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Leaks in the pipeline: separating demographic inertia from ongoing gender differences in academia

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Summary: Identification of the causes underlying the under-representation of women and minorities in academia is a source of ongoing concern and controversy. This is a critical issue in ensuring the openness and diversity of academia, yet differences in personal experiences and interpretations have mired it in controversy. We construct a simple model of the academic career that can be used to identify general trends, and separate the demographic effects of historical differences from ongoing biological or cultural gender differences. We apply the model to data on academics collected by the National Science Foundation (USA) over the past three decades, across all of Science and Engineering and within six disciplines (Agricultural and Biological Sciences, Engineering, Mathematics and Computer Sciences, Physical Sciences, Psychology, and Social Sciences). We show that the hiring and retention of women in academia have been affected by both demographic inertia and gender differences, but that the relative influence of gender differences appears to be dwindling for most disciplines and career transitions. Our model enables us to identify the two key non-structural bottlenecks restricting female participation in academia: choice of undergraduate major and application to faculty positions. These transitions are those in greatest need of detailed study and policy development.

Key Words: academic hiring; gender bias; women in science

Introduction

The prevalence and persistence of inequalities in academia is an important yet volatile issue. Despite widespread support for equality [1] women and many racial and ethnic minorities are under-represented in academia relative to their proportion in the general population [2]. Numerous studies have uncovered evidence for historical and continuing gender and ethnicity based differences in academia, attributed to various causes such as innate differences between the sexes [3], differences in career goals and interests [4, 5, 6], and explicit and implicit bias against female or minority academics [7, 8, 9]. The scale of these differences and their quantifiable impact on the demographic composition of academia remain controversial [10, 11, 12, 13]. Although it may be tempting to infer bias when current minority proportions in academic positions are below parity (in the case of gender discrimination) or below the proportions in the overall human population [14], such a comparison fails to account for enduring effects of historical inequalities. Because the time spent in each stage of an academic career lasts on the order of years to decades, changes in hiring practices or improvements of retention of under-represented groups may not lead to immediate, or even rapid, rectification of inequalities. This results in demographic inertia where some lag time is to be expected before the full effects of changes are seen [14, 15]. In conservatively organized institution such as academia, demographics can be the main promoter of structural changes (e.g. hiring policies, staff benefit plans, etc), and thus demographic inertia has the additional potential to reinforce structural inertia [16, 17]. Legal measures to guard against discrimination have been in place for decades in many countries, and yet the allegations of gender and racial bias remain. Here we make use of a common idealization of the 'typical' academic career to create a baseline expectation for gender equity in academia, accounting for demographic inertia. This baseline allows for the easy identification and quantification of particular career transitions and academic disciplines in which gender differences and/or discrimination may still play an important role.

We illustrate this framework by examining the participation of women in the natural and social sciences in the United States, using publicly available data from the National Science Foundation (NSF). The discussions of the seeming under-representation of women in academic careers have been fraught with conflicting views of the causes and solutions [11, 12, 14, 15], without clear definitions of a null baseline that accounts for inertial effects. The lack of a baseline makes it difficult to assess the extent to which gender-based differences have persisted since the introduction of fair hiring legislation (e.g. the Equal Employment Opportunity Act of 1972). Although we have chosen to focus on gender equity in US academia in this paper, the framework is easily applicable to minorities and/or other countries.

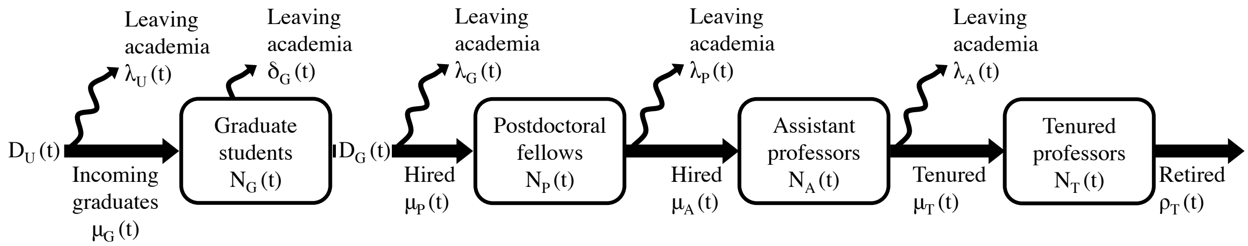

Figure 1: Schematic of academia as a "leaky pipeline", where individuals either progress through the series of academic stages, or leave academia altogether.

