must interpret the quality variable as a measurement of the program's time-invariant quality. See Black and Smith (2006) for the problems inherent in such an assumption.

measure of quality, and I used reputational scores for all other fields.

Most of the fields surveyed by USNWR have extensive coverage, ranging from 91% of law programs to 31% (274 of 884 programs) in education. In fields where coverage was large (more than half of the programs offering a degree are explicitly ranked) and published quality data was censored from the bottom, I imputed a quality quantile of one to programs with missing data, implying below-median selectivity.[7] In fields where the full range of the quality scale is observed, it was not reasonable to infer low quality from unreported data and I did not use any quality data for these programs.

Because these three sources of quality data use a number of different scales, I convert them all into quantile rankings. At the undergraduate level, I measure all schools on the same scale, while I rank PB programs only within their field. For schools with multiple majors in a given degree program, I calculate the completions-weighted mean quartile within that degree program and institution combination.

2.2 Attainment Rate Trends by Gender and Quality

Women are less likely to earn a degree from a high-quality program than a low-quality program, especially in masters and doctoral degree programs. Females have increased their attainment rates relative to males at every award level. Among masters degrees, this growth is almost exclusively from low-quality programs, and growth is faster among low-quality programs at every level. By field, female relative attainment rate growth is greatest in MD and biomedical doctoral programs, and is shrinking in the two most predominantly female fields, health science and education.

Table 1 presents the total number of degrees granted by gender.Women earned 6.9 times more bachelors degrees in 2000 than in 1950, 16 times as many masters degrees, 33 times as many doctoral degrees. Male bachelors degree numbers increased by less than double, increased by 3.3 times in masters degrees, and increased around 2.7 times in doctorates. These numbers present the story of female success: the increases are of an astounding magnitude, and show no indication of slowing.

It may be that as the number of bachelors granted to a certain group increases, the

[7] Fields and degrees in this group are masters in nursing, occupational therapy, physical therapy, public affairs, public health, social work and speech and language pathology. Doctorate programs in occupational therapy, physical therapy, and veterinary medicine are also included.

number of later PB degrees grows more or less mechanically. It is important to control for bachelors degree growth when looking at PB completion growth in subsequent years. Following Bowen, Turner and Witte (1992) and Groen and Rizzo (2004), I calculate PB completion rates by stating the number of PB degrees granted as a fraction of the bachelors degree graduating class, appropriately lagged.[8] Bachelors completion is stated relative to the size of the 18-year-old cohort five years previous.

Formally, let C_a^{st} be total number of completions of award a in year t to individuals of gender s. The mean time-to-completion for a is defined as τ_a so that, where B denotes bachelors degree completion in all fields, I define[9]

$$p_a^{st} \equiv \frac{C_a^{st}}{C_B^{s(t-\tau)}} \quad . \tag{1}$$

Propensity-to-complete (a term I use interchangeably with "completion rate") p_a^{st} is most properly interpreted as the probability that a randomly selected individual of gender s who obtained an undergraduate degree in year $t - \tau_a$ will earn award a by year t. This probability is conditional only on the size of the baseline population of gender s and no other observable characteristics. Undergraduate attainment trends, in this context, are interesting primarily as a control for a baseline comparison to PB education.

In figure 1, I plot the gender attainment rate ratio $\frac{p_a^{Ft}}{p_a^{Mt}}$ over time to describe relative changes in PB investment by gender. The number represents how much more likely a woman is than a man to earn the given degree. A value greater than one implies that women are more likely, less than one implies men are more likely.

Female relative attainment probabilities are growing in all award levels. This implies gender divergence in rates among bachelors and masters degrees, where women started out more likely to complete in the 1980s, and convergence in rates among professional and doctoral degrees. Since the relative rates are increasing sharply for bachelors degrees

[8]The relevant baseline populations are: for the Masters degree, the average size of the graduating bachelors degree cohorts 2-4 years prior; for the MBA, the average size of the graduating bachelors cohorts 3-4 years prior; for the JD, the average size of the graduating bachelors cohorts 4-5 years prior; for the MD degrees, the average size of the graduating bachelors cohorts 5-6 year prior; and for doctoral degrees, the average size of the graduating bachelors cohorts 8-10 years prior. In general, we take the average enrolled-time-to-degree and add one year as an approximate average time between degrees. For the doctoral degree, the NCES (Snyder at al 2006) states that the average time-to-degree from the bachelors to the doctorate increased from 8 to 10 years over the sample period.

[9]For the bachelors degree completion rate, substitute H for B and B for d in equation (1), where H is the population of 18-year-olds, and let τ_B=5.

(women are 42% more likely than men to earn a bachelors degree, up from 7% in the 1985 cohort), the upward-sloping PB lines imply female relative gains at an even greater rate at these award levels. This (proportional) growth is strongest in doctoral degrees, a 40% increase in the ratio.

Female relative success in PB education is not simply a matter of increasing representation among bachelors degrees holders. In fact, one might expect that as women increasingly earn bachelors degrees, they become increasingly negatively selected with respect to ability, so that while female representation among PB earners grows, in aggregate PB relative completion rates could fall. Figure 1 shows that this is clearly not so. Among professional and doctoral degrees, overall attainment rates are flat over time. This means that as women increase their attainment likelihoods in these degrees, male rates are simultaneously falling. This stands in contrast to the masters degree, where both male and female attainment rates are rising but female rates are rising faster (so that by the most recent cohort, more than 40% of female undergraduates go on to earn a masters degree), and to the bachelors degree, where male rates have been stagnant at around 29% for the last decade.

The gender attainment rate ratio by award level and quality is presented figure 2. Except among professional degrees, within award level women were always less likely (relative to men) to earn a degree from a high-quality program than a low-quality program. In 2007, women were 40% less likely as men to earn a doctoral degree from a top program, but equally likely to earn a degree from a low-ranked program. Relative to men, women's attainment rates were 60% higher at low-ranked schools than at high ranked schools at the bachelor's and master's degree levels. In undergraduate education, women are the majority group at every quality level by 2007, but were the minority among top-25% masters degree programs. In terms of attainment rates, women slightly lost ground relative to men in the top 25% of masters degree programs over the sample period.

Virtually all of women's relative gains in masters degree programs have come from low-quality programs. Women's relative attainment grew more uniformly across quality among doctoral degrees (with a stronger surge among the bottom category since the year 2000), which may explain why female relative gains were stronger in doctoral than in professional degrees. Women less likely to enroll in professional degree programs, but in a way that is largely unrelated to program quality.

Differential gender growth by field, with a few exceptions (concentrated in biomedical fields) can not explain women's relative success in PB education. The main correlate to the increases in their relative attainment rates is quality. I illustrate this argument in Table 2. The main component of Table 2 is the description of the (annualized) changes in the female-male attainment rate ratio, by degree program d and quality category q. To put these growth rates in context, I also provide the relative popularity of d in the form of the fraction of all PB degrees granted in that field, the fraction female in the first year for which I can calculate p_d^t for the indicated degree, and the overall change in popularity of the degree in the form of total change in attainment likelihood p_d^t over the sample period.

Those degree programs where women's relative attainment is rising fastest among top programs are largely the slowest-growing overall - masters programs in engineering, and doctoral programs in the humanities and social sciences. In the three most popular degree programs - education, business, and law - the changes in female relative attainment are either negative or very small in all quality levels.

The strongest contributors to the large female relative growth rate among masters degree programs are programs in public service (social work and public administration, primarily) and professional and doctoral biomedical programs. Public service is a large, quickly-growing field with large relative gains among women. MD programs are slow-growing, but are large, and they are the place where women's relative gains are largest. Doctoral biomedical programs are small, but fast-growing with large relative female gains. In all three of these program types, women's gains are largest in lower-ranked programs.

The two fields where women are most concentrated, masters programs in education and health, grew very quickly, but women's relative attainment fell across all quality levels with the fastest decrease at the bottom. The rapid growth of these female-intensive programs can not explain female relative success at the PB level.

The discussion of Table 2 is an informal way to reconcile aggregate degree program popularity, female clustering in certain fields, and changes in female relative attainment by degree program and quality. In the next program, I present a unified framework to perform this sort of analysis, decomposing the shares of degrees earned by men and women, into within-cell and between-cell changes in completions. Before doing so, I undertake a short digression to discuss the influence of race on PB completion and its relationship to quality and gender.

I have shown in this section that while women have become much more likely, relative to men, to earn PB degrees, there are a number of qualifications to this success story. The gains are focused in a narrow range of fields and, perhaps more importantly, in low-quality programs. Presumably, these are the PB programs where the least human capital is developed. If the private or social returns to education are also smallest in these programs, then the value these increases in attainment will smaller than expected. While there are many interesting trends with respect to race in PB education, I argue that they do not intersect substantially with changes in attainment according to quality or gender.

