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The Effect of Demographic Inertia on Increasing the Percent of Women on University Faculty

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INCREASING THE PERCENTAGE OF WOMEN ON UNIVERSITY FACULTY

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ABSTRACT

Despite years of personnel initiatives, equitable gender representation on university faculties remains difficult. We explore how demographic inertia, the numerically-induced resistance to change inherent in an organization's hiring and attrition rates, shapes and limits progress. Using data provided by a university, a mathematical model is used to project future gender distributions for its management and science departments given current hiring and attrition rates. The results show that change is slow and nonlinear. Early gains do not portend eventual success. In addition, while both departments show low percentages of female faculty at the beginning, their futures likely differ. The management department requires immediate, and likely uncomfortable, increases in hiring rates. The science department needs to retain low attrition rates. Thus, the two departments require different personnel interventions. The results demonstrate how university administrators might use such analyses to target demographic weak spots in departments.

Despite widespread agreement that women are, and should not be, underrepresented in the highest levels of professional careers, equitable representation of women in public and private organizations remains a thorny problem. Even when progress occurs, it remains slow. A study of U.S. State Government Agencies indicates it took forty years to increase the percentage of women serving as agency heads from three percent in 1964 to 26 percent in 2004 (Bowling et al. 2006). Yet the percentage of women in professional jobs remains lower than that in the population and concentrated in female-typed agencies such as mental health, social services, aging, library and public assistance. Research on academic institutions shows similarly small proportions at the highest levels. In data collected during 2002 and 2003 from top ranked U.S. chemistry departments, Nelson and Rogers (2005) found that 7.6 percent of full professors were women, whereas 21.5 percent were assistants and 20.5 percent were associates. Similarly, in a National Research Council study of civil engineering faculty (National Research Council 2010), although 22.3 percent of assistant professors were women, only 11.5 percent were associates and 3.5 percent were full professors.

Institutional solutions for such outcomes often begin with two assumptions. First, employers assume that when a given percentage of women is hired, the population will reflect that percentage. Second, they assume that women hired at the bottom of a career ladder reach the top in a reasonable time, where reasonable means the average time it takes to advance. In a 1997 study of U.S. sociology departments Roos (1997) found that between 1981 and 1991 over 50 percent of all sociology graduate students in PhD programs were women. She then notes that by 1993-94 women's "…representation in the recruitment pool has been of sufficiently long standing to lead us to expect that the percentage of females among full professors in graduate programs in sociology should be greater than 17 percent" (Roos 1997: 80). This seems to infer that progress is linear and therefore something is wrong because it is not.

Scholars have explored many explanations for this puzzle including gender stereotypes (Heilman 2012), insufficient numbers of women in high level jobs (Cohen, Broschak and Haveman 1998), leaky pipelines (Pell 1996), low status networks, work and family concerns (Adamo 2013; Mason and Goulden 2004), organizational sex ratios (Tolbert and Oberfield 1991; Tolbert et al. 1995), implicit biases (Jackson, Hillard and Schneider 2014), inadequate mentoring (Blau 2010) and gendered career aspirations (Correll 2004). While these studies consistently demonstrate significant connections with diversity outcomes and their authors propose diverse organizational interventions, underrepresentation persists.

One mechanism that has received less attention is demographic inertia, the numerically-induced resistance to change inherent in an organization's current demography, hiring and attrition rates. Contrary to the assumptions above, this literature suggests that changes in an organization's gender or minority composition are non-linear (e.g., Marschke et al. 2007). Early gains do not necessarily promise later success. Possibly the earliest of these studies (Lieberson and Fuguitt 1967) concerns the intergenerational occupational mobility of white and black men in the United States. Using fathers' and sons' occupational and educational mobility rates obtained from the Current Population Survey (U.S. Bureau of the Census 1961), they find that when rates are applied equally to both groups, it takes 60 years before black men approach status parity with whites and 140 years to reach parity. Thus, even if it were possible to eliminate all discrimination immediately, numerical parity would take a long time.

This paper examines the role demographic inertia might play in university policy and resource interventions designed to increase the representation of female faculty. Data were collected from two departments within a university, a management department and a science department. A mathematical model is used to project the gender composition of these departments using their recent hiring and attrition rates by gender and career level. The results confirm previous results on the slow speed of demographic change. However, they also suggest different progress assessments and resource interventions for the two departments. Relative to baselines, the management department is making less progress than the science department. The management school is hiring fewer women than are available, whereas the science school is hiring above availability. Although women's attrition is not high in the management department, it is almost zero in the science department. Interestingly, both departments would be worse off if attrition rates for men were applied to women.

Why Demographic Inertia

The empirical literature on demographic inertia is limited (See Appendix A), but it consistently shows that demographic change is slow. Three early studies examine racial minorities (Feinberg 1984; Feinberg 1990; Lieberson and Fuguitt 1967). Feinberg (1984) studied blacks' slow gains among 273 craftworkers at a Kaiser Aluminum and Chemical plant. Decision-makers had designed an affirmative action program for layoffs to increase the percentage of black employees until it matched that in the local labor force. However, Feinberg found that even if no black employees left and only black employees were hired it would still take 16 years to achieve equality. He concludes that "Efforts to increase the speed of change face a great structural disadvantage in attempting to overcome the arithmetic as well as the social consequences of the past, and we do a great disservice if we do not recognize that disadvantage" (1984: 180-181).

Recognizing this arithmetic is what makes demographic inertia an important phenomenon. It focuses us on the extent to which mathematical determinism constrains the speed of progress. Independent of decreasing cognitive biases, increasing availability of qualified PhD graduates or other mitigations, this arithmetic shapes and limits the speed of demographic change. No matter how sincere an institution's intention to eliminate underrepresentation, the pace at which this can be accomplished, even under the best of circumstances, is limited by the institution's current demography and its hiring and attrition rates. Thus, even if institutions could turn a switch and become highly desirable and inclusive work environments within a week, administrators would still have to fight demographic inertia to reach specific gender representation goals.

The policy and resource implications for stakeholders are significant. In the early 1980's the U.S. Supreme Court made two rulings that organizations could not use Affirmative Action rather than seniority as the basis for layoffs[1]. This caused considerable concern among those who had worked to eliminate extant inequality. However, Feinberg (1990) in a follow-up to his earlier work (1984) shows that even under extreme conditions, in which he varies organizational size, age distributions, reductions-in-force and rehiring practices, neither layoff policy produces significant changes in racial equality. Equal rights activists might have better spent resources on legal strategies examining other remedies.

Demographic inertia is typically studied using aggregated data from population-level sources. Hargens and Long (2002) examine women's representation in U.S. sociology departments beginning with the 1970 sex composition obtained from NSF's Survey of Earned Doctorates (National Science Foundation 1920-1995). Danell et al. (2013) examine Sweden's gendered promotion rates to full professor by matching data from a national database of all university employees between 1995 and 2010 (Statistics Sweden 2010) with a registry of all

[1] Stotts vs. Memphis Firefighters (#82-206) and Wygant vs. Jackson Board of Education (#84-1340) as cited in Feinberg (1990: 118).