The pipeline model

Academia is often metaphorically described as a pipeline [18], alluding to the notion that an academic career can be idealized as a linear progression from undergraduate education to tenured professorship (figure 1). The academic career pipeline is conceived of as consisting of 5 discrete stages: undergraduate studies (UG), graduate studies (GR), postdoctoral fellowships (PD), assistant professorship (AP; tenure-track) and tenured professorship (TP). This pipeline is often referred to as 'leaky', that is, individuals may leave academia at various stages in the process. Although obviously a simplification, the pipeline metaphor provides an excellent framework for establishing a model of academia within which the effects of gender-based differences may be tested. The career path of any individual academic may be more tortuous, and influenced by numerous non-academic events [19] but this does not undermine the heuristic usefulness of the pipeline idealization. A simple general model can identify otherwise obscure broad patterns and trends whose specific causes can be identified through more detailed studies.

We constructed such a model (see Electronic Supplementary Material for details), allowing us to establish a baseline free of gender-based differences while accounting for lags induced by historically low female participation in academia. Similar Markov modeling approaches have been applied to educational careers in a more limited scope; past studies have developed a model of high school and undergraduate education [20], and used a comparable framework to explore the outcomes of various policy scenarios at a single university [21]. Age-structured models have also been applied to this problem, however policies often target particular career moments rather than specific ages, making such an approach less helpful for the examination of specific policy impacts. We demonstrate how our more general model can be used to test for the presence and extent of gender-based differences in academia in the United States, across several decades and a wide range of scientific disciplines. We compare model output for each career stage to data collected by the National Science Foundation over a 28-year period (1979 to 2006). Gender inequalities that are not explained by the time lags in the model are indicative of gender-based differences or discrimination, allowing the rapid identification of key career stages and transitions for effective policy application.

Performance of the pipeline model

We calibrated and ran the pipeline model to examine female participation in academia (defined as the proportion of individuals in a pool that are female) across Science and Engineering in general, as well as for six disciplines (Agricultural and Biological Sciences, Engineering, Mathematics and Computer Sciences, Physical Sciences, Psychology, and Social Sciences) chosen to represent a variety of discipline sizes and ranging from male-dominated to female-dominated undergraduate pools.

Several factors may limit the realism of our model. Academic careers are not necessarily linear progressions within universities alone, and individuals may leave and return at various stages. Although it might seem that this would increase the lag associated with career transitions, it does not in fact affect the applicability of the model. What is important is the comparison of the gender composition of a career stage to the potential applicants, which will be unaffected by career detours during that transition. If there are gender differences in the likelihood of spending time away from academia during a particular career transition, these will be assessed as part of the overall gender difference associated with said transition.

There is some variance in the duration of various career stages, such as the time spent in graduate studies [22], postdoctoral employment [23, 24] or the age of retirement [22]. Realistic variation in the duration of career stages did not qualitatively affect the outcome of the model. We varied the average length of time spent both as an assistant (4-8 years; [25]) and tenured professor (20-30 years; [22]), and although the final outputs differ (shaded areas in figure 2), the predicted null female proportion of professors consistently exceeded actual demographics. Varying the length or number of postdoctoral fellowships taken by each individual had even less effect on final outcomes.

Many academics are highly internationally mobile. Many American academics have spent significant portions of their career abroad, and many foreign-born academics may spend parts or all of their careers in the US [22]. Non-American academic institutions can have significantly different gender composition, and our model is unable to account for these effects. We therefore assume that the percentage of female foreign hires is the same as that within the US system.