2.3 Degree Shares and Sorting by Field and Quality

In this section, I use group shares of degrees completed by two bachelors degree cohorts to decomposes changes in degree completions into shifts in a program's relative popularity ("between" changes) and shifts in a program's overall popularity ("within" changes). 72% of the change in the male-female degree completion share gap comes from increased entry into PB education, rather than relative changes in field-specific growth that would tend to favor women over men.

I construct two synthetic cohorts t for this section - one that completed the bachelor's degree in 1982, and the other that completed in 1997. Using the mean times-to-degree τ_d given in section 2.2, I define all degrees d earned in time $t + \tau_d$ to be granted to bachelors degre cohort t. Specify the share of all PB degrees earned by cohort t held by gender s as

$$S^{st} = \frac{C^{s(t+\tau_{df})}}{C^{(t+\tau_{df})}} = \frac{\sum_{d,q} C_{dq}^{s(t+\tau_d)}}{\sum_{s,d,q} C_{dq}^{s(t+\tau_d)}} = \sum_{d,q} \varphi_{dq}^t S_{dq}^{st} \quad , \tag{2}$$

where φ_{dq}^t is the fraction of all PB degrees that were granted in programs in group dq,

$$\varphi_{dq}^t = \frac{\sum_s C_{dq}^{s(t+\tau_d)}}{\sum_{s,d,q} C_{dq}^{s(t+\tau_d)}} = \frac{C_{dq}^{(t+\tau_d)}}{C^{(t+\tau_d)}} \quad . \tag{3}$$

Count the number of PB degrees in program type dq by each gender $s \in \{M, F\}$ in the 1982 bachelors degree cohort. Divide by the number of all PB degrees granted to the 1982 bachelors cohort to get S^{st}_{dq}. Multiply this number by the relative popularity of that PB program among all individuals who obtained PB degrees, φ^{t}_{dq}, and add up these products to recover S^{st}. This measures the share of degrees granted and not the probability that an individual in group s obtains a certain degree, and so the results below are not directly comparable to those in section 2.2.

Given equation (2), define the change in overall PB representation (i.e., in the total share of degrees earned) for group s between cohorts t_1 and t_2 to be

$$S^{Ft_2} - S^{Ft_1} = \left(\sum_{d,q} \varphi^{t_2}_{dq} S^{Ft_2}_{dq} - \sum_{d,q} \varphi^{t_2}_{dq} S^{Ft_1}_{dq}\right) - \left(\sum_{d,q} \varphi^{t_1}_{dq} S^{Ft_1}_{dq} - \sum_{d,q} \varphi^{t_2}_{dq} S^{Ft_1}_{dq}\right). \tag{4}$$

and since shares φ^{t}_{dq} are gender invariant, I can use the same measure to look at the change in the male-female degree share gap. The change from year t_1 to t_2 in the share gap between women and men is

$$\begin{aligned}(S^{Ft_2} - S^{Mt_2}) - (S^{Ft_1} - S^{Mt_1}) = &\left[\sum_{d,q} \varphi^{t_2}_{dq}\left(S^{Ft_2}_{dq} - S^{Mt_2}_{dq}\right) - \sum_{d,q} \varphi^{t_2}_{dq}\left(S^{Ft_1}_{dq} - S^{Mt_1}_{dq}\right)\right] \\ &+ \left[\sum_{d,q} \varphi^{t_2}_{dq}\left(S^{Ft_1}_{dq} - S^{Mt_1}_{dq}\right) - \sum_{d,q} \varphi^{t_1}_{dq}\left(S^{Ft_1}_{dq} - S^{Mt_1}_{dq}\right)\right]\end{aligned} \tag{5}$$

In both of the previous equations, the left parenthesized term represents the "within" variation: the change in the share of degrees earned (or, the gap in the share), holding the proportion of individuals obtaining that degree constant. The right parenthesized term is the "between" variation: the degree to which programs became relatively more or less popular, holding constant the share (or, gap in the share) of individuals of gender s in programs of that type. A positive sum of the two numbers indicates a relative shift in completions in favor of F. A positive within term implies that a greater fraction of degrees are going to F in t_2 than in t_1. A positive between term indicates that either a program where F tends to specialize has become more popular or a program where M tends to specialize has become less popular.

Since the summation in equation (2) is over d and q, I can partially sum over quality categories q to describe the contribution of quality to the overall variation in degree share changes. I do this in Table 3. The top line gives the proportion of all PB degrees earned by each gender in the 1982 and 1997 bachelors degree cohorts (the first and last cohorts with full IPEDS data).[10] The bottom line gives the representation of each gender in each cohort (from Census tabulations of 23-year-olds in the indicated year). The remaining entries state the fraction of all PB degrees that were granted to that award level, quality, and gender cell. For example, 38.65% of all PB degrees granted to the 1982 bachelors degree cohort were masters degrees earned by women. 1.86% of all PB degrees granted to the 1997 cohort to men in bottom-ranked professional degree programs. Since I include unranked programs in this tabulation, Tables 3 and 4 only include fields where I have quality data.

The righthand column is the change over time in the female-male difference in degree shares. In the 1982 cohort, the male share of total degrees was one percentage points higher than the female share. More masters degrees were granted to women, and men earned an almost exactly offsetting greater number of professional degrees. By the 1997 bachelors cohort, women's share of PB degrees was 19.7 percentage points higher than men's. Two-thirds of this gap change comes from masters degree growth, and three quarters of this gap change, in turn, comes from low-ranked and unranked programs. Women still earn, by my last observable cohort, slightly fewer professional degrees than men, but reversed the share gap in doctoral degrees.

Table 4 presents the within and between decomposition, according to equation (5), of the difference-in-difference presented in the righthand column of Table 3, by degree program and quality. Each award level row is the sum of its fields, and the award levels sum to the total at bottom right.

For example, we might ask why women increased their share of degrees earned in low-quality professional programs by 1.27%, relative to men. The answer is that the growth is almost all "within". 1.2 of these points is due to within-cell growth of women's attainment, while only 0.07 points are between. In fact, among professional degrees and doctoral degrees taken as a whole, the increased proportion of degrees going to women is largely within-cell growth. At every award level, both the within and between terms are

[10] Given our assumptions about time-to-degree, our first observation for a masters degree completion is for the 1982 bachelors class. Similarly, the 2006 doctoral degree class, on average, earned their bachelors degrees in 1997.

positive, favoring women, but professional and doctoral within terms swamp the between effects, accounting for 83% of women's share growth. The bottom rows sum effect over quality. Within and between effects are roughly the same size (with within effects typically slightly larger) for ranked programs, across quality.

Among unranked programs, with within effect is almost twenty times larger than the between effect. Unranked programs are the driving force behind the within variation. Almost half of women's increased degree share due to within variation, holding constant shifts degree-quality cell popularity, comes from unranked programs. If I omit unranked programs from Table 4 (that is, if I focus only on ranked programs), the increase women's relative master's degree share would be due in equal parts to within and between variation. Among ranked masters degree programs, women's gains are roughly in equal parts due to the secular increase in attainment likelihood and the fact that female-intensive fields like social work, education, and nursing are the fastest growing. But the masters degree within variation among unranked programs dominates the between effects of all quality levels. 86% of within-degree-program growth at the masters level comes from unranked and low-quality programs. These unranked and low-quality programs are an enormous contributor to the gains in women's PB attainment in the past two decades.

My main purpose in this section was to establish these trends as yet-unappreciated phenomena that exist to be disentangled. PB schooling is the primary source of the economy's highly skilled workforce (and of those who will train the future skilled workforce, in the case of the PhD). I document that women disproportionately attend low-quality PB programs, and the majority of women's relative growth in PB attainment comes from low-quality and unranked programs. Understanding why women disproportionately attend low-quality PB programs, and why this gap is growing, should be an especial concern for future economic and educational research.

3 Student selection by ability and quality: the path to a PB degree

In this section, I follow the 1993 Bachelors and Beyond cohort from completion of a bachelors degree, through to graduate degree attainment. The goal is to identify potential sources of gender differences that are consistent with the gender-quality gap described in section 2. There are four steps on the path to a PB degree, applications: admissions, enrollment, and attrition. Each is a place where gender-differential choices according to program quality or student ability could create gender differences in the quality of program from which students earn their degree. To the extent that continuation from undergraduate to PB schooling has been studied, it has either exclusively focused on enrollment or completion, with little attention paid to the other the steps (Mullen, Goyette, and Soares 2003), or has treated advancement in terms of year-to-year progress, rather than degree-to-degree (Cameron and Heckman 2001).

There are substantial selection forces among masters and doctoral applicants that tend to push women into low-quality programs. These come entirely from the initial application decision for masters degree students, but are stronger and more pervasive along the entire path among doctoral applicants. Admissions decisions tend to run contrary to the gender-quality gap among masters and professional degree applicants, showing preference for high-ability women. While differences in observable characteristics other than ability and quality can't generally explain the gender-quality gap, I show that males and females respond very differently to financial incentives to earn a degree.