Swedish PhDs since 1971. In an organizational setting, Robison-Cox et al. (2007) analyze imaginary small, medium and large firms based on demographic distributions in Fortune 500 firms (2006) and the distribution of managers across levels in a large U.S. firm (Hurley-Hanson et al. 2005). With one exception, Feinberg's (1984) study of the U.S. plant of 273 craftworkers, the smallest population represented in these studies is 1000 employees.

The Case for Department-Level Assessment

The purpose of this paper is to explore how demographic inertia might be used by university decision-makers as a tool to monitor and assess gender equity in academic careers. Research in university settings typically evaluates university-level questions and recommends university-level interventions. Administrators may provide all faculty with young children extra time on the tenure clock or give all departments additional resources to bring in a wider range of faculty job candidates. Yet research consistently shows that gender representation varies by discipline and department. Science, technology, engineering and mathematics (STEM) departments receive considerable attention as problem areas for gender representation (The National Academies 2007). However, humanities and social science departments show similar or greater variation (Girgus 2005: 9). Thus it seems likely that each department requires its own progress assessment and its own plans for improvement.

The U.S. National Research Council (2010: 125) provides an example of such department differences. They found that in science, engineering and mathematics, female candidates for tenure are most underrepresented in those disciplines where availability is highest. Although 36 percent of assistant professors in biology and 22 percent of those in chemistry were women, only 27 percent of those in biology and 15 percent of those in chemistry were eventually considered for tenure. The drop-off in biology is somewhat higher than that in chemistry. Thus, if these numbers represent significant long-term attrition differences, administrators might take a closer look at why they differ and treat the causes rather than the symptoms. Effective gender representation policies for the two departments may and perhaps should differ.

The explanation for these possible differences requires historical knowledge of a department's current gender distribution, hiring rates and attrition rates. It is possible that progress in a given biology or chemistry department would occur more rapidly if, rather than targeting attrition before tenure decisions, university administrators focused on increasing the percentage of women hired or decreasing the percentage who retire early. Decision-makers have limited resources and must make choices about where to deploy them. Their choices require assessing the potential impact of various change efforts. At what academic transitions will impediments to change make the most impact when removed and thus, on which interventions are the university's resources be best spent?

Scholars and administrators may argue that department-level analyses are misleading. The small faculty numbers in departments produce high variation in the results and the data likely include errors. Independent of errors, one or two faculty who are hired or leave may make projections unrealistically high or low. This is true. However, the variable impact of these small changes is part of the problem. At a local level, each individual faculty hire or separation can be explained. As a result, the distinction between systematic and random patterns is difficult to ascertain. Moreover, small differences accumulate over time, a problem Valian (1999) calls the accumulation of disadvantage. Thus if departments are not studied individually, the long-term effects of these small differences will be missing as university administrators work to increase the percentage of women among their academic faculty.

Monitoring Demographic Inertia

Monitoring the effects of change efforts requires gender representation projections and a definition of department-level goals. Studies of demographic inertia typically use one of two approaches to forecast future gender distributions. The first is some version of age-cohort component analysis (Shryock, Siegel and Associates 1976), which uses age cohorts to indicate stage in the academic career (Hargens and Long 2002; Lieberson and Fuguitt 1967; Marschke et al. 2007). Hargens & Long (2002), for example, use population-level "biological and occupational 'survival rates'" from the Survey of Earned Doctorates (National Science Foundation 1920-1995) for five year cohorts to project the age-sex distributions of tenure-track sociologists starting in 1970. The size of the youngest cohort in each five year increment is "the difference between the total number of tenure-track positions and the number of surviving members of older cohorts. Finally, using data on the proportions of new sociology PhDs during the period from T to T+5 who are women and assuming that women and men have the same probabilities of being hired, we construct the age-sex structure of faculty at T+5" (2002: 501).

The second approach, and the one used here, focuses on transitions between academic career levels, which produces models more closely related to leaky pipeline theories. For instance, Shaw and Stanton (2012) use a mathematical model to examine five transitions: from undergraduate to graduate school, graduate school to post-doctoral fellows, post-doctoral fellows to assistant professors and assistant professors to tenured professors. They compare predicted numbers of women before each transition to the actual numbers from the U.S. National Science Foundation (2008). In another example, Danell and Hjerm (2013) use event-history analysis to predict promotion rates from the time Swedish graduate students complete their PhD to the time they achieve a full professorship. They find that promotion rates for women and men are equal if both have held post-doctoral positions. For those who have not, women are disadvantaged relative to men.

Monitoring the effects of change efforts also requires a definition of goals. Most extant studies use some version of availability in the labor market as the desired end point. Marschke et al. (2007: 4) define the goal as "either equal gender representation among faculty or a percentage that matches the representation of available, qualified women (i.e., the PhD pools)". Shaw and Stanton (2012) compare the gender representation at each academic career stage with the availability in the previous age cohort using NSF data from 1979-2006. Hargens and Long (2002) propose that the goal is to achieve the availability of women represented in the new PhD pool.

There are many ways for a university to define gender representation goals (Blakely 1989). Each makes assumptions about what equality should look like. If administrators decide that gender representation should match population demographics, women and men will each hold 50 percent of all faculty jobs. Administrators could also assume that a department's representation should match the availability of female PhD graduates in that field. They could further refine this goal by limiting it to availability in the university's feeder schools. Thus, university administrators at a Research Extensive university might decide that the gender representation goal for economics is to match availability of female economists graduating from other Research Extensive universities, rather than availability of all PhD graduates in economics. Bikhchandani et al. (2006: 5) provide an example of using availability from management feeder schools as the goal.

Many U.S. universities use such goals. Cornell University's 2010 Strategic Plan (Strategic Planning Advisory Council 2010), for example, specifies that departments should achieve a “20% absolute standard or the pipeline level (whichever is higher), with the federal standard as a reference” (2010: 50). University of Washington sets targets based on the availability of qualified faculty in the relevant discipline who received PhDs during the previous 15 years (University of Washington 2013: 12). They report 2013 percentages, a 2015 target and the gap between the 2010 percentage and 2015 target. Each approach has advantages and disadvantages, but the only way to address the question of whether diversity policies are working, is for administrators to define what they are trying to accomplish.

From a policy perspective, university administrators select goals using some balance between gender representation and the reasonableness of what is required to reach that representation. There are many factors that enter into demographic change, some over which administrators have reasonable control and others over which they do not. For instance, they have more control over hiring a representative group of women from available PhD graduates than in keeping young women in high school science programs. They have more control over increasing representation in departments where the difference between the current percentage of female faculty and existing availability is large, rather than increasing it in departments where the difference is small.

We use a mathematical model to address three questions about the effects of demographic inertia on the gender representation of faculty in two departments within a university setting. The model assumes a three level academic career: assistant professor, associate professor and full professor. Each year, faculty are hired into and exit from all three. Our interest is how administrators might use this technique to evaluate a department’s progress and suggest most effective intervention timing and policies.