Inertia is not the whole story

The model predicted steady increases in female participation over time in all stages of academia. These increases are driven by a strong increase in the proportion of female un-

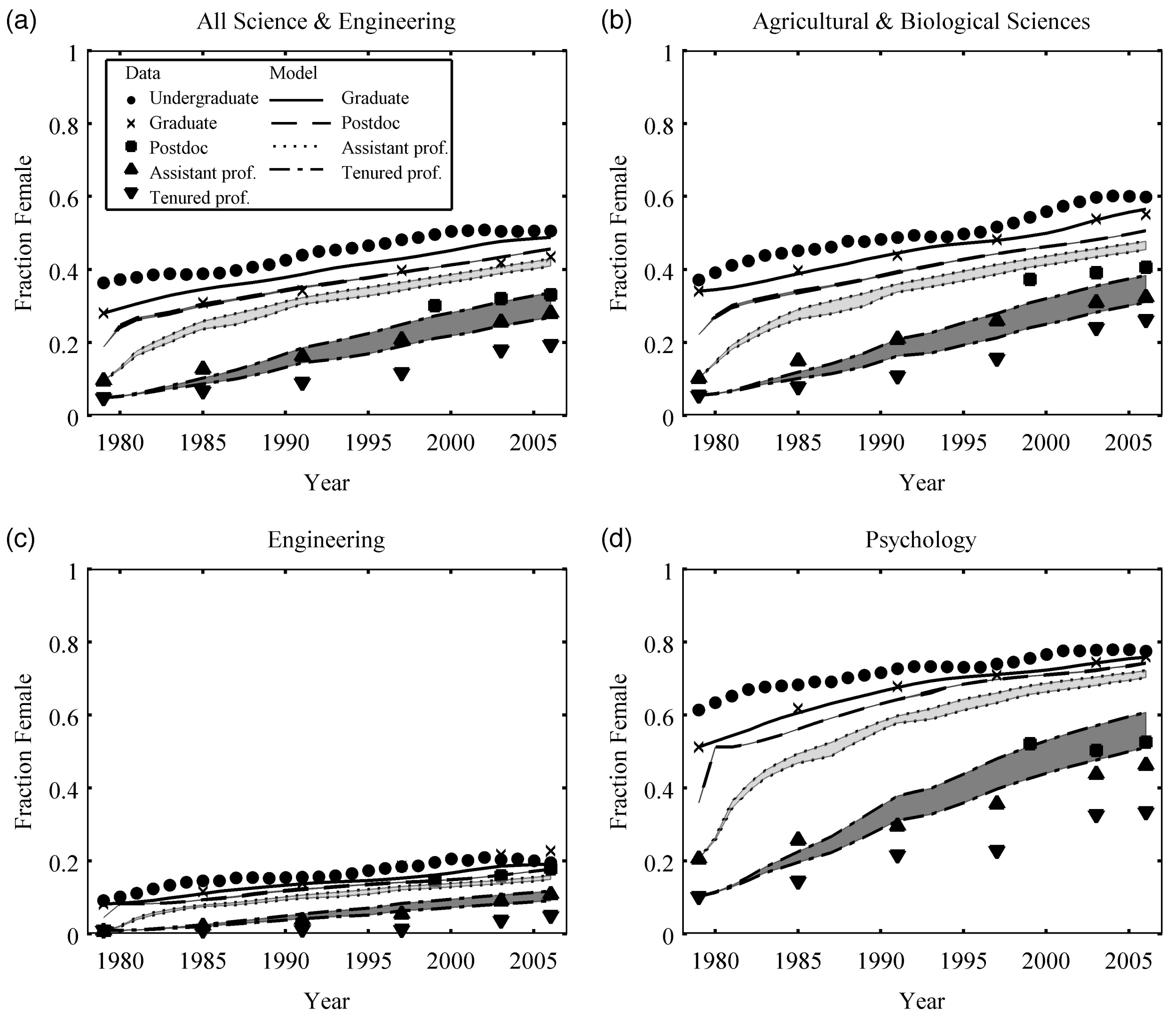

Figure 2: Comparison of female participation (female academics as a percentage of the academic population) as predicted under a null model (lines) versus actual National Science Foundation data (symbols) for (a) all of Science and Engineering, (b) Agricultural and Biological Sciences, (c) Engineering, and (d) Psychology. Shaded areas reflect the variation in model output under slightly different model structures (see text for details).

dergraduate students in the majority of scientific disciplines (figure 2). Increases in female proportions are slow under the no gender-based differences conditions of the model, reflecting demographic inertia slowing the rate of demographic change.