3.1 Gender and the path to a post-baccalaureate degree

I showed in section 2, using synthetic cohorts of PB students, that there are substantial differences in the quality of programs from which men and women earn their PB degrees. In this section, I ask if this is still true when I consider a true bachelors degree cohort, that of the 1993 B&B. I describe this gender distribution not only according to completions, as in section 2, but for each of the steps on the path to a PB degree. Does the gender composition change along the path, and if so, does this change tend to equalize or exaggerate gender differences? To look at the raw rates by gender in this section, and control for other observable characteristics, in a regression framework, in the next section.

From the completion of a bachelors degree, the path to a PB degree has four steps.[11]

[11] My conceptualization of the path to a degree is very similar to that of Manski and Wise (1983). Arcidiacono (2005) analyzed the same path (at the undergraduate level, as in Manski and Wise) in the context of a structural model that allows for a correlated error process across steps. This correction only affects his estimates of the labor market returns to ability and field. Since I am not concerned here with this step, my estimates suppose a simple uncorrelated error process across steps.

First, students face the multinomial choice of whether to apply, and if so, to a program of which award level and quality? After this initial application choice, a series of binary choices follow. In the admissions step, each program chooses to admit or decline each applicant. Students with admissions offers then make an enrollment decision by choose whether or not to accept each admissions offer they recieve. Finally, the student makes attrition decisions - does she drop out, or persist in school until she earns a degree?

I use the Baccalaureate and Beyond (B&B) survey from the National Center for Educational Statistics for my individual-level data, which I can match to the quality data using the IPEDS institutional identification number. The B&B started as a representative sample of all individuals who earned a bachelors degree from accredited U.S. institutions in 1993. Follow-up surveys were given in 1994, 1997, and 2003.

The 1993 and 1994 surveys of the B&B (one year after bachelors degree attainment) contain detailed application and acceptance data. Students were asked the names of the two most-preferred institutions that they applied to, the highest award level (but not field or majors) to which they applied, and whether they were accepted into and enrolled in each. The median number of applications for all B&B students who ever apply is one (the mean is 2.2), so for the typical student, even this limited reporting is very informative. Students do not report the degree program they applied to, so I use the (total-completions-weighted) average PB program quality within the institution in the application, admissions, and enrollment steps.[12] To maintain a consistent sample, I restrict my analysis of completions behavior to the pool of students who enrolled by 1994.

In figure 3, I plot the fraction female at each of the four steps, by the highest award level to which the student applied by 1994 and program quality. The quality categories in this figure are mutually exclusive. In doctoral programs, there is a clear stratification across quality in terms of gender. Women are substantially under-represented among those who complete degrees from high-quality programs and over-represented among low-quality programs. This over-representation at the bottom is relative to both the population of

[12] This aggregation is only problematic for my purposes if the programs that females apply to are systematically over- or under-ranked within institution. For example, if females are more likely to apply to education programs than to law programs, AND education programs are systematically ranked higher (relative to other education programs) than law programs (relative to other law programs) within an institution, then females will appear to be apply to lower-quality programs than is true. Among students who enroll in PB education, however, there is not a systematic or significant difference by gender in program quality within institution.

bachelor's degree holders, and relative to the attainment rates seen in the IPEDS.

The masters degree data shows a similar pattern - more women are more likely to complete degrees from low-quality programs than from high-quality programs. Women are 45% of the applicants to from top masters programs are women, but they are 60% of the applicants to bottom-ranked programs. Women are almost equally represented among the applicants to all qualities of professional degree programs, but are a smaller fraction of the graduates from low-quality programs and a greater fraction of the graduates from high-quality programs. In fact, this is largely a composition effect: women differentially select out of law programs as they progress, but men differentially select out of medical programs. Top medical programs are larger than top law programs, and vice-versa at the bottom, generating the observed pattern.

In top programs of every award level, the fraction of applicants who are women is smaller than the fraction who are accepted. Relative to the applicant pool, the people accepted into top programs are disproportionately female. The representation of women does not appear to change substantially as a function of who accepts admissions offers and enrolls.

3.2 Ability, quality, and the path to a post-baccalaureate degree

I show in this section that there are strong gender differences in the pattern of admissions offers from masters and professional degree programs. Selection into the masters degree applicant pool reinforces the over-representation of women among low-ability bachelors degree holders. In steps other than admissions, gender differences are almost always either small or run contrary to the phenomenon of female under-representation in high-quality programs.

In each step along the path to a PB degree, there are two effects consistent with a gender quality gap. First, if women systematically apply to lower-ranked programs than men, the gap would arise, all else equal. Second, taking applications as an example, if low-ability females are more likely to apply to PB education than low-ability men, and this difference is greater than among high-ability students, then a gender-quality gap may emerge, since lower-ability students tend to apply to lower-quality programs.

To measure ability, I take the individual's SAT or ACT score and convert them into a z-score of the U.S. population's test score distribution. That is, ability is measured in standard deviation units above or below the population mean. If both test scores are available, I take the mean of the z-scores. The tests are taken prior to college entry and scores come from administrative data when possible.[13]

There is some concern that the SAT and ACT are downward-biased measures of ability for females. The average women's SAT score in 1988, when most of the B&B students would have taken the exam, was 0.26 standard deviations below the average man's (College Board 2008). Two alternatives are available, undergraduate grade point average (UGGPA) and PB entrance exam scores (the GRE, etc.). While women tend to have higher UGGPAs , it is not clear how to compare UGGPAs between undergraduate majors, much less between institutions. There is no significant relationship between UGGPA and PB program quality. The number of students reporting PB entrance exam scores in the B&B is relatively limited. Controlling for family and demographic characteristics, the SAT/ACT and PB entrance exams have very similar mean gender gaps, both around a quarter of a standard deviation. Without alternate measures of ability like subject test performance or high school coursework, we can't draw conclusions regarding whether the test score difference is caused by bias or selection (since females are more likely to earn bachelors degrees and therefore B&B women are disproportionately selected from low-ability individuals). Figure 4 suggests the latter is plausible, since there are statistically equal numbers of high-ability men and women earning bachelors degrees, but many more low-ability women. To maximize the sample size, I define the SAT/ACT measure to be "ability".

Another issue is the existence unobserved heterogeneity in the rewards, scarcity, distribution, or other characteristics of program quality that correlate with the gender distribution across degree programs. For example, most primary and secondary school teachers have a union-mandated item in their contract that guarantees a substantial salary increase once the teacher earns a masters degree, and many states require teachers to earn a masters degree. This is not indexed to quality, student performance, or course workload of the degree program. The net returns to quality for the student are likely to be very low (or even negative) in this situation. The programs where these conditions tend

[13]They are therefore "pre-market" in the sense of Neal and Johnson (1996).

to exist are exactly those where females tend to cluster - the “applied” masters degree programs such as education, communications and media, public service, and health science. I control directly for the fixed effects of field of study on continuation choices in the admissions, enrollment and attrition decisions steps. In the application decision, I control for field-of-study indirectly, via its influence on income expectations.

Before any individual sets along the path to a PB degree, we have the pool of potential applicants, all bachelors degree holders. In Figure 4, I plot the frequency of all B&B males and females across the ability distribution. The sample is 54.9% female, and the ability of potential female applicants is significantly lower, 0.21, than that of potential male applicants, at 0.5. At abilities above one, there are statistically equivalent numbers of males and females. Below, there are significantly more females.

I now run a series of discrete choice regressions for each step along the path to a PB degree. The goal is to ask whether, at each step along the path, there are gender-differential selection effects that tend to push women out of top programs. These effects must work, all else equal, by either selecting high-ability women out of PB education, or by selecting women in high-quality programs out of PB education, relative to men. As such, the coefficients associated with the interaction of gender and either ability or quality are the focus of this section. I treat ability as a fixed student characteristic throughout. Program quality and award level are modeled as a choice variables in step 1, applications, and are taken as given throughout the remainder of a student's progress towards a degree.

Each step also involves a unique set of choices, constraints, and heuristics that are potentially correlated with these variables. To control for the effects of these shifters, in each step I include a separate set of relevant right-hand-side X^j variables (where j counts the four steps). I describe the precise elements of each X_j as I discuss the regression results. In table 5, I describe the average student ability and program quality, broken down by award level and gender, along the path to a PB degree. This allows us to see how these variables evolve as students progress. Table 5 also shows the results of a t-test of differences between the genders for each step and award level. Among students who applied to master's programs, women consistently have lower measured ability. The quality of programs applied to and enrolled in is significantly lower among women on the path to a doctoral degree than among men (as seen in figure 3).

3.2.1 Applications Decisions

Analytically, the initial application choice is the most complicated stage of the four steps to a PB degree. The bachelor's degree holder must decide whether to continue on in their educational progress (or to opt out, into the job market), and conditional on deciding deciding to apply to school, they must make a joint choice of award level and program quality. The problem is analytically difficult because it is not clear *ex ante* whether, for example, a mid-range professional degree program is preferable to a top master's degree program. We must be careful as econometricians to avoid imposing conditions that treat this choice as a foregone conclusion.