Q1. Will each department achieve its gender representation goal if there are no changes in hiring and attrition rates?

Q2. What changes in hiring and attrition rates are required for each department to achieve its gender representation goal within ten to fifteen years?

Q3. What policy and resource interventions are required to facilitate each department's success?

Method

The data come from the faculty personnel office of a university in the western United States. Eight years of faculty data were obtained for the management department, 2004-05 through 2012-13, and five years were obtained for the science department, 2005-06 through 2010-11. The latter represent a subset of the university's STEM faculty.[2] The data follow the hiring, promotion and attrition of each full-time, ladder faculty member during the period of data collection. Hiring includes all faculty hired externally for assistant, associate and full professor positions. Attrition includes faculty who leave for any reason: getting a job elsewhere, not achieving tenure or retirement. Promotions include individual faculty who move from assistant to associate professor or associate to full professor during the year. The data include no cases of assistant professors skipping directly to full professor. This analysis differs from many demographic inertia studies because it follows each individual's mobility rather than using aggregated or cohort data.

Measures

Gender representation goals are the percentage targets selected by university decision-makers who hold the responsibility and authority to set them and use them to evaluate

[2] For this study, "science" includes the physical sciences (atmospheric and oceanic sciences, chemistry and biochemistry, earth and space sciences, mathematics, physics and astronomy and statistics) and the engineering and applied sciences (bioengineering, chemical and biomolecular engineering, civil and environmental engineering, computer sciences, electrical engineering, materials science and engineering and mechanical and aerospace engineering).

departmental progress. To the best of our knowledge, the university studied here does not set department-level gender representation goals, so we used the U.S. national percentage of women graduating with PhDs in similar disciplines during the initial year of data collection: 2004-05 in the management department and 2005-06 in the science department. The University receives these annual data from the National Opinion Research Center. For comparison, we also provide availability data for both departments in the last year of data collection. These provide some indication of how the labor supply is changing but are not used in the analysis. Availability in both departments increased during the years studied. Thus using availability from the initial year seems a reasonable gender representation goal.

The goal for the management department, based on national availability reported for 2004-05, is 29.4 percent female faculty. In 2012-13, availability was 34.6 percent. The goal for the science department, based on national availability reported for 2005-06, is 18.7 percent. Availability for the science department is the weighted average of national availability in the physical sciences, 22.2 percent, and the engineering and applied sciences, 16.6 percent. The number of tenure track faculty in each area is used for weighting. In 2010-11, availability was 21.0 percent.

In this context, a department is *successful* when it achieves its gender representation goal. A *baseline* is a department's projected gender distribution by career level if hiring and attrition rates remain the same. *Progress* is a baseline that falls along the critical path to success. Most university administrators want to achieve success within a reasonable time, defined here as ten to fifteen years. Thus, if the model shows that the department's baseline achieves its gender representation goal within ten to fifteen years, the department is making progress.

One obstacle to evaluating progress is the difficulty of distinguishing between random and systematic change. In the management department studied here, the hiring rate for women during the eight years of data collection from 2004-05 through 2012-13 is .200. However, there is high year-to-year variation. Yearly rates for female faculty range from .000 to .429. This makes sensitivity analyses a critical component of evaluation.

Faculty size. Table 1 shows the number of faculty at the beginning of the initial and last academic years of data collection by department, by gender and by career level.

-----Table 1 About Here-----

Hiring and attrition rates. Table 2 shows hiring and attrition rates by department, by gender and by career level. Each year departments hire new employees and lose existing employees. Faculty distributions do not change during the year, rather they change during the transition from one year to the next. The data used here are left censored so data on transitions before the initial year are unavailable. Consequently, the initial year is defined as Year 0 and the following year, for which transition data are available, is Year 1.[3]

---- Table 2 About Here ----

The hiring rate for women is the proportion of all faculty hires for a career level over a given time period who are women. For this study:

$$RW_L = \sum_{t=1}^{n} \frac{W_L(t)}{W_L(t) + M_L(t)}$$

Where RW_L is the hiring rate for women in a career level, $t = 1$ is the initial year of transition data, $t = n$ is the last year of transition data, $W_{L,t}$ is the number of women hired at that level in the given year and $M_{L,t}$ is the number of men hired at that level in the given year. For example, the management department's data from 2004-05 through 2012-13 provide hiring

[3] This is similar to a birthday calculation. Babies are 0 years old when they are born. They are not one year old until the first anniversary of their birth day.

information on eight transitions. Calculating the female assistant professor hiring rate begins by summing the total number of female and male assistant professors hired during those eight transitions: five women and 24 men. Thus, the hiring rate for female assistant professors is five divided by 29 or .172.

The attrition rate for women is the proportion of all faculty in a career level who leave over a given time period who are women. A department's attrition rates are computed by summing the total number of faculty who leave by gender and by career level across all transitions in the data. This number is then divided by the sum of the total number of faculty of that gender in that level. For example, the science department's actual data from 2005-06 through 2010-11 provide attrition information on five transitions. The attrition rate for full professors begins by summing the total number of full professors who left by gender during the five transitions: two women and 54 men. Next, the total number of full professors by gender is calculated. Over the five transitions, there were a total of 121 women and 1641 men. Thus, the attrition rate for female full professors is two divided by 121 or .017. The attrition rate for male full professors is 54 divided by 1641 or .033.

Career mobility. Figure 1 shows an illustration of how the model manages career mobility. The data are imaginary and were selected for ease of interpretation. The initial faculty distribution and subsequent hiring and attrition rates are used to standardize yearly changes in faculty size. The illustration begins with a department of 100 faculty. Of these, 50 are full professors, 15 are associate professors and 35 are assistant professors.

-----Figure 1 About Here-----

At the end of the initial year, ten full professors, one associate professor and six assistant professors leave. Of the ten full professors who must be replaced, the .400 external hiring rate specifies that four of the ten positions will be outside hires. The remaining six positions are filled by randomly selected associate professors. This leaves eight associate professor positions that must be filled: the two who left at the end of the initial year plus the six who are promoted to full professor. The .500 external hiring rate for associate professors means that four of the eight will be outside hires. This leaves four associate professor positions that must be filled. These four are randomly selected for promotion from the group of assistant professors.

At this point, ten assistant professor positions must be filled: the six who left at the end of the previous year plus the four who have been promoted to associate professor. These ten positions are filled by outside hires. At the end of the year, the distribution and size of the faculty is the same. There are 50 full, 15 associate and 35 assistant professors.

Career mobility in this example and that in the actual model differ in one regard. Although all assistant professors are hired from outside, some associate and full professors are also hired externally. The model includes hiring rates for these women. Using the example above, assume that of the four full professors who are replaced by external hires, the hiring rate for women is .500. This means that two of the four external hires are women. If, of the four externally-hired associate professors, the replacement rate for women is .250, one of the four is a woman. All assistant professors are hired externally, so if the replacement rate for women is 0.500, five of the new hires are women. Thus, in total, eight of the department's 18 outside hires are women: two full professors, one associate professor and five assistant professors.

