1-1-2019

Academic Preparation for Business, Industry, and Government Positions

Alejandra Alvarado
Naval Surface Warfare Center

Candice R. Price
University of San Diego, cprice@smith.edu

Association for Women in Mathematics Series

Susan D'Agostino
Sarah Bryant
Amy Buchmann
Michelle Craddock Guinn
Leona Harris *Editors*

A Celebration of the EDGE Program's Impact on the Mathematics Community and Beyond

AWM
ASSOCIATION FOR WOMEN IN MATHEMATICS

Springer

Academic Preparation for Business, Industry, and Government Positions

Alejandra Alvarado and Candice R. Price

Abstract According to the 2015 Annual Survey of the Mathematical Sciences, 1901 PhDs were awarded in the USA. The report shows that 52% of those recipients are working in academia. This is a decrease from the 2014 survey which stated that 56% of new doctoral recipients went on to academia. Thus, what support do we, as academics, provide to this growing population of business/industry, or government job seekers? The goal of this paper is to provide insight into programs tackling this question along with relevant information and advice for new PhDs interested in jobs outside of academia as well as those interested in making successful mid-career moves.

1 Introduction

Recently, a trend in academic conferences has been to include a panel session on business/industry or government (BIG) jobs for academics and recent graduates. Often these sessions include someone that started in a tenure track or tenured position before being seduced by the allure of industry.

At the Infinite Possibilities Conference in 2018 [9], there was such a panel session entitled, *Mid-Career Moves and New Opportunities*. The session included four female mathematicians with varied experiences working in government, industry, and academia. According to Dr. Carla Cotwright-Williams, who currently works for the Department of Defense, many first generation graduate students don't know what they are signing up for when they enter graduate school. Cotwright-Williams goes on to say that a career in academia can be very fulfilling, assuming

A. Alvarado (✉)
Naval Surface Warfare Center, Panama City Beach, FL, USA
e-mail: aalvarado2@eiu.edu

C. R. Price
University of San Diego, San Diego, CA, USA
e-mail: cprice@sandiego.edu

S. D'Agostino et al. (eds.), *A Celebration of the EDGE Program's Impact on the Mathematics Community and Beyond*, Association for Women in Mathematics Series 18, https://doi.org/10.1007/978-3-030-19486-4_8

the individual knows what it entails. If a student does not have professional role models growing up, they are at a disadvantage—not knowing their options or opportunities—*even* before entering college. This was the case with both authors of this paper. The assumption was that a PhD in mathematics only meant a job teaching at the university level. Many students are not exposed to the multitude of possible careers in STEM, much less the career opportunities within the mathematical sciences.

From the authors own experiences and through conversations with colleagues, they learned that many faculty themselves don't realize the vast opportunities within academia as well as in BIG; switching from one career to another is a possibility but requires preparation.

Another panelist Dr. Karoline Pershell, currently with the Association for Women in Mathematics, and Service Robotics and Technologies, noted that she had to be comfortable taking risks and not be afraid to fail in her career moves. After her postdoctoral position, panelist Dr. Maria Garcia took several years off due to a family situation that required her full attention. Her goal was always to return to work but was unsure when and where. After hiring a career coach, and networking, she received several job offers for many different types of positions. Although she had originally planned to stay in academia, she happily accepted a position at the US Bureau of the Census, where she has been for the last 20 years.

Another important piece of this story is the conversation around those underrepresented in mathematics. Included in the panelist presentations was a discussion on the lack of representation in the mathematical sciences and its impact on the question of career choice. How does a society encourage women to pursue PhDs when it appears that jobs are scarce? Data shows that women hold about a third of PhDs in the mathematical sciences, but only about 23% of women with STEM degrees actually work in STEM fields [18].

The IPC panel session inspired the theme of this paper. The potential for women to make significant contributions in the STEM workforce, specifically in higher paying careers and leadership positions, is vital. We need to insure women, especially women of color, have a seat at the table, and that their voices are heard. Perhaps exposure to more career opportunities for those with STEM degrees, mathematics in particular, will help shift the needle to a more balanced representation.