To estimate the parameters of this joint choice over where and whether to apply, I model the application decision as a multinomial choice over award level and quality combinations (the following exposition closely follows that of Ackerberg et. al. (2007)). This approach differs from that typically taken in the literature (and that I take in the other steps), which models applications choices as a function of student characteristics, rather than choice characteristics (Bedard and Herman (2008), Eide and Waehr (1998), Mullen, et. al. (2003))

I take the twelve categories presented in figure 3 (three degree levels by four quality categories) plus the outside option of no school and define each as a "program type" aq over which students choose. Students draw value from program characteristics, and this value is potentially heterogeneous according to observable characteristics X_i and unobservable characteristics ν_i of the student.

One particularly important consideration in this choice is the student's expected income from choice aq, $\overline{I_i^{aq}}$. To estimate this value, I use the 2003 wave of the B&B to regress income on cubic polynomials in ability and age[14], racial indicators, plus a set of indicators interacting the aq level of an individual's degree attainment, undergraduate field of study, and gender. $\overline{I_i^{aq}}$, then, is the gender- and undergraduate-field-specific expected income of choice aq, conditional on ability and demographic effects.

Each aq choice is described by a vector of the mean characteristics of the degree programs within the category, Z^{aq}. Where $Z_i^{aq} = [Z^{aq} \quad \overline{I_i^{aq}}]$, I state individual i's utility

[14]Since all B&B participants earned their bachelor's degrees in 1993, I can not separately identify the effect of potential experience and educational choice in the data.

to earning a degree from a program in category aq as

$$U_i^{aq} = Z_i^{aq}(\theta' + \theta_x' X_i^1 + \theta_\nu' \nu_i) + \varepsilon_i^{aq} \quad , \tag{6}$$

where θ, θ_x, and θ_ν are vectors of parameters to be estimated. With the further assumptions that ν_i is the same length as Z_i^{aq}, $\nu_i \sim N(0, \Sigma)$, and that ε_i^{aq} is distributed according to the type-II extreme value distribution, this framework is the standard random-coefficients, or "mixed", logit (Revelt and Train 1998). An important part of this specification is that the covariance matrix Σ need not be diagonal. For example, a student with an unobserved preference shock in favor of shorter programs may be more likely to choose a master's degree program of any quality, conditional on all other factors. Thus, this specification allows for realistic substitution pattern across aq choices.

X_i^1 contains ability and an indicator for the student's gender. Z^{aq} contains data on the selectivity of programs[15], the average ability level of enrolled students, the average net annual tuition paid (tuition minus all financial aid), and the average program length, measured in months. Table 6 presents the estimates of equation 6. One column presents the fixed parameters θ, θ_x, and θ_ν, and the other column gives the diagonal elements of Σ. The off-diagonal elements were estimated, but are not reported here. Most elements are not statistically significant, but there is a positive covariance between the random parameters associated with selectivity and expected income, and between mean ability and net tuition. In terms of the distribution of θ_ν, only the value associated with tuition payments exhibits significant and substantial heterogeneity. The top 1% of students are essentially indifferent to tuition payments. Because of the correlation between mean ability and tuition, these tend to be the students who most strongly value ability in their peers.

In terms of gender differences in the application choice, the first important result is that there is no systematic heterogeneity in preferences according to gender. None of the interactions between the gender indicator and choice characteristics are statistically significant. Men and women attach equal value to selectivity and expected income, and attach the same disutility to tuition payments and time-in-school. There is minimal

[15] I use $S^{aq} = 1 - Y^{aq}$, where yield Y^{aq} equals the number of students enrolled at the aq level, as a proportion of the number who applied. Thus, selectivity S^{aq} increases as a smaller proportion of applicants enroll.

heterogeneity with respect to ability, as well. High-ability students attach substantially more value to being surrounded by other high-ability students. Since figure 4 shows that women are over-represented among lower-ability bachelors degree holders, this can explain some of the over-representation of women in the applicant pools of lower-quality programs.

This first step determines the award level and program quality that the student potentially progress through. For the rest of the analysis, I take these characteristics to be fixed. Choice decisions are modeled separately (allowed to vary freely) according to award level. All further choice regressions will include quality as a continuous control variable, to investigate whether women are disproportionately into or out of high-quality programs, conditional on their sunk application choice.

3.2.2 The Admissions Decision

I turn now to admissions. I include among the X^2 variables undergraduate GPA, student undergraduate program quality, and whether any honors are reported on the student's undergraduate transcript, since these are clearly observable and presumably important to admissions committees. I also interact GPA and undergraduate quality to allow for the possibility that programs weight GPAs differently, depending on their sources.

Among professional degree applicants, men and women are virtually identical. Their average ability is not significantly different, nor is the average quality of the programs they apply to. Among masters and doctoral degree applicants, men are more ambitious applicants, applying to significantly higher-ranked programs than the women. This is true even as the men and women who apply to doctoral programs are not otherwise observably different at the mean. The men who apply to masters degree programs have a mean ability score 0.3 standard deviations above the women, but are less distinguished that the women in terms of undergraduate GPA and honors received.

In the first three columns of table 7, I present the results of the regressions that ask whether admissions policy has the effect of sorting students of each gender differently across programs of varying quality. The dependent variable here is an indicator for whether the student was accepted into her specific first-choice program p:

$$\begin{aligned}\mathcal{I}(admitted_i^p|applied_i^l = 1) = \beta_0^l + \beta_1^l F_i + \beta_2^l a_i + \beta_3^l a_i^2 + \beta_4^l Q_p + \beta_5^l Q_p^2 \\ + \beta_6^l F_i a_i + \beta_7^l F_i a_i^2 + \beta_8^l F_i Q_p + \beta_9^l F_i Q_p^2 + \beta_{10}^l X_i^2 + D_d^l + \varepsilon_i^l \quad .\end{aligned} \tag{7}$$

This specification will be used in the remaining regressions in this section, changing the dependent variable, the decision it is conditional upon, and X^j as appropriate.

There is a positive interaction between ability and gender among masters degree applicants. All else equal, masters and professional programs prefer high-ability women to similar men. The effect is more or less linear among masters degree applicants. At ability $= A =$0.5 (a half a standard deviation above the population mean, roughly the ability of the average masters degree applicant), the marginal effect implies that women are 3.1% more likely than men to draw an admissions offer. The effects of ability on admissions are more non-linear for women applying to professional degree programs. The average female applicant (A=1) is 12% less likely to draw an admissions offer,, while at A=2, women are 7% more likely to draw an offer from their top-choice program.

While gender differences do not appear with respect to ability among doctoral degree applicants, significant gender differences do appear. First, the gender dummy itself is very large. The large coefficient is consistent with the idea that women consistently "undershoot" in PhD applications, clustering in low-quality programs where the likelihood of drawing an admissions offer is high. Second, both gender interactions with respect to quality are statistically significant. Women are actually less likely to be admitted to lower-quality programs than men. This admissions gap is effectively zero among applicants to top-quality programs.

3.2.3 The Enrollment Decision

Once the student draws admissions offers, the student must decide whether she expects the costs of attendance to be worth the expected benefits. In the enrollment regressions, I include covariates that may shift a student's willingness-to-pay as of the date of acceptance, relative to the characteristics and expectations modeled in the application choice. I control for family resources and constraints by including parental household income and its square, and whether the student is married or has children. I control for the applicant's financial constraints by including a continuous undergraduate debt variable, a separate indicator for "no debt" (to allow for a discontinuity at zero), and an indicator for whether the offering program included any financial aid as part of the admissions offer.[16]

If the female-male difference in enrollment likelihood is greater among low-ability students than among high-ability students, or if females are more likely to accept admissions offers from low-quality programs, a gender-quality gap would arise. The middle three columns of table 7 present estimates of the likelihood of enrollment given the presence of an admissions offer.

There are no gender differences according to student ability among programs of any award level. All else equal, women are significantly less likely to accept a doctoral admissions offer, and are more likely to accept an offer from a low-quality program than a high-quality program. As in the admissions and application steps, this is a tendency pushing towards under-representation among lower-tier programs.

3.2.4 The Attrition Decision

Finally, the last three columns of table 7 show the effects of ability and program quality on the probability of degree attainment by 2003, given some enrollment by 1994. For attrition to explain the large female completion rates in low quality programs, there must be either relatively high attrition among high-ability females, or among females in high-quality programs. Once enrolled, I assume that the X^4 variables should be those that cause shocks to resources that make completion more or less likely. Time is a particularly relevant resource here, and so I control for academic choices that delay graduation, including part-time enrollment or any changes in field of study. I also control for shocks to family status, including entry or exit from marriage, and the arrival of a first child. Finally, I control for the total amount of annual financial aid received by the student.