Although demographic inertia slows the rate at which parity is attained, actual demographic data also consistently diverged from the baseline predicted by the model, suggesting that gender-based differences also play a role. In all disciplines, including those with greater than parity female participation at some career stages (Agricultural and Biological Sciences, and Psychology), female participation was lower than expected under complete gender neutrality (figure 2).

Undergraduate enrollment and faculty hire: a bimodal academic bottleneck

To get a sense of the relative importance of demographic inertia compared with all other gender-based differences, we calculated the amount of the divergence between current demographics and parity that can be attributed to demographic inertia (i.e. accounted for by the pipeline model; see Electronic Supplementary Material for details). The value, which we term the inertial effect (IE), can be calculated for each career transition (table 1). An IE value equal to 1 indicates that actual female participation within a class and discipline exactly matches that predicted by inertia alone, while a value less than 1 indicates that women are less represented than would be expected by demographic inertia, and a value greater than 1 indicates that they are more represented.

Paradoxically, career stages with lower female participation often showed greater demographic inertia effects. For example, essentially all of the current deviation from parity amongst tenured professors is explained by the earlier female proportion of assistant professors combined with inertia in the granting of tenure, with the exception of faculty in Mathematics and Computer Sciences (table 1: Assistant Professor to Tenured Professor). Some disciplines with low numbers of female undergraduates (Engineering, Mathematics and Computer Sciences) have IE values well over 1 for the transition to graduate school (table 1: Undergraduate Student to Graduate Student), suggesting that female undergraduates are more likely to pursue graduate studies than their male counterparts. This pattern disappears entirely for academic retention after graduate school, for which these disciplines exhibit the greatest non-inertial gender differences.

Across all disciplines the career transition divergence least explained by demographic inertia effects is that from graduate student or postdoctoral researcher to the professoriate. This is a career transition that has been identified as difficult by other authors [26, 27, 28], and frequently coincides with family formation for educated professionals [18], as well as the highest degree transferable to non-academic professions (e.g. industry).

Table 1: The proportion of female individuals in each class, in the year 2006 from NSF data and our model predictions, as well as the inertial effect (IE): how much can be accounted for by demographic inertia in the transitions between classes. Results are shown for all of Science and Engineering (S & E), and by discipline: Agricultural and Biological Sciences (BIO), Engineering (ENG), Mathematics (MAT), Physical Sciences (PHY), Psychology (PSY), and Social Sciences (SOC).

Graduate students (GR)							
	S&E	BIO	ENG	MAT	PHY	PSY	SOC
data	0.43	0.55	0.23	0.37	0.33	0.76	0.54
model	0.49	0.56	0.19	0.31	0.41	0.76	0.52
Postdoctoral fellows (PD)							
	S&E	BIO	ENG	MAT	PHY	PSY	SOC
data	0.33	0.41	0.18	0.22	0.21	0.53	0.46
model	0.42	0.53	0.22	0.37	0.31	0.76	0.54
Assistant professors (AP)							
	S&E	BIO	ENG	MAT	PHY	PSY	SOC
data	0.28	0.32	0.11	0.17	0.17	0.46	0.34
model	0.39	0.48	0.19	0.37	0.28	0.73	0.51
Tenured professors (TP)							
	S&E	BIO	ENG	MAT	PHY	PSY	SOC
data	0.19	0.26	0.05	0.09	0.08	0.33	0.23
model	0.18	0.22	0.05	0.10	0.08	0.32	0.21
IE in transitions between classes							
	S&E	BIO	ENG	MAT	PHY	PSY	SOC
UG to GR	0.89	0.97	1.19	1.19	0.80	1.00	1.04
GR to PD	0.79	0.77	0.82	0.59	0.68	0.69	0.86
GR to AP	0.71	0.67	0.57	0.47	0.60	0.64	0.66
AP to TP	1.09	1.18	1.03	0.86	0.98	1.04	1.07