Mathematical Models

As with any method, mathematical models have weaknesses and strengths. The biggest weakness is that the mechanism for change is mathematics. Models do not capture perceptions, culture or any meanings that faculty experience every day. Another weakness in this particular study is that data on subjects' ages and years in level were unavailable. Although current age effects are reflected in attrition rates, the data do not accommodate period effects, such as the anticipated wave of baby boom retirements over the next ten to fifteen years. To estimate this effect, several scenarios include higher rates of full professor attrition. Finally, the model is not dynamic. It does not allow for changes in hiring, promotion or attrition rates and assumes that faculty size at each level remains constant over time by using rates and percentages.

The strengths include model parameters based on actual hiring, promotion and attrition rates for each subject in each department for all three levels in the academic career: assistant, associate and full professor. The level specific results are not reported here. This contrasts with much previous work that uses fictitious populations or models the overall percentage of women rather than the percentage at each academic transition. Another strength is that actual department-level and career-level data are used to validate the initial years of baseline projections. Sensitivity analyses provide estimates of best and worst case scenarios. Finally, research on demographic inertia shows that progress is not linear. The results of a mathematical model are limited, but they incorporate this non-linear process.

The mathematical model used here differs from a Markov simulation because attrition and hiring rates produce the same results in every run. If the attrition rate for male full professors is .046, then exactly.046 of male full professors leave each year. In a Markov simulation, each full professor is independently assigned a .046 probability of leaving, so the results of multiple runs produce different numbers of full professors leaving.

The models begin with each department's actual gender distribution in the last year of data collection and project forward. For the management department this is 2012-13. For the science department it is 2010-11. All models were run for 100 years. The accumulation of differences between projected and actual gender distributions likely make results increasingly inaccurate over time, so we focus on the first ten to 15 years.

Although hiring and attrition rates change locally over time, some large scale demographic changes are predictable. The group of U.S. faculty born during the baby boom, between 1946 and 1964, will retire in the near future. As a result, full professor attrition rates will increase markedly. As both departments hire more female assistant and associate professors than full professors, higher full professor attrition should decrease the time to success. Attrition adjustments are based on the 2010 U.S. Census (Howden and Meyer 2011), which shows that 72 percent of those born between 1946 and 1964 will be 63 or older by 2023. Thus, it seems reasonable to assume that approximately 72 percent of full professors in the management department starting in 2012-13 and the science department starting in 2010-11 will leave and require replacement during the subsequent ten to 15 years.

To provide some feel for the magnitude of change represented by hiring and attrition rate adjustments, we also describe what would have happened if the adjusted rates were substituted for actual rates during the years of data collection. In the science department, for instance, no female full professors were hired between 2005-06 and 2010-11 so the actual hiring rate is .000. If instead, the hiring rate for female full professors had been five percent then between 2005-06 and 2010-11 the department would have hired one female full professor rather than none.

-----Table 2 About Here-----

Results

Model validity. Before evaluating baseline results, the model's validity was assessed by comparing the actual and expected gender distributions during the initial and last year of data collection for each department. In both cases, the projected percentages are slightly lower than what actually occurred. Hence, results for the scenarios presented later may be pessimistic.

In the management department's initial year of data collection, 2004-05, the actual percentage of female faculty was 10.8 percent. In the last year of data collection, 2012-13, it was 14.6 percent. This provides eight transition years of hiring and attrition rates. When the model is run using these rates and starting with the actual gender distribution in 2004-05, it projects a female faculty of 14.0 percent in 2012-13. The difference between the actual and projected percentages is .6 percent.

In the science department's initial year of data collection, 2005-06, the actual percentage of female faculty was 10.6 percent. At the end of the last year, 2010-11, it was 13.2 percent. This provides five transition years of hiring and attrition rates. When the model is run using these rates and beginning with the actual gender distribution in 2005-06, it projects a female faculty of 12.8 percent in 2010-11. The difference between the actual and projected numbers is .4 percent.

Question 1. Will each department successfully achieve its gender representation goal if there are no changes in hiring and attrition rates?

Figure 2 shows baseline results for both departments. The management department will not achieve its gender representation goal of 29.4 percent female faculty given its current hiring and attrition rates. In ten years, 2022-2023, the percentage is 16.3 percent, in 15 years, 2027-2028, it is 17.0 percent and in 100 years it reaches 18.8 percent. The 100-year projection is not useful for projection purposes, but it illustrates the non-linearity of demographic change.

-----Figure 2 About Here-----

The analysis for the science department shows it will reach its goal of 18.7 percent female faculty in 14 years, 2024-25, given its current hiring and attrition rates. In 15 years, 2025-26, the percentage is 19.1 and in 100 years, 2110-11, the percentage is 33.1.

Interestingly, if women's attrition rates in the two departments matched those of men's, progress would slow. In the management department, the only career level where women's attrition rates exceed men's is full professor (women=.074, men=.040). When women's rates are set equal to men's for all career levels, in ten years, 2022-23, the percentage of female faculty is 16.2 rather than 16.4. In 15 years, 2027-28, the percentage is 16.7 rather than 17.0. As before, the management department never achieves its gender representation goal. In the science department, women's attrition rates are lower than men's at all three career levels. When attrition rates for women are increased to match those of men, in ten years, 2020-21, the percentage of female faculty is 15.8 rather than 17.3. In 15 years, 2025-26, the percentage is 16.9 rather than 19.1. In this scenario, the science department achieves its gender representation goal in 27 rather than 14 years.

Question 2. What changes in hiring and attrition rates are required for each department to achieve its gender representation goal within ten to fifteen years?

Table 3 shows rates for the baseline model just discussed and three scenarios that explore each department's sensitivity to changes in hiring and attrition rates. The first scenario shows the positive effects of simple but optimistic changes, simple in that they require reasonable, likely achievable adjustments. The next shows the effects of more optimistic changes that require more demanding, possibly difficult adjustments. The last shows the negative effects of modest increases in attrition rates. The definitions of what is more and less optimistic are chosen as illustrations, understanding that there may be many change impediments or facilitators of which we are unaware.

-----Table 3 About Here-----

Optimistic Scenario. Figure 3 shows results of the optimistic scenario for both departments. In the management department, the .172 hiring rate for female assistants and .167 hiring rate for female full professors are low relative to availability, which increased from .294 in 2004-05 to .346 in 2012-13. This suggests that increases to .300 starting in 2012-13 represent a reasonable objective. If these rates had been the actual rates during data collection, 8.7 rather than five female assistant professors and 1.8 rather than one female full professor would have been hired[4]. The .400 hiring rate for female associate professors is already above availability and therefore not adjusted.

-----Figure 3 About Here-----

Accommodating baby boom retirements requires increasing attrition rates for female full professors from .074 to .146 and for male full professors from .040 to .112. If these rates had been the actual rates during data collection, four rather than two female full professors and 39.3 rather than 14 male full professors would have left.

With these relatively simple changes, the management department achieves its gender representation goal in 20 years. In ten years, 2022-23, the percentage of female faculty is 25.8 percent and in fifteen years, 2027-28, it is 28.2 percent.