There are again no differential gender effects according to ability or quality at the masters or professional level. In fact, very few factors are individually significant. And again at the doctoral level, the gender interaction with quality is statistically significant in explaining completion. And again, enrollees at low-quality programs are more likely to complete their degree than enrollees at high-quality programs, all else equal, pushing

[16]The B&B only asks about the size of financial aid for those who enroll. This is variation I will exploit in the completion step.

further towards the under-representation of women earning degrees from top doctoral programs.

In sum, there are powerful selection forces, according to ability, into the PB applicant pool. These draw low-ability students into less costly, less selective programs. Since the pool of women completing undergraduate education is larger and more negatively selected than the pool of men, applications decisions tend to create a pipeline of women into lower-quality programs, namely masters degrees and bottom-ranked PhD programs. This establishes the groundwork for the observed gender-quality gap. After this initial negative selection, the only forces I can find among masters and professional degree applicants run contrary to the gender-quality gap. Admissions committees, all else equal, prefer high-ability women to otherwise similar men. Similarly, women are more likely than men to draw admissions offers from high-quality doctoral programs. Among doctoral applicants, at every other step, selection among women is negative. Women on average apply to lower-quality programs, are less likely to accept admissions offers from high-quality programs, and are less likely to continue once enrolled.

4 Conclusion

I have documented that there is a substantial gender-quality gap in PB education: women are much more likely than men to enroll in low-quality programs, and this gap has grown over the last 30 years, particularly at the master's degree level. This paper provides an initial investigation into the sources of the post-baccalaureate gender-quality gap.

Two sets of results come out of this analysis. The first set of results is negative. I show that the under-representation of women in top programs can not be explained by changes in gendered patterns of sorting across fields. For example, masters programs in education are popular among women, they are growing rapidly, and there are hundreds of low-ranked education programs. But if anything, women are decreasing their representation in these programs relative to men. The same holds for other female-intensive programs like masters programs in nursing or the arts. With one major exception discussed below, the intersection of program quality and field-of-study is not fertile ground for further investigation of the gender-quality gap. I also show that there is very little evidence of gender differences in educational continuation decisions once students draw an admissions offer.

The other set of results are constructive. I show that to the extent that field-of-study can explain gendered patterns in program quality, the explanation lies entirely in the biomedical field. MD and PhD bioscience programs are popular choices among women, they are growing quickly, and their growth is disproportionately in low-ranked programs. Further study is merited, into the questions of why women select into these PB programs, and why the enrollment growth there is relatively bottom-driven. Most of the growth in the gender-quality gap comes from within-field sorting by quality. My micro-level analysis shows that this sorting comes almost entirely from gender differences in the initial application choice. There are important gender-differential effects in admissions offers, but these run uniformly towards placing more women into top programs, not less. To the extent that women are more likely than men to complete degrees from lower-ranked programs, it is by and large because they apply to lower-ranked programs. I show that the composition of the bachelor's degree cohort in terms of ability plays an important role in this phenomenon, and the differential selection into the applicant pool of low-ranked programs is not driven by gender differences in subjective value associated with the selectivity and monetary characteristics of various PB programs.

A Appendix: Degree Programs

Below is the list of the degree programs I define, with their most popular component majors. Within broad academic discipline I group "applied" masters programs, "academic" masters programs, and all doctoral programs. The parenthesized numbers next to degree program titles are the fraction of all B&B enrollees in that group. The italicized and parenthesized numbers (which may not sum to 100 due to rounding or omitted majors) indicate the proportion of that degree program's students in each listed major.

- Humanities
  1. Masters in liberal arts (4.8%): religion & pastoral (*34%*), english (*33%*), languages (*12.8%*), etc.
  2. Masters in communications and media (4.6%): library science (*45%*) fine and performing arts (*32%*), communications (*17%*) , etc.
  3. Doctorate in humanities and education (2.6%).
- Social Sciences

4. Masters in social sciences (5.3%): psychology (*46%*), history (*16%*), sociology (*12%*), etc.
5. Masters in public service (4.6%): social work (*31%*), public administration (*26%*), leisure and recreational studies (*11%*), etc.
6. Doctorate in social science (3.0%).

- Hard Sciences

7. Masters in physical sciences (1.7%): mathematics (*34%*), geoscience (*26%*), chemistry (*17%*), physics (*10%*), etc.
8. Masters in engineering and technology (5.0%)
9. Doctorate in hard science (2.0%).

- Biomedical Sciences

10. Masters in biological science (2.7%): biology (*73%*), environmental science (*14%*), agricultural science (*13%*), .
11. Masters in health sciences (7.4%): nursing (*75%*), community and public health (*25%*).
12. Doctorate in biomedical science (2.4%).

- Professional and vocational fields

13. Masters in business (16.4%).
14. Masters in education (25.6%).
15. Law (JD) (6.4%).
16. Medicine (MD) (3.6%).

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Figure 1: Gender ratio in attainment rate trends, by award level