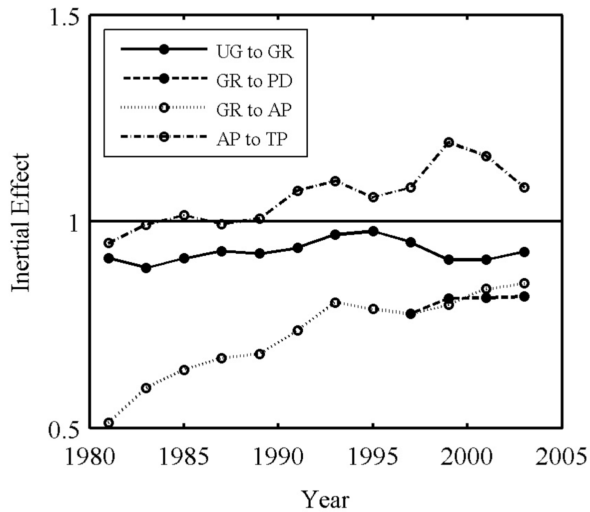

Figure 3: The inertial effect over time for each transition in academic pipeline for Science and Engineering.

Steady but incomplete improvement through time

We also looked at how IE values have changed over the past 30 years. The IE value for most transitions and disciplines shows a tendency to approach a value of 1, suggesting that they have become increasingly egalitarian over time (figure 3; table S1). Admission to graduate school and granting of tenure do not seem to have been associated with strong gender differences in the past, and currently closely resemble the predictions of a null model, with the possible exception of the granting of tenure in Mathematics and Computer Sciences.

The greatest gender difference, both historically and currently, is in the continuation of an academic career after graduate school. The gender difference associated with the transition has decreased considerably since the beginning of the available data set in the 1970's, with particularly strong gains made in Engineering and Physical Sciences. In Mathematics and Computer Sciences, although much progress has been made, gender differences remain comparable to those in many other disciplines 30 years ago.

The strong gains in female participation in academia over recent decades lend support to the notion that cultural and societal pressures, rather than inherent biological differences, were responsible for historically low participation of women in science. They are probably also evidence of (partially) successful measures to increase fairness of hiring. There is little indication that an equilibrium has been reached, as IE values continue to change, in particular for the transition to faculty positions.

Why do differences persist?

Much of the current underparticipation of women in academia can be explained by the time-lags associated with overcoming historically very low representation. However, although gender differences associated with academic career transitions have diminished, they remain significant, and two transitions are particularly problematic: enrollment in undergraduate majors in some disciplines and retention in academia after a graduate degree.

Female enrollment in science and engineering undergraduate majors has greatly increased over recent decades, however the increase has not affected all disciplines equally. Agricultural and Biological Sciences, Social Sciences, and Psychology now have female undergraduate enrollment exceeding 50%, but numbers of female students remain low in Engineering, Mathematics and Computer Science, and Physical Sciences. Low numbers of female undergraduate majors will have lasting repercussions for the gender composition of faculty in those disciplines, even when there are minimal gender differences associated with later career transitions. The proportion of female starting university students intending to study these disciplines is much lower than that of male students, suggesting that factors prior to university are likely to be as or more important than attrition during the undergraduate studies [29]. This gender difference is absent in disciplines such as Agricultural and Biological Science and Social Sciences. Male high school students tend to be more proficient in mathematics and science by some metrics [22], however the differences are marginal and hardly account for the differences seen at the undergraduate level. This would suggest that the differences in undergraduate enrollment are not caused by differences in innate ability.

The most difficult academic transition for women (when compared to men) appears to be retention in academia after the doctorate. This has been true historically, and although the gender gap appears to be closing in most disciplines, it remains a problematic stage. Unfortunately our model cannot distinguish among the potential gender-based differences, and although possible causes have been discussed in depth by numerous authors [5, 6, 8, 9, 27, 30], they remain controversial. One study that examined the composition of applicants for faculty positions found no evidence of discrimination in the choice of interviewees or hires, and in fact that women were slightly more likely to be interviewed and hired [28]. This same study found that the fraction of female applicants was much lower than the fraction of graduating female PhDs, suggesting that the gender difference lies primarily in the decision to apply for an academic position [28]. However, others have reported perception biases at this stage, as measured by differences likelihood of hiring [8], and recommendation letter content [9], by applicant gender. It is perhaps telling that the two most problematic transitions are associated with the largest shifts in institutional roles. Transitioning to university from high-school and seeking a faculty position involve taking on novel roles and responsibilities, making them stages at which positive role models and societal pressures can be particularly important.