The science department faces a different situation. The current .310 hiring rate for female assistant professors is already above availability of both .187 in 2005-06 and .222 in 2010-11. The optimistic model thus includes small increases in hiring rates of female associate and full professors. The rate for associate professors is increased from .222 to .322 and that for full professors from .000 to .050. If these rates had been the actual rates during data collection, three rather than two female associates and one rather than zero female full professors would have been hired. Although the suggested increases are modest, larger increases may prove

[4] This was computed as follows. The current hiring rate for female assistant professors is .172, which represents five out of the 29 assistant professor hires between 2004-05 and 2012-13 (.172*29=4.988). If the hiring rate was .300, the total number of female assistant professors hired would have been 8.7 rather than five (.300*29=8.7).

difficult. Availability of senior female faculty is growing, but it is likely lower than that for junior faculty.

Similar to the estimate for full professor retirements in the management department, the attrition rate of full professors is increased to simulate anticipated baby boom retirements. The attrition rate of female full professors increases from .017 to .069 and that of male full professors from .033 to .085. If these rates had been the actual rates during data collection, 8.3 rather than two female full professors and 139.5 rather than 54 male full professors would have left.

The results show that with these hiring and attrition changes, the science department achieves its gender representation goal of 18.7 percent in six years. In ten years, 2020-21, the percentage of female faculty is 21.4 percent and in 15 years, 2025-26, it is 23.8 percent.

Most Optimistic Scenario. In the management department, hiring rates for women are increased from .172 to .400 for assistant professors and from .167 to .300 for full professors. If these rates had been the actual rates during data collection, 11.6 rather than five female assistant professors and 1.8 rather than one female full professor would have been hired. These changes may be difficult but they are possible. Both hiring rates are relatively close to 2012-13 availability of 34.6. The hiring rate for female associate professors is already .400 and is unchanged.

The attrition rates of female assistant and full professors are decreased by .020. The assistant professor attrition rate is decreased from .056 to .036. The full professor attrition rate is decreased from .074 to .054.[5] If these rates had been the actual rates during data collection, 1.3 rather than two female assistants and 1.5 rather than two female full professors would have left. The attrition rate for female associate professors is already .000. The attrition rate for male full

[5] The attrition rate for female full professors may be unrealistically low because retirements will affect women as well as men. However, a model run with a higher retirement-adjusted rate shows it would take longer than does the lower attrition rate. The department would achieve its gender representation goal in eight rather than seven years.

professors is increased from .040 to .112 to simulate increasing retirements. If this rate had been the actual rate during data collection, 39 rather 14 male full professors would have left.

The results in Figure 4 show that given these most optimistic hiring and attrition changes, the management department achieves its gender representation goal of 29.4 percent in seven years rather than the 20 required in the optimistic scenario. In ten years, 2020-21, the percentage of female faculty is 36.2 percent and in 15 years, 2027-28, it is 42.7 percent.

---- Figure 4 About Here ----

In the science department, the more demanding changes involve increasing the hiring rate of female assistants from .310 to .400, female associates from .222 to .322 and female full professors from .000 to .100. If these rates had been the actual rates during data collection, 16.8 rather than 13 female assistants, 2.9 rather than two and 2.1 rather than zero female full professors would have been hired. It is not possible to reduce attrition for female assistant and associate professors, but attrition for female full professors is reduced to zero as well. The two women who left would still be there. The attrition rate for male full professors is increased from .033 to .085 to accommodate expected retirements. If this rate had been the actual rate during data collection, 139.5 rather than 54 male full professors would have left.

The results in Figure 4 show that given these most optimistic hiring and attrition changes, the science department achieves its gender representation goal of 18.7 percent in four rather than 14 years. In ten years, 2020-21, the percentage of female faculty is 28.7 and in 15 years, 2025-26 it is 35.2.

Pessimistic Scenario. In both departments, gender representation declines with modest increases in attrition rates. In the management department, the attrition rate for all female faculty is increased by .050. If these rates had been substituted for the actual rates during data collection, the department would have lost 3.8 rather than two female assistants, one rather than zero female associates and 3.4 rather than two female full professors. The attrition rate for male full professors is increased to simulate one-half of the anticipated retirements, from .040 to .076. If these rates had been substituted for the actual rates during data collection, the department would have lost 26.7 rather than 14 male full professors.

Figure 5 shows that these modest increases in female faculty attrition result in a decline in the overall percentage of women. Starting at 14.6 percent in 2012-13, the percentage of women declines to 14.4 percent in ten years, 2022-23, and 14.3 percent in 15 years, 2027-28. The management department never achieves its gender representation goal.

---- Figure 5 About Here ----

In the science department, attrition rates for women are already extremely low. During the five years of data collection, only two female faculty left, both full professors. In this pessimistic scenario, the attrition rate for all female faculty is increased by .050. If these rates had been substituted for the actual rates during data collection, 4.7 rather than zero female assistants, two rather than zero female associates and 5.2 rather than two female full professors would have left. As in the management department, attrition rates for male full professors are increased by half of that required to retire 72 percent in ten to 15 years, which is .026. If this rate had been substituted for the actual rate during data collection, 96.8 rather than 54 male full professors would have left.

Figure 5 shows that with these modest attrition increases, it takes 23 rather than 14 years for the science department to achieve its gender representation goal of 18.7 percent. In ten years, 2020-21, the percentage of female faculty is 16.4 percent and in 15 years, 2025-25, it is 17.5 percent.

Question 3. What policy and resource interventions are required to facilitate each department's success?

The results explore which demographic interventions produce the largest changes in the percentage of female faculty. They also identify which interventions are likely to increase or decrease the disruption experienced by university administrators and department faculty and thus their resistance to change.

Management Department. The management department has not made as much progress as the science department. If hiring and attrition rates do not change, the management department will never achieve its gender representation goal whereas the science department will achieve its goal in 14 years. This conclusion is not obvious given the original gender distributions of the two departments. The management department's percentage of female faculty during 2012-13 is 14.6 percent, which is higher than the 13.2 percent of the science department in 2010-11. The management department's average yearly increase in the percentage of female faculty during data collection was .48 percent, which is slightly lower than the .52 percent of the science department. On the surface, these departments appear relatively similar. The large differences between their baseline projections would not likely be evident without demographic analysis.

Policy changes in the management department should begin by increasing hiring rates for women. At minimum, hiring rates for female assistant professors should match availability. The current hiring rate of .172 is over ten percent below availability in 2004-05 and over 15 percent lower in 2012-13. Thus, increasing it to .294 should not be difficult. The .167 hiring rate for female full professors also seems low, but the percentage of appropriate and available female candidates is likely lower than that for assistant professors.

However, even in the optimistic scenario, it takes 20 years for the department to achieve its gender representation goal. To succeed within ten to 15 years requires more demanding intervention. Associate professor hiring is currently above availability and attrition is zero, so if rates are maintained, this transition need not be targeted. However, in order to succeed within a reasonable time, hiring rates for female assistant and full professors must more than double, female attrition rates at all levels must decrease by several percent and male full professors must retire at the most optimistic, higher attrition rates. Even under these conditions, it takes seven years to achieve the department's gender representation goal.