In this work, we explore several support networks for those with degrees in the mathematical sciences that are interested in BIG career opportunities. We conclude by providing advice collected from various resources.

2 Programs Supporting Interest in Business, Industry, or Government Positions

According to the most recent AMS Annual Survey, Report on the 2015–2016 New Doctoral Recipients, the number of new PhDs taking positions in BIG has increased

to 495 this year compared to 409 two years prior. US academic hiring has decreased while US nonacademic hiring has increased, since 2012.

It should also be noted that while the overall unemployment rate of those who receive a PhD in the mathematical sciences is 5.9%, new doctorates from the Small Public Institutions reported the highest unemployment rate at 13.7% while new doctorates from the Biostatistics group have consistently reported the lowest unemployment. A 2016 Pilot Study, conducted by Dr. Amy Cohen, that looked at the transition from a research postdoctoral position into immediate employment, found that about a third went on to a tenure-track position, while 8% went into a BIG career [7]. As more mathematicians are shifting into positions in BIG, quite a few programs and groups have been formed around the primary mission of supporting mathematicians interested in business, industry, or government positions.

The *Business, Industry, and Government (BIG) Math Network* [3] brings together the mathematical sciences community to address several issues surrounding the connections between academia and positions outside of academia. The BIG Math Network is a collaborative effort between mathematical sciences societies, institutes, labs, businesses, government agencies, and academic partners. The goals for the network include bringing together the mathematical sciences community to build job opportunities for mathematicians; communicating the value of mathematical science in the workplace; cultivating connections between students, faculty, recruiters, and managers; increasing knowledge about internships and how to prepare for them; providing viable models for internship logistics (including timing, intellectual property, and training), and creating regional networks. The network realizes these goals by accomplishing three primary objectives:

1. The network's website includes information for students and departments, opportunities for job seekers, and blog posts from people with careers outside of academia.
2. The network has cosponsored career panels at conferences.
3. The network has created a tool to support departments to assess their current initiatives to connect with BIG and make strategic plans to do more. The network has also initiated the program *Math to Industry Bootcamp* at the Institute for Mathematics and its Applications in Minneapolis.

The Math to Industry Bootcamp is a 6-week summer program that provides about 30 graduate students the training and experience that is valuable in industry positions [3].

The Mathematics Association of America (MAA) program *Preparation for Industrial Careers in Mathematical Sciences* (PIC Math) prepares mathematical sciences undergraduate students for industrial careers by engaging them in research problems that come directly from industry by supporting faculty [16]. The PIC Math program has three specific aims:

1. Increase awareness among mathematical sciences faculty and undergraduates about nonacademic career options.
2. Provide research experience working on real problems from BIG.
3. Prepare students for industrial careers.

PIC Math provides a program that supports faculty by equipping them with content for a spring semester research and credit-bearing course focused on solving industrial problems. Each faculty participant is asked to assemble a team of three to five students and work with them to develop their problem solving, teamwork, and communication skills. Each team will choose from one of five problems that are real-world problems yet suitable for undergraduate students to work on. The resources for students and faculty participating in PIC Math include a series of training videos on techniques for generating solutions and decision aids useful for coping with "messy" real-world problems [16].

This program includes a 3-day summer training workshop for faculty at US institutions. This workshop provides participants with information on BIG careers to share with their students; guidance on developing BIG connections; exposure to problems that arise in industry; and often overlooked, training on how to help students develop skills that are valued by employers.

The BIG Math Network officially kicked off in the early 2017, while PIC Math received its first round of funding in 2013. But as far as longevity, the Society for Industrial and Applied Mathematics (SIAM) [17] has a long-standing representation of encouraging opportunities in industry. Its website includes a web page dedicated to organizations hiring mathematicians, profiles of various mathematicians who hold positions in BIG, and a download-able careers brochure.