Conclusions

Inequalities in hiring and retention can take numerous forms, and varied personal experience can color the interpretation of the current state of women in academia. We propose that the use of a simple model can help identify general trends, and separate the demographic effects of historical discrimination from ongoing gender differences. This approach is also applicable to other historically under-represented groups in academia, and can help provide a context for more detailed examination of the causes and solutions to particularly differentiating career transitions.

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Electronic supplementary material: Detailed methods

All simulations and calculations were done using *Matlab*. M-files are available upon request from the authors.

Creation of pipeline

We modeled the academic career pipeline as a series of 5 pools (undergraduate studies, graduate studies, postdoctoral fellowships, assistant professorship and tenured professorship) where scholars are transferred between pools at a rate inversely proportional to the average length of time spent in the pool (equivalent to a turnover time). Individuals moving out of one pool were eligible to move up and fill empty positions in the next pool, and those that did not move up left the pipeline.

We generated the structure of the pipeline model from National Science Foundation data as follows. Since the number of academics in the U.S. has dramatically increased over the past thirty years, we set the model pool sizes as the actual number of graduate students, postdoctoral fellows, assistant professors, and tenured professors (annual National Science Foundation data from 1979-2006; NSB 10-01, NSF 10-307). We did not model an undergraduate pool explicitly, but rather used the number of bachelor's degrees awarded in a given year (NSF 08-321) to calculate the number of potential graduate student candidates, as well as to identify a loss rate associated with the transition to graduate school. Due to the absence of data on postdoctoral fellows prior to 1993, we estimated the number of fellows between 1979 and 1992 based on a linear regression of the number of fellows from 1993 to 2006. Due to the rapid turnover rate of this pool, any offset caused by this assumption was overcome within the first few years of the simulation, and therefore is unlikely to have had any lasting effects on the model results.

We set the proportion of undergraduate degrees awarded to women for each year of the simulation to National Science Foundation data values. For the other pools (graduate students, postdoctoral fellows, assistant professors, and tenured professors), we set initial female participation as the National Science Foundation data values from 1979 (NSF 08-308, NSF 09-305, NSF 10-307), and simulated female participation for subsequent years. We started simulations in the year 1979 since National Science Foundation data on pool sizes were not available for earlier years. In longer career stages, the use of a single value for female participation is unrealistic, as retirement or promotion is primarily from the older individuals. We therefore partitioned the graduate student and tenured professor pools into 2 and 5 sub-pools respectively.

We constructed a pipeline model for all Science and Engineering (S & E), as well as for several disciplines: Agricultural and Biological Sciences (BIO), Engineering (ENG), Mathematics (MAT; includes mathematics and statistics), Physical Sciences (PHY; includes physics and chemistry), Psychology (PSY), and Social Sciences (SOC). Earth, Atmospheric and Ocean Sciences could not be included due to the lack of data on faculty composition in the National Science Foundation databases.

Model simulation

For each year we calculated the number of individuals moving in and out of each pool as estimated based on transition rates and changing pool sizes (figure 1). We first removed the estimated number of retiring tenured professors from that pool, filling empty slots with available assistant professors. We then filled the empty slots created in the assistant professor pool with available postdoctoral fellows, in turn filling any postdoctoral open slots with available graduating doctoral students, and lastly filled open slots in the doctoral student pool with graduating bachelors students. The actual transition rates were calculated as:

$$\begin{aligned}
\mu_G(t) &= N_G(t+1) - N_G(t) + \left(\frac{1}{\tau_G}\right) N_G(t) && (1)\\
\mu_P(t) &= N_P(t+1) - N_P(t) + \left(\frac{1}{\tau_P}\right) N_P(t) && (2)\\
\mu_A(t) &= N_A(t+1) - N_A(t) + \left(\frac{1}{\tau_A}\right) N_A(t) && (3)\\
\mu_T(t) &= N_T(t+1) - N_T(t) + \rho_T(t) && (4)\\
\rho_T(t) &= \left(\frac{1}{\tau_T}\right) N_T(t) && (5)\\
\lambda_U(t) &= D_U(t) - \mu_G(t) && (6)\\
\lambda_G(t) &= D_G(t) - \mu_P(t) && (7)\\
\lambda_P(t) &= \left(\frac{1}{\tau_P}\right) N_P(t) - \mu_A(t) && (8)\\
\lambda_A(t) &= \left(\frac{1}{\tau_A}\right) N_A(t) - \mu_T(t) && (9)\\
\delta_G(t) &= \left(\frac{1}{\tau_G}\right) N_G(t) D_G(t) && (10)
\end{aligned}$$