Before pressuring the department about these changes, university administrators need to understand why women's hiring rates are low. There are many possibilities. One may be that availability is higher in some disciplines than others. For instance, marketing and management typically have higher availability than finance and economics. The department's needs may not align with those disciplines in which more women are available. Another explanation may result from faculty assumptions regarding linear change. University administrators and faculty who have watched the department increase its overall percentage of female faculty from a low of 9.9 in 2005-06 to a high of 14.9 in 2011-12, may believe sufficient progress is being made. A third is that increasing hiring rates for women means decreasing them for men. Extant faculty, either consciously or unconsciously, may find these changes uncomfortable. Finally, the department may make sufficient offers to desirable female candidates, but these candidates may disproportionately accept jobs elsewhere. Changing gender distributions is complex and university administrators need to understand why things are the way they are before deciding what needs to be done.

It will take considerable work for the management department to achieve its gender representation goal and small downward variations in hiring and upward variations in attrition may make it impossible. Moreover, availability is increasing and the .294 is a conservative moving target. This means the department's hiring and attrition rates require close, yearly monitoring by gender and by career level.

Science Department. The science department is farther along on its critical path than the management department. Without any change, it reaches its gender representation goal in 14 years. However, there is little room for improvement and considerable opportunity for decline.

On the positive side, the science department is doing extremely well in hiring female assistant and associate professors. The hiring rates for both exceed availability of 18.7 percent. The rate for assistants is .310 and for associates it is .222. University administrators should learn what produced this success and ensure that the department has sufficient resources to maintain it. If the science department's strategy is generalizable, administrators may be able to export whatever-it-is-that's-working to other departments. In addition, they should ascertain whether this success is widespread across the science disciplines or concentrated in a few. The information we received from the personnel office identified fifteen science disciplines and each has its own labor market. Thus while overall hiring is high, this provides room for considerable variation across disciplines. Some disciplines may require more attention than others.

One area for improvement is increasing the hiring rate for female full professors. During the five years of data collection, almost 30 percent of all hires at any level were male full professors. No female full professors were hired. University administrators might check current availability of female full professors to decide if increasing hiring rates is warranted, and if not, to estimate roughly how many years it will take before increases are possible.

On the negative side, the science department's major strength is its major weakness. The attrition rate for female faculty is almost zero, which is an important reason for the department's success. However, this also raises the possibility of a large failure. Five years of data may be insufficient to capture representative attrition rates. Moreover, the analysis shows that small increases in attrition exert a large negative impact on success. Attrition rates should be watched closely.

Discussion

Demographic inertia is a powerful structural phenomenon that limits change in the percentage of female faculty independent of any other mechanisms that affect women's career mobility. It requires tempering two assumptions administrators typically make when evaluating demographic change. The first is that when a given percentage of women is hired, the population will eventually reflect that percentage. The second is that women hired at the bottom of a career ladder will reach the top in a reasonable time, where reasonable means the average time it takes to advance. The results for this study show that only some optimistic scenarios warrant both assumptions and these are difficult to identify without demographic analysis. Early changes often look like progress but they may not be progress.

The difficulty of identifying successful baselines and the snail-like speed of demographic change means the arithmetic requires attention. Consistent with previous research, the models show that demographic change is slow. However, they also illustrate the wide variation in results induced by small gendered differences in hiring and attrition rates across career levels. Most administrators apply blanket policies throughout a university. However, the results presented here and elsewhere suggest that pinpointing demographic weak spots may be more effective. Marschke et al.'s (2007) study of Mountain University found large gendered attrition differences in two age groups. Female assistant professors under 40 and female faculty between

50 and 59 were more likely to leave than men in their age cohort. Most university policies focus on younger women during childbearing years, but Marschke et al.'s finding and those presented here suggest that the gains and potential losses for policies affecting senior faculty may be just as significant.

This then is perhaps the most important finding from this study. Administrators need to know what needs fixing before applying myriad, undifferentiated efforts across the university. There may be several strategies that yield desired departmental results and each may require different costs and provide different benefits. Demographic inertia analysis provides a starting point, an arc of change that describes the broad constraints within which administrators must work.

Although there are some university-specific issues discussed in this paper, the mathematics involved apply to any minority in any organization. A model such as the one used here represents an important addition to an organization's grab bag of strategies designed to increase diversity. Kalev et al. (2006) find that of all strategies organizations use, structural responsibility solutions provide the most effective results for increasing diversity. A demographic diagnosis targets structural loci where administrators can apply such interventions.

There is no reason to expect that one set of strategies fits all and this warrants more detailed department-level analyses. An important caveat, however, is that although the results provide the mathematics, they are insufficient without adding university administrators' understanding of why things are the way they are. Demographic analysis does not provide meaning or explain behavior. It may target low hiring rates as the biggest impediment to change, but hiring rates may be low because trailing partners cannot find adequate jobs, faculty resist uncomfortable changes in who-we-hire-around-here, or the best candidates receive competitive offers elsewhere. Identifying the mathematical limits to demographic change is only a first step in designing effective policy.

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Table 1

FACULTY GENDER DISTRIBUTIONS BY DEPARTMENT AND CAREER LEVEL

Management Department

	2004-05					2012-13				
	Assistant Professors	Associate Professors	Full Professors	Total N	Total %	Assistant Professors	Associate Professors	Full Professors	Total N	Total %
Women	3	3	2	8	10.8	3	3	6	12	14.6
Men	11	12	43	66	89.2	16	12	42	70	85.4
Total	14	15	45	74	100.0	19	15	48	82	100.0

Science Department

	2005-06					2010-11				
	Assistant Professors	Associate Professors	Full Professors	Total N	Total %	Assistant Professors	Associate Professors	Full Professors	Total N	Total %
Women	14	3	19	36	10.6	18	9	21	48	13.2
Men	37	28	239	304	89.4	32	42	242	316	86.8
Total	51	31	258	340	100.0	50	51	263	364	100.0

Table 2

HIRING AND ATTRITION RATES BY DEPARTMENT AND CAREER LEVEL

	Management Department 2004-05 to 2012-13				
	Assistant	Associate	Full	Total	
Hiring	Professors	Professors	Professors	N	%
Women	0.172	0.400	0.167	8	20
Men	0.828	0.600	0.833	32	80
Total N	29	5	6	40	100
	Assistant	Associate	Full	Total	
Attrition	Professors	Professors	Professors	N	%
Women	0.056	0.000	0.074	4	12.5
Men	0.069	0.057	0.040	28	87.5
Total N	24	13	50	32	100

	Science Department 2005-06 to 2010-11				
	Assistant	Associate	Full	Total	
Hiring	Professors	Professors	Professors	N	%
Women	0.309	0.222	0.000	15	20.8
Men	0.690	0.778	1.000	57	79.2
Total N	42	9	21	72	100
	Assistant	Associate	Full	Total	
Attrition	Professors	Professors	Professors	N	%
Women	0.000	0.000	0.020	2	3.6
Men	0.010	0.020	0.040	53	96.4
Total N	2	4	49	55	100