While not explicitly a program for positions outside of academia, the Enhancing Diversity in Graduate Education (EDGE) has been a large source of support for its participants interested in positions outside of academia [8]. The EDGE program is a summer math program with the goal "of strengthening the ability of women students to successfully complete PhD programs in the mathematical sciences and place more women in visible leadership roles in the mathematics community" [8]. Being a part of the EDGE network provides participants with a network that includes women in positions outside of academia who can provide mentor-ship for BIG careers. In fact, Cotwright-Williams and Pershell are both members of the EDGE network.

Some companies have programs focused on recruiting those with PhD, thus giving applicants the opportunity to intern in industry during the summer or sabbaticals. One such program is run by the Institute for Defense Analyses (IDA) [10]. Since the 1950s, the IDA Center for Communications and Computing "has performed fundamental research in support of the National Security Agency's mission in cryptology," which includes both foreign signals intelligence and protecting the communications of the US Government [10]. The Center is a nonprofit entity consisting of the Centers for Communications Research with offices in Princeton, New Jersey (CCR-P), and La Jolla, California (CCR-L), and the Center for Computing Sciences in Bowie, Maryland (CCS). While the three offices have distinct areas of focus, they work closely with each other and share many overlapping research teams. For this paper, the most important collaboration occurs during the summer workshops, called SCAMPs. These workshops bring in academics and others to use a "team-style" approach to tackling several difficult problems each summer. The participants for these workshops are diverse in many ways: some come from the academic community while others from research organizations; there are many

levels of experience ranging from seasoned researchers and distinguished faculty to advanced graduate students or exceptional undergraduate students; and disciplinary backgrounds can vary to include mathematics, computer science, statistics, physics, and electrical engineering. In a typical summer, the workshop has more than a hundred visitors across the three centers. The intense and collegial atmosphere is well known.

There also exist several programs that offer internship-like opportunities that post-PhD mathematicians can take advantage of. The American Association for the Advancement of Science (AAAS) offers visiting scholar positions and fellowship opportunities to "science and engineering professionals to participate in and develop leadership skills for government, policy-making, and mass media roles" [1]. The National Security Agency (NSA) offers sabbaticals ranging from 9 months to 2 years [13]. These visiting mathematicians have the opportunity to work on a variety of problems in different areas of mathematics. The Office of Naval Research is another government entity that has an internship-like appointment, the Summer Faculty Research Program [15]. Science and engineering faculty members can work at US Navy laboratories, on a recurring basis. The National Science Foundation (NSF) offers temporary/rotator programs where math PhDs can be temporary program directors and recommend which proposals to fund and have an influence on scientific direction, while still being affiliated with their current institution [12]. Usually after a year or two, participants in both of these visiting positions return to their institution with "new insights and experiences." Returning faculty have the opportunity to share their experiences and provide new knowledge about the diversity of career options for mathematicians with their students and peers.

3 Preparing Students for Careers in Business, Industry, or Government

Graduate students in the mathematical sciences work to advance the understanding of a relatively narrow field of study. Preparation for future careers is typically in an academic setting, for academic purposes, directed by academics. Thus many graduates aspire to receive faculty positions, specifically, tenure-track positions. But, the supply of newly trained PhDs outnumber faculty replacement needs. Hence, BIG employment offers alternative opportunities for these "surplus" graduates. According to a 2015 NSF-IPAM Mathematical Sciences Internship Workshop report [11], the number of PhDs in the USA has approximately doubled in the past 10 years, while the number of tenure-track positions is decreasing.

This has led to what is academia is calling, the "career diversity" movement [5]. These same issues are being seen not just in mathematics but across many disciplines. It has become increasingly important to begin training students, undergraduate and graduate, for diverse careers, rather than only training them for academia.

In [4], the authors state, "Many graduate students will continue to follow a traditional academic career path, but having the option to choose careers in industry and governmental organizations will benefit all of them." So the question becomes: how does one prepare students for careers outside of those offered in academia, especially when all you know is academia? Some programs have made this a priority at their institutions. They find that it is important to have more than one area of training. One institution and program that has been recognized for its efforts in the area is the University of Illinois Urbana-Champaign (UIUC) Department of Mathematics. UIUC has an NSF funded program that has been successfully helped place students in BIG positions through internships [11]. UIUC also offers a summer computational boot camp to their graduate students, with the goal "to teach practical computational mathematics techniques using Python programming in 2 weeks to someone with little or no programming experience." The results have been rewarding.