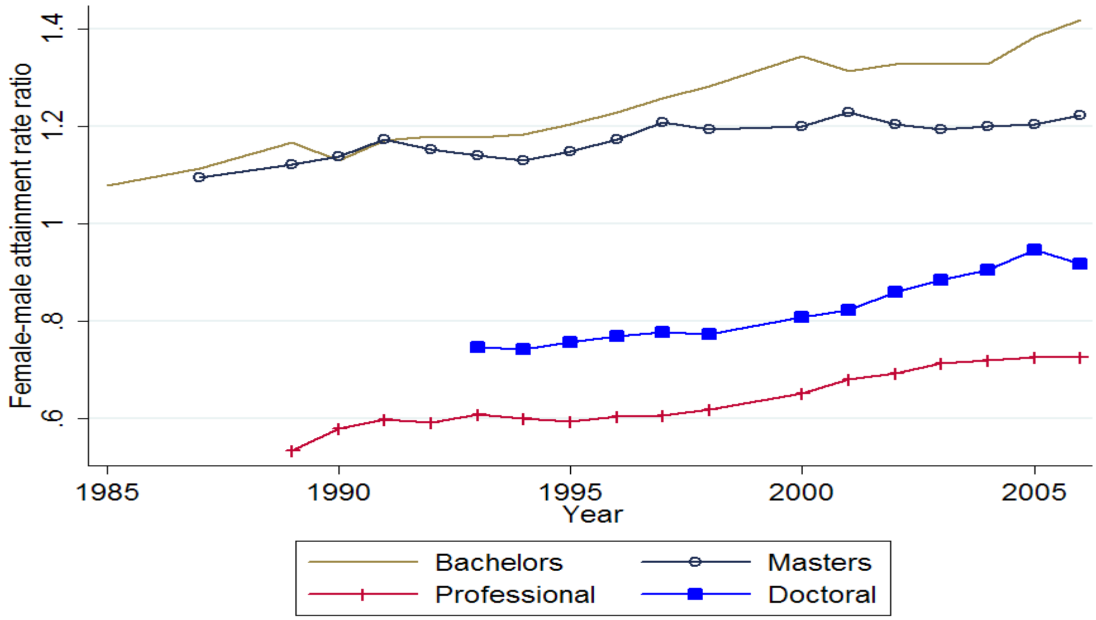
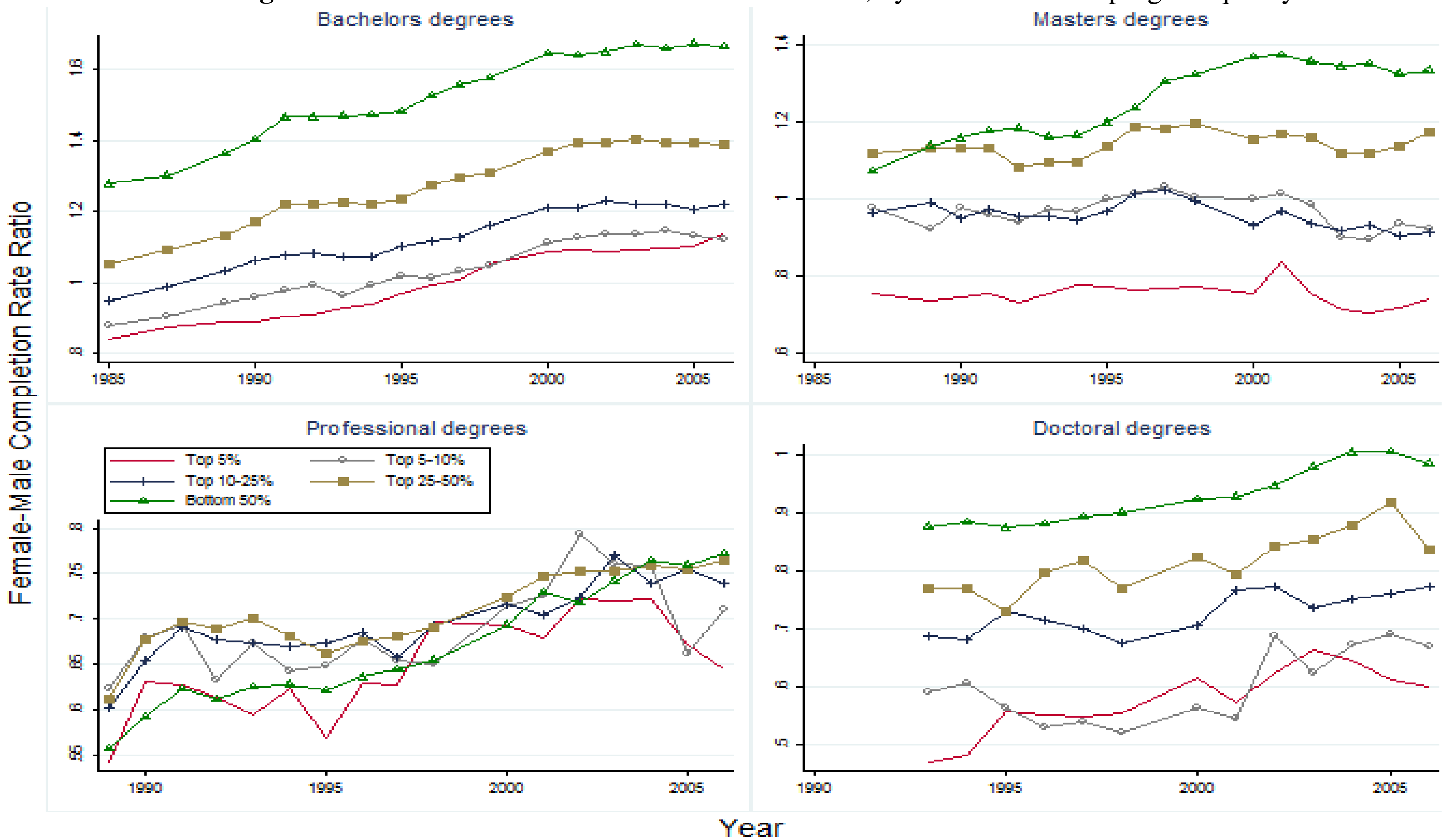
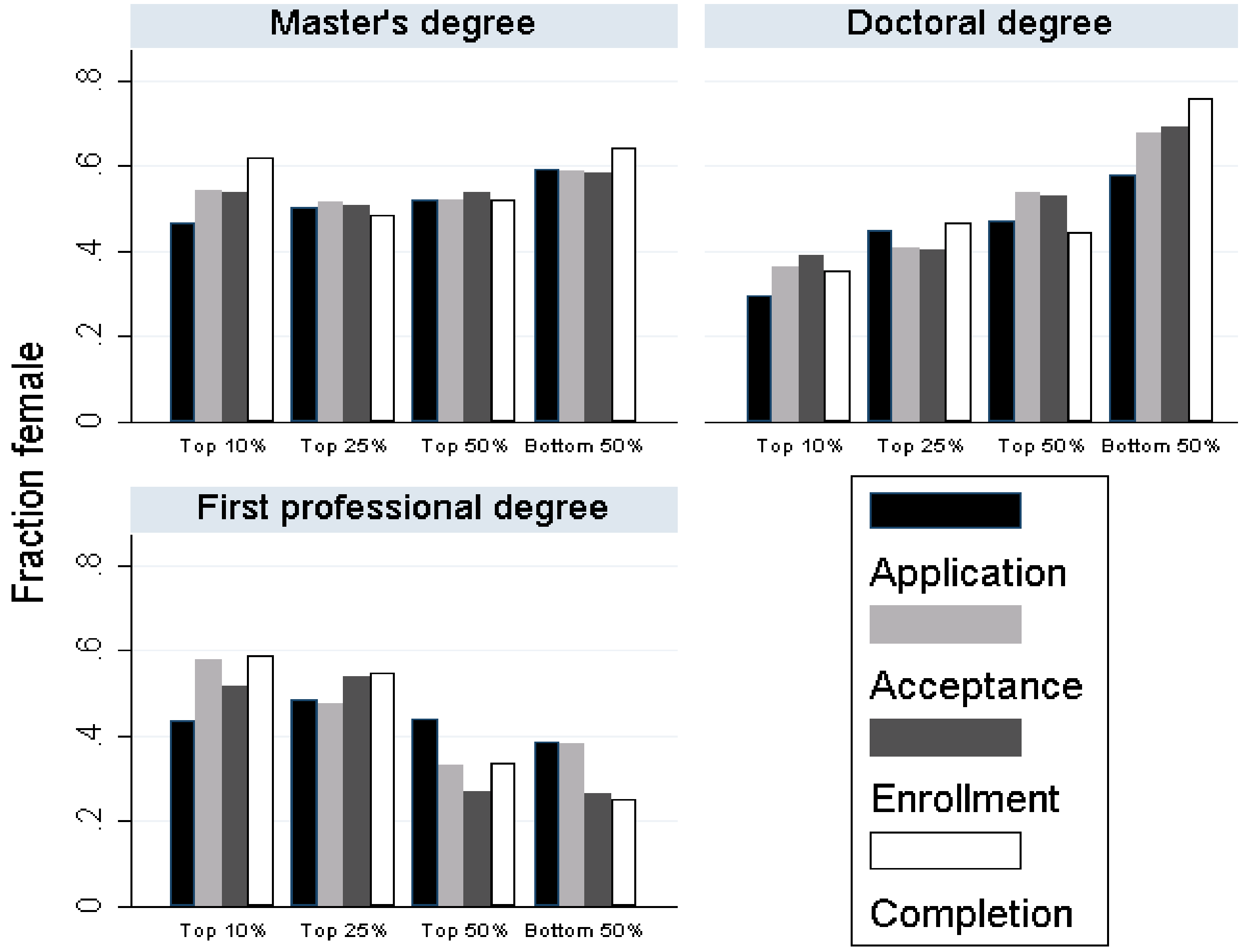


Figure 2: Female-male ratio in attainment rate trends, by award level and program quality



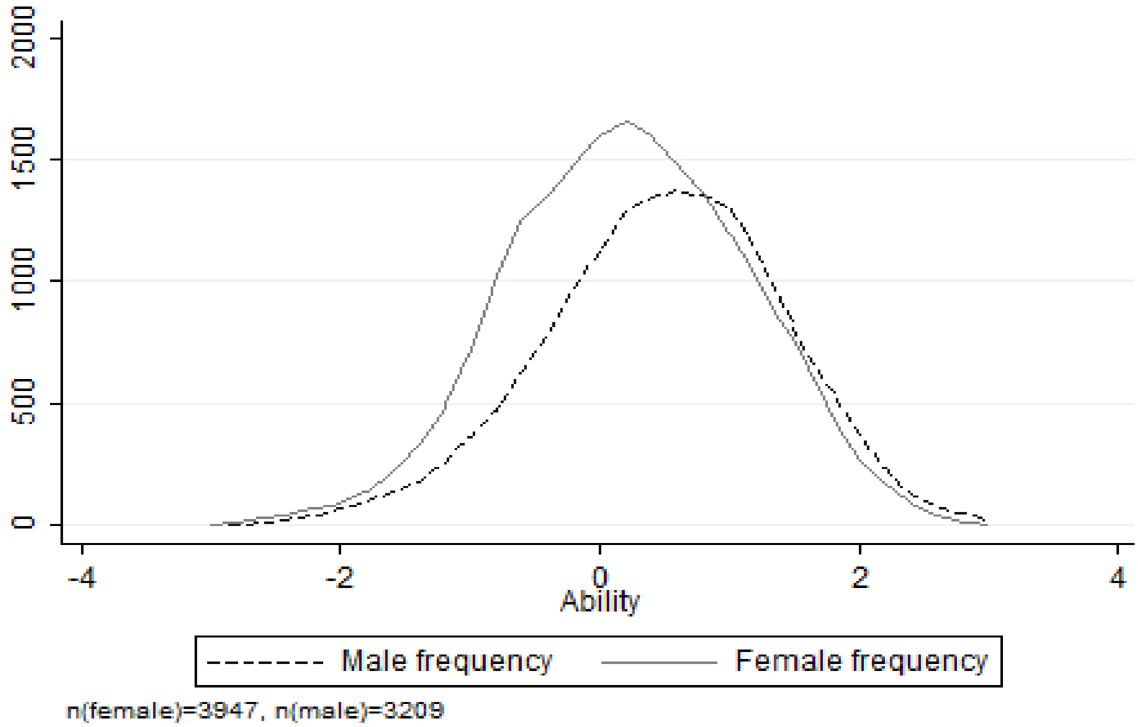
Note : Baselines are defined as in Figure 2.1. The quality categories described here are mutually exclusive.

Figure 3: Fraction female over progression to a post-baccalaureate degree, by award level and quality



Note : Fraction female by highest award level applied and program quality among those who applied, were accepted, and enrolled by 1994, and of these, who completed by 2003.