Table 3

FOUR SCENARIOS OF DEMOGRAPHIC CHANGE

	Baseline		Optimistic		Most Optimistic		Pessimistic	
Rates[1]	Mgmt	Science	Mgmt	Science	Mgmt	Science	Mgmt	Science
Attrition								
Women								
Assistant	0.056	0.000	0.056	0.000	**0.036**	0.000	**0.106**	**0.050**
Associate	0.000	0.000	0.000	0.000	0.000	0.000	**0.050**	**0.050**
Full	0.074	0.017	**0.146**	**0.069**	**0.054**	**0.000**	**0.124**	**0.043**
Men								
Assistant	0.069	0.009	0.069	0.009	0.069	0.009	0.069	0.009
Associate	0.057	0.017	0.057	0.017	0.057	0.017	0.057	0.017
Full	0.040	0.033	**0.112**	**0.085**	**0.112**	**0.085**	**0.076**	**0.059**
Hiring								
External Replacements from outside[2]								
Associate	0.125	0.158	0.125	0.158	0.125	0.158	0.125	0.158
Full	0.150	0.339	0.150	0.339	0.150	0.339	0.150	0.339
Replacements who are women								
Assistant	0.172	0.310	**0.300**	0.310	**0.400**	**0.400**	0.172	0.310
Associate	0.400	0.222	0.400	**0.322**	0.400	**0.322**	0.400	0.222
Full	0.167	0.000	**0.300**	**0.050**	**0.300**	**0.100**	0.167	0.000
Years until percentage women > availability[3]	100+	14	20	6	7	4	100+	23
Percentage in 15 years	17.0	34.4	28.2	26.2	42.7	36.0	16.2	17.5

1 = Rates in these columns come from actual values calculated for each department

2 = Replacements include promotions and hires

3 = Number of years until percentage of women exceeds availability: Management=29.4%, Science=18.7%

Numbers in boldface indicate rates that differ from baseline

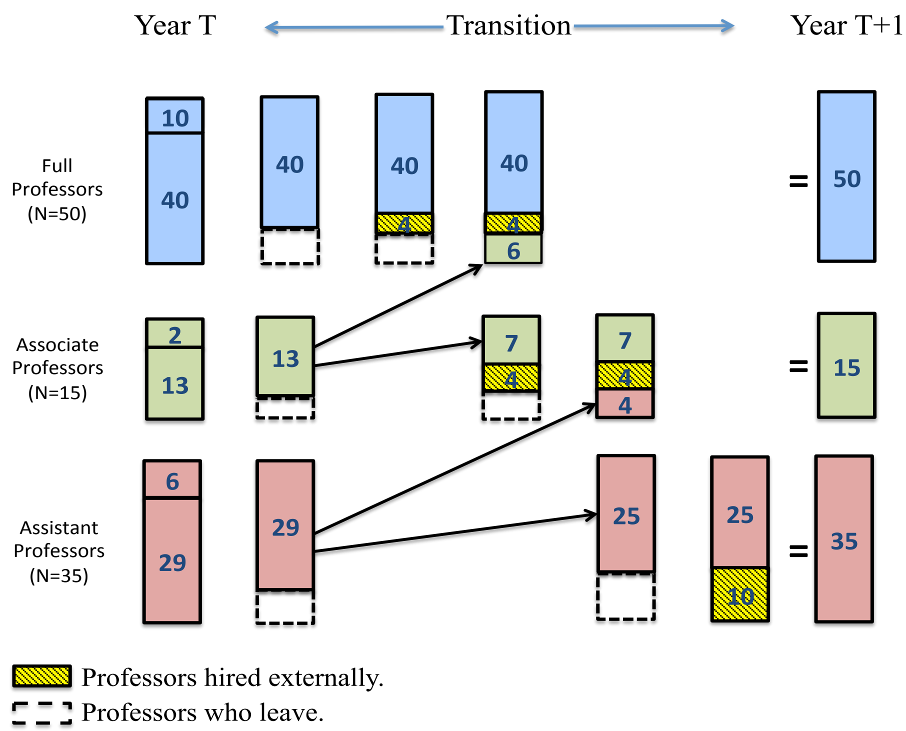


Figure 1. An illustration of how career mobility works in the model. The first column is Year T and the last column is Year T+1. The five columns between the two show the transition from Year T to Year T+1.

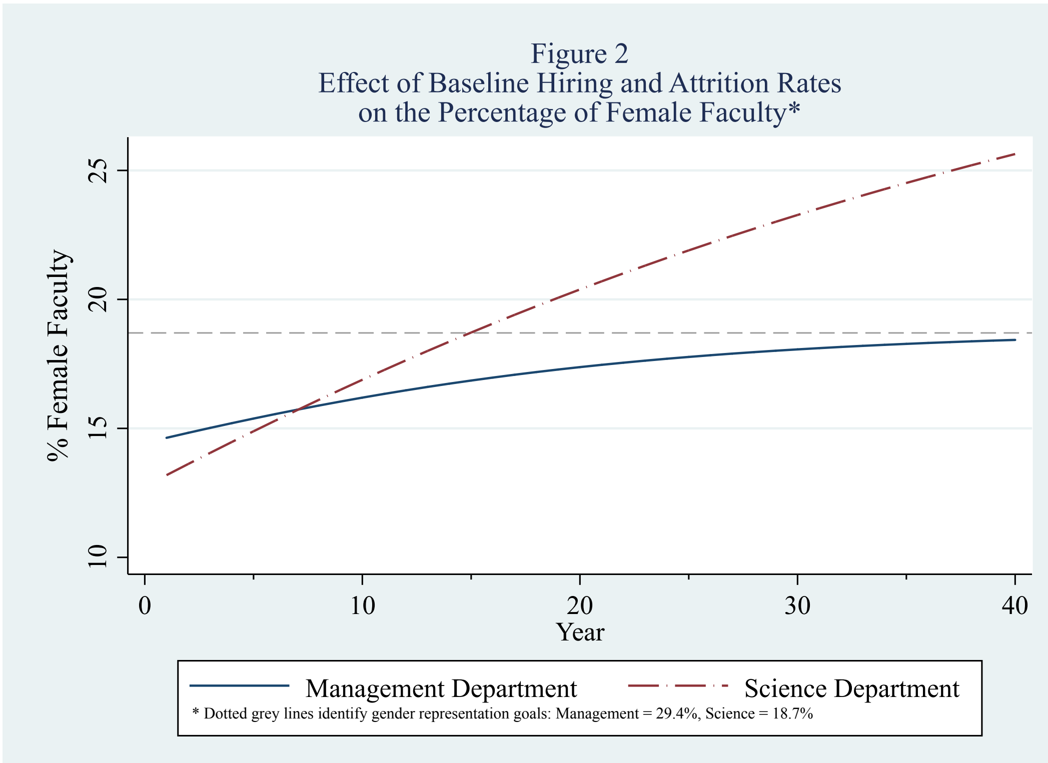


Figure 2
Effect of Baseline Hiring and Attrition Rates
on the Percentage of Female Faculty*
% Female Faculty
10
15
20
25
0
10
20
30
40
Year
Management Department
Science Department
* Dotted grey lines identify gender representation goals: Management = 29.4%, Science = 18.7%