"At UIUC, several students who might not think of their thesis focus as applied or industrial mathematics topics have participated in internships, sometimes through on-campus collaborations with lab groups in other departments. For example, a combinatorist modeled infectious disease in sheep, in a veterinary medicine lab. A number theorist modeled ant colonies, in the entomology department. A functional analyst worked with an e-commerce analytics firm. A graph theorist worked with a financial trading firm and a student interested in differential equations worked on agricultural data analytics. One helpful mechanism for placing students in the internships is interviewing them about their interests outside of mathematics."

4 Advice for Mathematicians Interested in Careers in Business, Industry, or Government

Transitioning from academia to positions outside of academia is increasingly more common. According to the American Mathematical Society's 2015 Annual Survey of the Mathematical Sciences in the USA, 1901 PhDs were awarded [2]. The report shows that 52% of those recipients are working in academia. This is a decrease from the 2014 survey which stated that 56% of doctoral recipients went on to academia. This transition is not obvious nor is it smooth. For a job in academia, an applicant would highlight their individual achievements to stand out among a large number of candidates. Yet, according to *How to sail smoothly from academia to industry* "To beat the stiff competition, highlight your skills in collaboration, teamwork and meeting deadlines." Refocusing on collaboration, as opposed to individual achievements is more beneficial if one wants to enter the corporate world [14].

One of the authors of this work, Dr. Candice R. Price, spent 3 years in the mathematics department at the US Military Academy (USMA) in West Point, NY. This is an institution whose goal is to train future army officers and leaders in the USA. The mathematics curriculum at USMA, which includes mathematical

modeling, calculus, and probability and statistics, has been structured intentionally to broaden the mathematical training of all West Point cadets. Because USMA is traditionally an engineering school, all cadets earn a Bachelors of Science with the goal of beginning a military career directly after graduation. Few graduates go on to graduate school and medical school. As an instructor at this institute, Price found that because the goal of the curriculum was to train students for specific jobs in the government, all of the math courses included real-world applications, public speaking, and professional writing. Price found that these intentional inclusion of these skills in the mathematics setting allowed the cadets to learn how to talk about mathematics in all setting, an important skill for any mathematician. When looking about at her own mathematical training, Price realized that it wasn't until her master's program were these skills introduced, and that was in the math education setting. On reflection, the inclusion of these techniques in the undergraduate mathematical curriculum at every stage allows students to hone the skills needed in any arena. This is one area that is being addressed by PIC Math programs. A benefit of this style of curriculum is that it allows for the opportunity to expose undergraduates to the many career options that mathematical training provides.

Several mathematicians who transitioned from academia echoed previous thoughts on the skills needed in their transitions. Dr. David Tello, formerly an assistant professor, transitioned to being an analyst at a financial institution, partly to spend more time with his ailing mother. He found that while his soft skills were lacking, his technical skills were excellent, and in the end was one of the reasons he was hired. Tello states, "Graduate programs need to concentrate on teaching these soft skills. Basic lectures on emotional intelligence, business writing, protocol in company meetings, and business etiquette are vital to survive the corporate world." Dr. Brie Finegold also transitioned from academia to industry as a research mathematician, also due to a family situation. Her research at the time was mostly theoretical and she had minimal programming experience. "However", Finegold states, "I realized that I could learn many of the things I needed on the job, and I demonstrated on interview that I was capable of thinking on my feet and that I was genuinely curious." Her problem-solving and writing skills acquired in academia were valuable in her new position.