Figure 4: Ability frequency in the Baccalaureate and Beyond



Note : Data is for all B&B students with ability data surveyed in 1997.

Table 1: Total degree completion by decade and award level (in thousands)

Year	Bachelors			Masters			Professional			Doctoral			Total PB		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
1950	432.06	328.84	103.22	58.18	41.22	16.96	*	*	*	6.42	5.80	0.62	*	*	*
1960	365.17	224.54	140.64	84.61	57.83	26.78	25.25	24.58	0.68	10.58	9.46	1.11	120.44	91.87	28.57
1970	839.73	475.59	364.14	230.51	138.15	92.36	37.95	35.54	2.40	32.11	27.53	4.58	300.56	201.22	99.34
1980	935.14	469.88	465.26	295.74	147.04	148.70	71.96	52.79	19.16	32.96	22.71	10.25	400.65	222.55	178.11
1990	1,094.54	504.05	590.49	337.17	156.48	180.69	71.95	43.85	28.10	39.29	24.76	14.54	448.41	225.08	223.33
2000	1,244.17	531.84	712.33	468.48	194.35	274.13	79.71	42.86	36.85	44.90	24.73	20.18	593.09	261.94	331.15

Note : Data is from the NCES *Digest of Educational Statistics* (Snyder et. al. 2004). The * indicates that professional degrees were included in the tabulation of bachelor's degrees.

Table 2: Changes in the female-male attainment rate ratio, by degree and quality category

	% of all PB degrees granted in initial year	% Female in initial year	Total growth, % of college grads earning degree	Annualized growth in female-male attainment rate ratio: Top 5%	Top 5-10%	Top 10-25%	Top 25-50%	Bottom 50%
Masters	73.3%	53.8%	43.0%	-0.07%	-0.27%	-0.26%	0.24%	1.22%
Liberal Arts	3.6%	51.4%	19.5%	-1.61%	-1.44%	-0.18%	-0.77%	-0.37%
Comm and Media	4.5%	63.4%	20.5%	-0.82%	-0.90%	-1.33%	-0.39%	-0.71%
Social Science	5.1%	56.9%	37.9%	1.45%	0.27%	0.39%	1.61%	1.85%
Public Service	5.1%	62.2%	53.0%	0.73%	2.61%	0.42%	3.55%	2.68%
Engineering	7.3%	20.6%	-1.8%	1.85%	0.37%	0.66%	-0.31%	-0.61%
Physical Science	2.0%	31.2%	-23.1%	1.01%	0.67%	1.71%	1.12%	1.98%
Biological Science	2.9%	43.0%	9.0%	0.37%	-0.57%	0.74%	0.12%	0.53%
Health Science	5.0%	80.1%	98.1%	-0.68%	-0.38%	-1.78%	-1.12%	-1.19%
Education	20.7%	74.8%	64.1%	-0.72%	0.41%	-0.64%	-0.77%	-1.13%
Business	17.1%	34.0%	43.1%	-1.22%	-1.40%	-1.07%	-1.00%	0.66%
Professional	18.8%	38.1%	-3.7%	0.94%	0.69%	1.14%	1.25%	1.91%
JD	10.4%	40.7%	-9.5%	0.40%	-0.07%	0.28%	-0.27%	0.82%
MD	8.4%	33.6%	3.3%	3.37%	2.47%	3.20%	4.18%	4.76%
Doctoral	7.9%	44.3%	7.7%	1.37%	0.65%	0.62%	0.42%	0.62%
Humanities & Ed	2.9%	52.6%	-8.2%	0.83%	-1.08%	0.08%	-1.94%	-0.34%
Social Science	2.0%	52.2%	1.2%	3.57%	0.00%	0.01%	0.79%	1.60%
Hard Science	1.6%	18.9%	-17.9%	0.78%	2.37%	3.48%	2.43%	0.51%
Biomedical Science	1.4%	46.1%	79.9%	2.58%	1.72%	0.87%	3.69%	2.51%

Note : the changes (and "initial year") are computed over the same time period as plotted in Figures 2 and 3 which varies by award level.

Table 3: Share of all post-baccalaureate degrees granted by sex, for two bachelor's degree cohort.

	1982		1997		Change in
	Female	Male	Female	Male	F-M Gap
Fraction of all PB degrees	49.50	50.50	59.35	40.65	19.69
Masters	38.65	33.67	47.21	29.30	12.93
Top 5%	1.58	2.06	1.37	1.59	0.25
Top 5-10%	1.86	1.55	1.69	1.25	0.13
Top 10-25%	4.62	4.38	4.63	3.59	0.80
Top 25-50%	5.59	5.02	5.89	4.10	1.22
Bottom 50%	7.21	7.30	10.16	5.76	4.49
Unranked	17.79	13.36	23.47	13.01	6.03
Professional	7.34	12.38	7.87	7.98	4.93
Top 5%	0.31	0.55	0.30	0.33	0.22
Top 5-10%	0.50	0.75	0.41	0.39	0.28
Top 10-25%	1.10	1.65	0.98	1.03	0.50
Top 25-50%	1.64	2.46	1.60	1.58	0.84
Bottom 50%	2.46	4.36	2.74	2.79	1.83
Unranked	1.33	2.61	1.84	1.86	1.27
Doctoral	3.50	4.45	4.26	3.38	1.83
Top 5%	0.20	0.31	0.17	0.18	0.10
Top 5-10%	0.26	0.36	0.23	0.21	0.12
Top 10-25%	0.67	0.91	0.61	0.59	0.27
Top 25-50%	0.71	1.04	0.71	0.68	0.36
Bottom 50%	0.70	0.93	0.69	0.59	0.33
Unranked	0.98	0.90	1.86	1.13	0.66
Fraction of cohort pop	49.99	50.01	50.74	49.26	1.50

Note : The top line indicates the fraction of all PB degrees earned males or females from a given cohort. The remainder of the entries are the fraction of all degrees that were granted in that award leve, quality, and gender combination in each cohort. The last line is the share of the entire birth cohort that is either male or female in that age group.

Table 4: Within-between decomoposition of the change in degree share gaps

	Top 5%		Top 5-10%		Top 10-25%		Top 25-50%		Bottom 50%		Unranked		Sum over qualities		Total change in share difference
	Within	Between	Within	Between	Within	Between	Within	Between	Within	Between	Within	Between	Within	Between	
Masters	0.09	0.16	0.14	-0.01	0.37	0.44	0.56	0.66	2.02	2.47	5.47	0.55	8.66	4.26	12.93
Liberal Arts	0.001	0.003	0.001	0.002	-0.003	-0.010	-0.020	-0.034	0.018	-0.021	0.008	0.014	0.01	-0.05	-0.04
Comm. & Media	0.002	-0.002	-0.004	-0.011	0.006	-0.031	0.028	-0.041	0.020	-0.046	-0.057	-0.105	-0.01	-0.24	-0.24
Social Science	0.016	0.006	0.016	0.006	0.064	0.012	0.084	0.004	0.240	0.003	0.909	0.043	1.33	0.07	1.40
Public Service	0.061	-0.001	0.080	0.003	0.073	0.031	0.145	0.037	0.367	0.011	0.184	0.110	0.91	0.19	1.10
Engineering	0.017	0.047	0.016	0.078	0.064	0.195	0.107	0.285	0.158	0.398	0.312	-0.069	0.67	0.93	1.61
Physical Science	0.008	0.012	0.002	0.027	0.047	0.072	0.051	0.090	0.076	0.121	0.091	0.069	0.27	0.39	0.67
Biology	0.007	0.001	-0.002	0.000	-0.002	-0.003	0.011	0.000	0.034	0.006	0.206	-0.001	0.25	0.00	0.26
Health Science	0.012	0.039	0.020	-0.015	-0.035	0.220	-0.090	0.470	0.111	0.895	0.103	0.361	0.12	1.97	2.09
Education	0.021	-0.085	-0.002	-0.100	0.077	-0.111	0.083	-0.169	0.373	0.818	0.999	1.006	1.55	1.36	2.91
Business	-0.050	0.139	0.019	-0.002	0.077	0.061	0.166	0.016	0.624	0.284	2.717	-0.876	3.55	-0.38	3.17
Professional	0.15	0.07	0.18	0.09	0.36	0.14	0.67	0.17	1.50	0.33	1.20	0.07	4.06	0.87	4.93
Law	0.102	0.040	0.117	0.064	0.146	0.096	0.192	0.090	0.618	0.251	0.116	0.019	1.29	0.56	1.85
Medicine	0.048	0.029	0.066	0.029	0.214	0.041	0.478	0.080	0.883	0.084	1.079	0.051	2.77	0.31	3.08
Doctoral	0.07	0.03	0.08	0.04	0.21	0.06	0.27	0.09	0.26	0.07	0.61	0.04	1.50	0.33	1.83
Hum. and Educ.	0.001	-0.017	0.023	-0.015	0.016	-0.035	0.019	-0.018	0.057	-0.001	0.077	0.012	0.19	-0.07	0.12
Social Science	0.016	0.002	0.016	0.005	0.033	-0.001	0.038	-0.004	0.104	-0.013	0.147	-0.002	0.35	-0.01	0.34
"Hard" Science	0.018	0.048	0.017	0.051	0.079	0.099	0.072	0.106	0.028	0.078	0.019	-0.018	0.23	0.36	0.60
Biomed. Science	0.036	-0.006	0.024	0.000	0.079	-0.003	0.141	0.003	0.074	0.003	0.371	0.052	0.72	0.05	0.77
Sum over degrees	0.31	0.25	0.41	0.12	0.93	0.63	1.51	0.91	3.78	2.87	7.28	0.67	14.23	5.46	
Total change in share difference	0.57		0.53		1.57		2.42		6.65		7.95				19.69

Note : see text for details of the calculation. Categories may not sum due to rounding.