Figure 3
Effect of Optimistic Hiring and Attrition Rates
on the Percentage of Female Faculty*

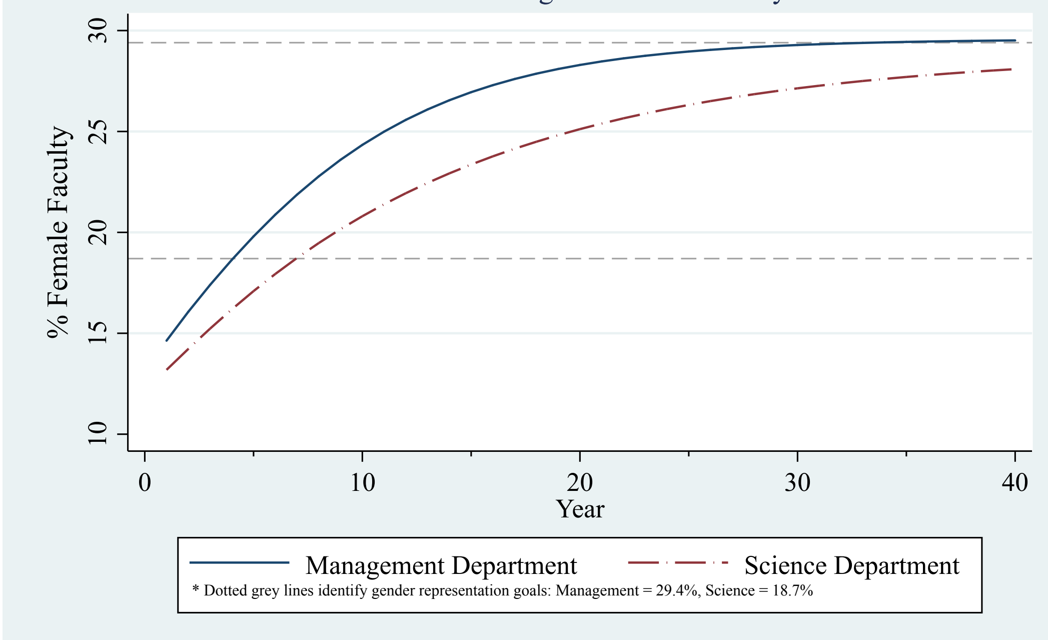
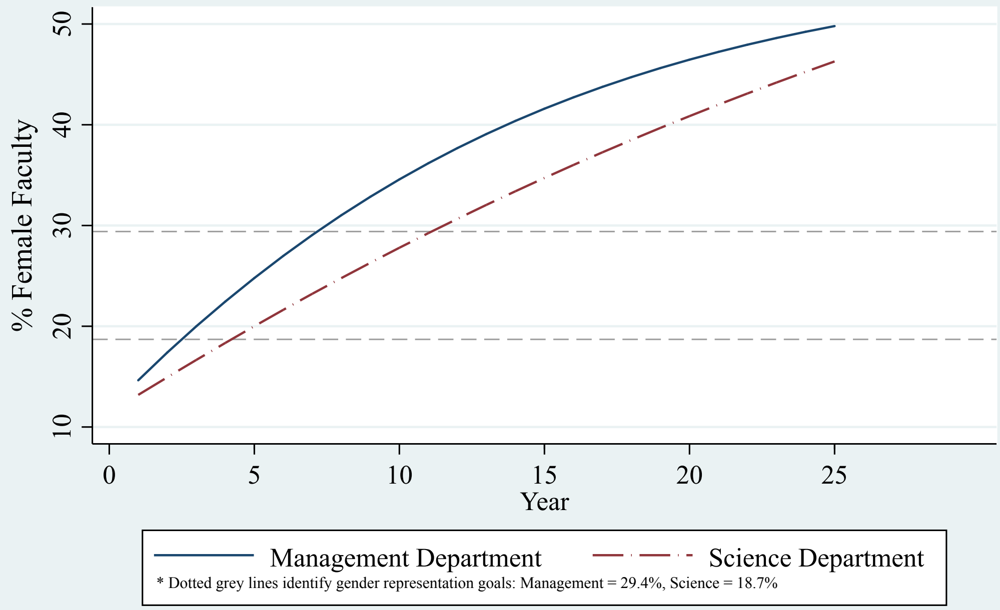
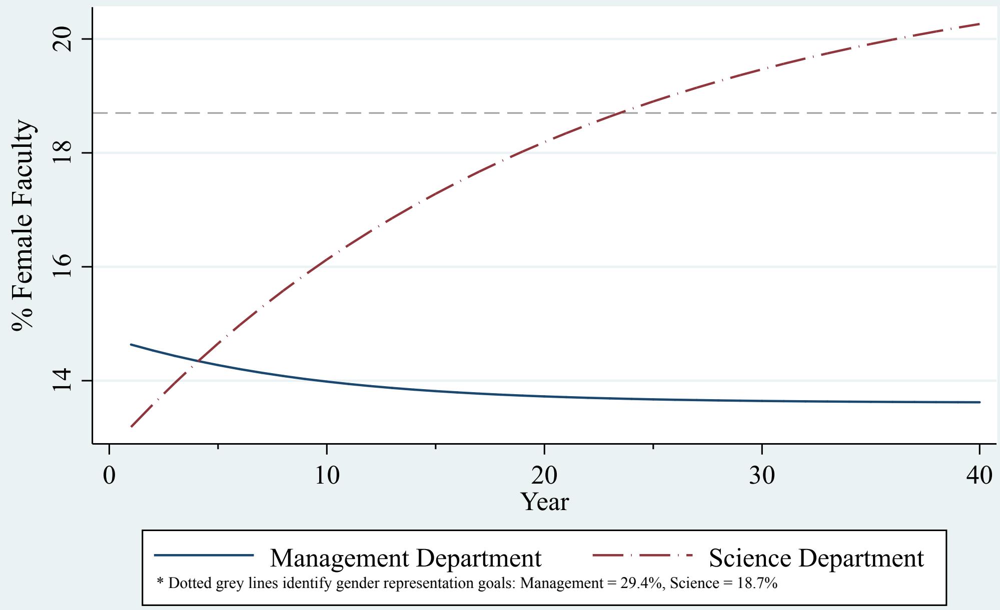


Figure 4
Effect of Most Optimistic Hiring and Attrition Rates
on the Percentage of Female Faculty*



* Dotted grey lines identify gender representation goals: Management = 29.4%, Science = 18.7%

Figure 5
Effect of Pessimistic Hiring and Attrition Rates
on the Percentage of Female Faculty*



* Dotted grey lines identify gender representation goals: Management = 29.4%, Science = 18.7%

Appendix A

Empirical studies of demographic inertia.

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