In [6], Cohen noted "The health of the mathematical community requires that graduate students and early-career mathematicians see a broad range of paths to respected and satisfying careers, whether inside or outside academia" [6]. We hope that more mathematical science departments nationwide are encouraged to prepare students for all employment opportunities. To close out this work, we include some pointed advice, gathered from the mathematicians and references mentioned throughout this paper, on how to make a transition to BIG smoother:

- Attend panels or presentations by those in positions outside of academia. These are becoming more common at mathematical sciences conferences. Include professional development opportunities that provide information, training, or support for transitioning to positions in BIG.

- If currently in academia, teach courses that will make the transition easier and incorporate mathematical software. Computer programming is important but there is no need to be an expert.
- Make yourself visible on professional social media, such as LinkedIn, and include your resume. Network and seek out others in careers you find interesting.
- Seek the assistance from someone in BIG who can help turn your CV into a resume specifically for nonacademic positions.
- Current trends are conferences and workshops in data science, and applications of mathematics to political and social science. Explore a non-mathematical domain area and how mathematics is applied, through conferences.

Acknowledgements The authors would like to acknowledge the EDGE program, Rachel Levy, Suzanne Weekes, the Infinite Possibilities Conference, Leona Harris, Carla Cotwright-Williams, Karoline Pershell, Maria Garcia, the editors of this volume, and the anonymous reviewers.

References

1. American Association for the Advancement of Science, "https://www.aaas.org/", retrieved 22 August 2018.
2. American Mathematical Society, "http://www.ams.org/profession/data/annual-survey/annual-survey", retrieved 22 August 2018.
3. Fadil Santosa, *Big Math Network: Connecting Mathematical Scientists in Business, Industry, Government, and Academia*, " https://bigmathnetwork.org/", retrieved 22 August 2018.
4. Yuliy Baryshnikov, Lee DeVille, and Richard Laugesen, *Math PhD Careers: New Opportunities Emerging Amidst Crisis*, Notices of the AMS, March 2017, Vol. 64, no. 3, pp. 260–264.
5. Leonard Cassuto, *Can You Train Your Ph.D.s for Diverse Careers When You Don't Have One?*, 22 August 2018, "https://chroniclevitae.com/news/2092-can-you-train-your-ph-d-s-for-diverse-careers-when-you-don-t-have-one?cid=VTEVPMSED1"
6. Amy Cohen, *Disruptions of the Academic Math Employment Market*, Notices of the AMS, October 2016, Vol. 63, no. 9, pp. 1057–1060.
7. Amy Cohen, *Results from a 2016 Pilot Survey on Math Post-docs*, "https://arxiv.org/pdf/1703.06772.pdf", retrieved 27 January 2019.
8. The EDGE Program, "https://www.edgeforwomen.org/", retrieved 27 January 2019.
9. Infinite Possibilities Conference 2018, "http://www.msri.org/web/msri/activities/infinite", retrieved 27 January 2019.
10. IDA Center for Communications and Computing, "https://www.ida.org", retrieved 27 January 2019.
11. Rachel Levy, *2015 NSF-IPAM Mathematical Sciences Internship Workshop Report*, "http://www.ipam.ucla.edu/reports/2015-nsf-ipam-mathematical-sciences-internship-workshop-report/"
12. National Science Foundation, "https://www.nsf.gov/careers/rotator/", retrieved 22 August 2018.
13. National Security Agency, "https://www.nsa.gov/what-we-do/research/math-sciences-program/sabbaticals/", retrieved 22 August 2018.
14. Kendall Powell, *How to sail smoothly from academia to industry*, "https://www.nature.com/articles/d41586-018-03306-1", retrieved 22 August 2018.
15. Office of Naval Research, "https://www.onr.navy.mil/en/Education-Outreach/faculty/summer-faculty-research-program", retrieved 27 January 2019.

16. PIC Math - Preparation for Industrial Careers in Mathematical Sciences, "https://www.maa.org/programs-and-communities/professional-development/pic-math", retrieved 22 August 2018.
17. Society for Industrial and Applied Mathematics, "https://www.siam.org/", retrieved 22 August 2018.
18. Ryan Noonan, *Women in STEM: 2017 Update* US Department of Commerce, Economics and Statistics Administration, Office of the Chief Economist, November 13, 2017