where $\mu_i(t)$ are the number of individuals transitioning into class i (G for graduate student, P for postdoctoral fellow, A for assistant professor and T for tenured professor) from the previous class in year t, $\lambda_i(t)$ are the number of individuals in class i that do not go on to the next class in year t (and instead leak out of the pipeline), $\delta_G(t)$ is the number of graduate students dropping out in year t (before receiving degree), and $\rho_T(t)$ is the number of tenured professors retiring in year t. The remaining parameters in equations (1-10) came from National Science Foundation data: $N_i(t)$ are the number of individuals in class i in year

t (NSB 10-01, NSF 10-307), $D_i(t)$ is the number of degrees of class i awarded in year t (NSF 08-321), τ_i is the average number of years spent in each class (7.2, 7.3, 7.0, 6.9, 6.4, 7.3, 8.9 and for graduate studies in S&E, BIO, ENG, MAT, PHY, PSY and SOC, respectively; and 1.9, 2.2, 1.3, 1.7, 1.9, 1.2, and 1.2 for postdoctoral fellowships in S&E, BIO, ENG, MAT, PHY, PSY and SOC, respectively; NSB 10-01, NSF 08-307). For the results presented in this paper we assumed individuals went through two postdoctoral fellowships before moving on to become an assistant professor.

For postdoctoral fellows and assistant professors we could not distinguish between individuals leaving the pipeline in the middle and those leaving at transition points (e.g. an assistant professor leaving before, or just after, receiving tenure) so we lumped together both losses in a general loss term for each class (λ_P and λ_A). Similarly we could not distinguish between tenured professors leaving early and those retiring at the end of their career, so we lumped these together in a single term, retirement (ρ_T). However, since data is available for the number of doctoral degrees each year, we were able to distinguish between graduate students leaving the pipeline during grad school (δ_G) and those receiving doctoral degrees but leaving academia (λ_G).

In some simulation years the numbers did not quite match up and we had to make the following adjustments. When the number of empty tenured professor slots exceeded the number of assistant professors available (as estimated from turnover times), then we moved as many assistant professors as necessary into tenured slots. Similarly we moved up as many postdoctoral fellows as necessary to fill empty assistant professor slots, even when it exceeded the estimated number of available postdoctoral fellows. This was only necessary during the earliest years of the model simulations (1980's), which we believe reflects the fact that during this time it was typical to spend little or no time as a postdoctoral fellow. If the number of empty assistant professor slots exceeded the total number of existing postdoctoral fellows in that discipline in that year, then we assumed that all fellows were hired as assistant professors, and the remaining professor slots were filled with fellows from outside the pool (coming from other scientific disciplines or returning to academia after having previously left), but in the same sex ratio as the pool of postdoctoral fellows. Similarly, if the number of empty postdoctoral fellow slots exceeded the number of students receiving doctoral degrees in that year, we assumed the remaining slots were filled with doctoral graduates from outside the pool (either from other scientific disciplines or graduates from previous years that had temporarily left academia).

As mentioned, the graduate student and tenured professor pools were partitioned into two and five sub-pools, respectively. Transitions between sub-pools were estimated based on turnover time (the amount of time spent in each sub-pool within a pool was approximately equal). Graduate students leaving the pipeline before receiving a degree (δ_G) were pulled from both sub-pools (half from each), but graduate students leaving the pool with a doctoral degree were assumed to come only from the second sub-pool. Tenured professors retiring

(ρ_T) were pulled only from the last sub-pool.