Table 5: Baccalaureate and Beyond summary statistics, by award level applied, gender, and progress to a PB degree

Panel a: Applications

	Bachelors degree holders		p(Male =
	Male	Female	Female)
Ability	0.505	0.202	0.000
	(0.017)	(0.015)	
N	3209	3947	

Panel b: Admissions

	Masters		p(Male =	Professional		p(Male =	Doctoral		p(Male =
	Male	Female	Female)	Male	Female	Female)	Male	Female	Female)
Ability (if applied)	0.617	0.295	0.000	1.066	0.917	0.150	1.253	1.022	0.097
	(0.055)	(0.042)		(0.068)	(0.078)		(0.104)	(0.094)	
Quality applied	55.5	51.8	0.050	59.4	60.6	0.745	72.1	66.2	0.034
	(1.5)	(1.2)		(2.2)	(2.8)		(2.0)	(2.6)	
N	522	674		187	145		106	89	

Panel c: Students offered admissions

	Masters		p(Male =	Professional		p(Male =	Doctoral		p(Male =
	Male	Female	Female)	Male	Female	Female)	Male	Female	Female)
Ability (if admitted)	0.645	0.372	0.001	1.134	1.077	0.694	1.419	1.088	0.054
	(0.068)	(0.052)		(0.093)	(0.118)		(0.112)	(0.131)	
Quality admitted	52.2	49.1	0.148	54.0	58.5	0.379	73.0	64.3	0.025
	(1.7)	(1.5)		(2.7)	(4.1)		(2.5)	(3.7)	
N	416	549		110	94		73	61	

Panel d: Enrolled students

	Masters		p(Male =	Professional		p(Male =	Doctoral		p(Male =
	Male	Female	Female)	Male	Female	Female)	Male	Female	Female)
Ability (if enrolled)	0.712	0.435	0.001	1.108	1.052	0.709	1.460	1.128	0.063
	(0.066)	(0.055)		(0.114)	(0.125)		(0.102)	(0.158)	
Quality enrolled	54.4	49.7	0.063	52.2	61.6	0.114	70.0	65.0	0.197
	(1.9)	(1.8)		(3.1)	(4.9)		(2.9)	(4.1)	
N	283	372		76	53		57	49	

Note : Summary statistics for ability and quality, by award level and gender, along the path to a PB degree. Statistics are weighted to account for sample structure, and are taken conditional on reaching that step in the path to attainment of a PB degree. Standard errors are in parenthesis.

Table 6: Mixed logit estimation of highest level of PB application by 1994

	Fixed Coefficient	S.D. of random coefficient
selectivity at A-by-Q level (SAQ)	3.19**	0.267
	(1.118)	(1.528)
female x SAQ	-0.309	
	(0.923)	
ability x SAQ	-0.061	
	(0.570)	
mean ability at A-by-Q level (AAQ)	-0.465	5.007
	(1.499)	(3.394)
female x AAQ	-0.272	
	(0.514)	
ability x AAQ	1.399**	
	(0.347)	
mean net tuition at A-by-Q level (TAQ)	-0.769**	0.342**
	(0.114)	(0.092)
female x TAQ	0.023	
	(0.065)	
ability x TAQ	0.064	
	(0.040)	
mean program length at A-by-Q level (LAQ)	-0.164**	0.007
	(0.034)	(0.005)
female x LAQ	0.007	
	(0.011)	
ability x LAQ	0.000	
	(0.006)	
expected income from completion at A-by-Q level (IAQ)	0.013**	0.001
	(0.004)	(0.001)
female x IAQ	-0.005	
	(0.004)	
ability x IAQ	-0.003	
	(0.002)	
N	6452	

Note : Mixed logit regression with five unobservably heterogeneous parameters. The unobservable preference to parameters are allowed are distributed according to the mumtivariate normal N(0, Σ). The diagonal elements of Σ are reported above, while the off-diagonal covariances have been estimated, but are omitted from the table.

Table 7: Progress through post-baccalaureate education, by award level

	Admissions offer to top choice			Enrollment, given admissions			Completion, given enrollment		
	Masters degree	Profess-ional degree	Doctoral degree	Masters degree	Profess-ional degree	Doctoral degree	Masters degree	Profess-ional degree	Doctoral degree
female	0.242	0.049	6.097**	0.685*	-0.718	-14.919**	0.489	0.202	-4.174
	(0.352)	(0.662)	(2.049)	(0.347)	(0.812)	(5.573)	(0.546)	(1.091)	(3.009)
ability	0.033	0.488	0.206	0.051	0.591	0.456	0.303	-1.104	2.284*
	(0.087)	(0.329)	(0.156)	(0.087)	(0.531)	(0.424)	(0.168)	(0.722)	(0.969)
$ability^2$	0.037	-0.191	0.085	-0.049	-0.174	0.057	-0.105	0.340	-0.668*
	(0.033)	(0.136)	(0.054)	(0.045)	(0.214)	(0.179)	(0.092)	(0.288)	(0.340)
ability x Female	0.226*	-0.918*	-0.045	0.111	-0.535	-1.958	-0.066	0.172	-2.904**
	(0.107)	(0.423)	(0.293)	(0.119)	(0.684)	(1.200)	(0.251)	(1.014)	(1.108)
$ability^2$ x Female	0.124	0.518**	-0.075	0.079	-0.035	0.670	0.189	0.351	1.252**
	(0.068)	(0.199)	(0.131)	(0.078)	(0.295)	(0.493)	(0.177)	(0.485)	(0.444)
program quality	0.009	-0.020	0.114**	0.010	-0.021	-0.359*	-0.004	0.016	-0.129
	(0.012)	(0.019)	(0.042)	(0.012)	(0.025)	(0.147)	(0.019)	(0.033)	(0.083)
$quality^2/100$	-0.025*	0.002	-0.091**	-0.010	0.016	0.244*	0.013	-0.010	0.108
	(0.011)	(0.018)	(0.032)	(0.012)	(0.023)	(0.104)	(0.019)	(0.029)	(0.061)
quality x female	-0.015	-0.017	-0.170*	-0.020	0.029	0.492**	-0.008	-0.006	0.208*
	(0.015)	(0.027)	(0.066)	(0.015)	(0.035)	(0.165)	(0.023)	(0.043)	(0.106)
($quality^2$ x female)/100	0.014	0.023	0.124*	0.008	-0.019	-0.379**	-0.005	0.001	-0.178*
	(0.014)	(0.025)	(0.054)	(0.016)	(0.033)	(0.122)	(0.023)	(0.041)	(0.083)
Admissions shifters?	Yes	Yes	Yes	No	No	No	No	No	No
Enrollment shifters?	No	No	No	Yes	Yes	Yes	No	No	No
Completion shifters?	No	No	No	No	No	No	Yes	Yes	Yes
N	1175	328	191	938	181	92	385	108	83
Pseudo-R^2	0.133	0.138	0.141	0.089	0.158	0.271	0.193	0.142	0.294

Note : Each column is a separate probit regression. Acceptance regressions model an admissions offer in 1994 into the student's first-choice program, given application. Enrollment regressions model enrollment into top-choice PB program by 1994, given an acceptance. Completions regressions model completion of some PB degree by 2003, given enrollment in top-choice program by 1994. Admissions and enrollment regressions control for undergraduate field of study. Completions regressions control for graduate field of study. Admissions shifters include the applicant's undergraduate GPA, undergraduate school quality, an interaction between the GPA and undergraduate quality, and an indicator for the presence of honors on the student's undergrautate transcript .Enrollment shifters include the presence of a financial aid offer, the quantity of undergraduate debt, the student's dependency status, linear and quadtratic terms in parent income, whether the student is married, and whether the student has children. Completions shifters include the size of the student's financial aid package,whether the student was working or enrolled part time while in school, and indicators for whether the student married, divorced, or had their first child after enrollment. Regressions are weighted to account for sample construction. Standard errors are in parenthesis. * indicates p<0.05, ** indicates p<0.01.