Once the number of individuals moving in and out of each class was calculated, we subdivided this based on the proportion of female academics in each class. Initial female participation in each pool was taken from National Science Foundation 1979 data, except for the case of postdoctoral fellows where female participation was not available before 1999. In this case we assumed an initial female participation that was the mean of the values for graduate students and assistant professors. As with pool sizes, any minor offsets created by this assumption were rapidly overcome within the first few years of the simulation. We calculated the number of women in each pool as

$$\begin{aligned}
F_G(t+1) &= F_G(t) - D_G(t)f_G(t) - \delta_G(t)f_G(t) + \mu_G(t)f_U(t) && (11)\\
F_P(t+1) &= F_P(t) - \mu_A(t)f_P(t) - \lambda_P(t)f_P(t) + \mu_P(t)f_G(t) && (12)\\
F_A(t+1) &= F_A(t) - \mu_T(t)f_A(t) - \lambda_A(t)f_A(t) + \mu_A(t)f_P(t) && (13)\\
F_T(t+1) &= F_T(t) - \rho_T(t)f_T(t) + \mu_T(t)f_A(t) && (14)
\end{aligned}$$

where $F_i(t)$ is the simulated number of women in class i at time t, $f_i(t)$ is the proportion of individuals in class i at time t who are female, and other variables are as listed above. With our pipeline model structure in place, we then simulated the flow of individuals through the pipeline. We assumed that at each transition, all types of individuals (males and females, in this case) were equally likely to continue on in the pipeline or leak out, and therefore individuals entering a given pool were drawn from the pool below in proportion to the sex ratio in that lower pool.

Calculation of Inertial Effect

The inertial effect (IE) was calculated as the ratio between the proportion of individuals in a class and within discipline that were female from the data, to the predicted proportion from the model. This gives a metric for how much female participation can be accounted for by demographic inertia alone, where an IE value equal to 1 indicates that the data exactly match the prediction under demographic inertia alone, while a value less than one indicates that women are less represented than would be expected by demographic inertia, and a value greater than one indicates that they are more represented. The IE by class (table 1) was determined by running the pipeline model, assuming no gender differences in attrition, and starting with National Science Foundation data from 1979-2006 for the proportion of females in the previous class for which there is long-term data (UG for GR, GR for PD, GR for AP, AP for TP). The IE over time (figure 3, table S1) was determined by running the pipeline model, assuming no gender differences in attrition, and starting with National Science Foundation data on the proportion of females at the undergrad level, starting in different years and recording the simulated proportion of women 5 years later.

Electronic Supplementary Material: Additional Results

Table S1: The inertial effect (IE) over time: most disciplines and transitions show improvement towards and IE value closer to 1.

IE in undergrad to grad student transition							
years	S&E	BIO	ENG	MAT	PHY	PSY	SOC
1979-1985	0.89	1.02	1.05	0.89	0.87	1.02	1.01
1986-1992	0.91	0.98	1.03	0.92	0.87	1.00	1.01
1993-1999	0.96	1.02	1.18	1.10	0.87	1.00	1.06
2000-2006	0.91	0.97	1.12	1.17	0.83	1.00	1.01
IE in grad student to postdoc transition							
years	S&E	BIO	ENG	MAT	PHY	PSY	SOC
1979-1985	NA	NA	NA	NA	NA	NA	NA
1986-1992	NA	NA	NA	NA	NA	NA	NA
1993-1999	0.80	0.82	0.82	0.58	0.64	0.73	0.86
2000-2006	0.81	0.79	0.83	0.59	0.70	0.69	0.86
IE in grad to assistant professor transition							
years	S&E	BIO	ENG	MAT	PHY	PSY	SOC
1979-1985	0.50	0.52	0.23	0.35	0.36	0.50	0.48
1986-1992	0.66	0.68	0.41	0.31	0.43	0.55	0.57
1993-1999	0.76	0.74	0.50	0.52	0.61	0.62	0.65
2000-2006	0.83	0.78	0.70	0.51	0.74	0.72	0.75
IE in assistant to tenured professor transition							
years	S&E	BIO	ENG	MAT	PHY	PSY	SOC
1979-1985	0.95	0.98	0.89	0.90	1.00	0.92	0.96
1986-1992	1.00	1.95	0.77	0.85	0.83	1.20	0.93
1993-1999	1.10	1.08	0.90	1.20	1.17	1.04	1.11
2000-2006	1.11	1.19	1.26	0.84	1.02	1.05	1.09

Electronic Supplementary Material: References

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