Data Brief

Voices of Innovation

An Analysis of Influential AI Researchers in the United States

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Executive Summary

Artificial intelligence (AI) research has grown exponentially in the past several decades, and many of the most exciting breakthroughs have come out of U.S. universities, companies, and research institutions.[1] Although highly accomplished AI researchers are by no means the only talent driving research, development, and commercialization in this field, their role is paramount. Understanding the profiles and careers of current leading U.S. researchers can help decisionmakers understand the existing state of the elite research workforce, and, importantly, how to cultivate the next generation of leading AI researchers.

This brief uses scholarly publication data and curated career histories to identify leading AI researchers in the United States between 2010 and 2021. We examined their demographic profiles, educational and national backgrounds, research collaboration rates, and stay rates in the United States. The overlap between the top 100 most-published, most-cited, and highest-h-indexed AI researchers in the United States (based on all the AI-related papers published between 2010 and 2021) yielded 217 distinct researchers. Our key findings are as follows.

Demographic characteristics and institutional affiliations

- As of September 2022, the top AI researchers in the United States were a homogeneous group in terms of gender, career stage, and institutional affiliation. Men accounted for 94 percent, and women for 6 percent. Most of these leading AI researchers were at the later stages of their careers or retired.
- Sixty-two percent were concentrated in 10 elite universities and top companies.
- About 74 percent of the top U.S. AI researchers held positions at universities while publishing their work during the past decade, though some had spent time at major tech companies such as Google and Microsoft.
- By comparison with the most-published and highest-h-indexed researchers, the most-cited researchers were disproportionately more likely to work in companies rather than at universities.

Foreign-born or foreign-educated AI researchers in the United States: Countries of origin and retention rates

- Of all leading AI researchers in the United States, 70 percent were foreign-born or foreign-educated. The most common places of origin were China (50

researchers) and India (14), followed by the United Kingdom (10) and Taiwan (9).

- 87 percent of the foreign-born or foreign-educated leading AI researchers in the United States remained affiliated with a U.S.-based institution as of September 2022.

International research collaboration

- Among the top U.S. AI researchers in our dataset, foreign-born or foreign-educated researchers had higher rates of international collaboration (50 percent) than their U.S. born/educated counterparts (38 percent). Foreign-born or foreign-educated researchers were generally more likely to collaborate frequently with researchers from their probable country of origin than other researchers.

- The top U.S. AI researchers—regardless of background or country of origin—collaborated most frequently with researchers from China. These patterns of international collaboration are not surprising given that China is the top global producer of AI research.

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Introduction

Talented researchers propel scientific breakthroughs, develop technical solutions to complex real-world problems, and drive innovation and progress in emerging technologies such as artificial intelligence (AI). Demand for their expertise is growing as emerging technologies reshape the global economic and security landscape. Yet supply of such top talent is limited as countries compete to recruit and retain the world's best and brightest minds.

Fostering, attracting, and retaining researchers and innovators has long been a competitive advantage for the United States. The nation has historically invested the most in research and development and awarded the most advanced degrees; it has competitive protections for intellectual property and a robust science and technology ecosystem that supports innovation and technological progress.[2] Aspiring scientists and researchers from around the world come to the United States to pursue their education. Most of this U.S.-trained talent remains in the country to pursue further career opportunities. For instance, almost half of science, technology, engineering, and mathematics (STEM) graduate students in 2017 were international students.[3] About 74 percent of foreign-born graduates from top-ranked AI PhD programs in the United States said they planned to apply for permanent residency or U.S. citizenship when eligible. Over the years, these international researchers have filled gaps in the U.S. tech workforce, catalyzed groundbreaking original research in AI disciplines, and contributed to intellectual diversity that multiple studies have shown is a boon to innovation.[4]

With private companies, academia, and governments around the world increasingly in competition over top AI talent, the makeup of this select group is of much interest to policymakers.

This report builds on other analyses studying researcher profiles and migration patterns of "top researchers" to develop profiles of leading AI researchers in the United States between 2010 and 2021.[5] For this analysis, we used three distinct measures for defining and identifying leading researchers—AI publication counts, citations of AI publications, and h-index using AI publications—to approximate productivity and influence in the AI research community as well as and the larger research and commercial ecosystem. The data used here is drawn from the CSET merged corpus of scholarly literature from Digital Science Dimensions, Clarivate's Web of Science, Microsoft Academic Graph, China National Knowledge Infrastructure, arXiv, and Papers with Code.[6]

In what follows, we examine the demographic profile and institutional affiliations of the top AI researchers in the United States to better understand their career trajectories; assess their countries of origin to estimate how many were foreign-born or foreign-educated, as well as explore stay rates to decipher what percentage remain the United States throughout their careers; and finally, examine the international collaboration patterns of these top U.S. AI researchers to get a more nuanced sense of the interconnected nature of global AI research.

Methodology

This study assesses top AI research talent in the United States by examining the most prolific, cited, and impactful authors of AI papers published with an affiliation to a U.S. institution—mainly universities, companies, and government research institutes—between 2010 and 2021, using CSET's merged corpus of scholarly literature. Within this dataset, from 2010 to 2021, the total number of AI papers published worldwide was 3,151,289, and the total number of AI papers published by U.S-affiliated authors was 460,609. Previous CSET reports discuss how CSET classifies AI papers.[7]

What makes for top AI talent? Because there is no consensus on the definition of "top-tier AI talent," in order to assess research productivity and impact, scholars have considered factors such as overall publication record, participation in major research conferences, and citations. However, each such indicator is inherently limited; thus, this study uses three different and commonly accepted measures of scientific accomplishment to identify top-ranking AI research paper authors in our dataset:

1. Most-published: researchers with the highest number of AI papers published between 2010 and 2021
2. Most-cited: researchers with the highest number of citations of their AI papers published between 2010 and 2021
3. Most cumulative impact: researchers with the highest h-index based on papers published between 2010 and 2021[8]

From each of these three categories, we pulled a list of prolific authors and narrowed it down to the top 100 researchers linked to U.S.-based institutions. This results in an imperfect measure, but we believe the top 100 helps to capture the most accomplished researchers with potentially extraordinary skills. Moreover, within this top 100, we observed high values on all of our three indicators—number of papers, number of citations, and h-index—followed by a long tail of average values; when plotted, such a

graph resembles an inverse-square relation (see Figure A1 in the appendix). The three lists were not mutually exclusive: as one might expect, there was overlap in the top 100 researchers across all three metrics. All in all, we identified 217 top AI researchers who were affiliated with a U.S. institution between 2010 and 2021.

Note that some researchers have questioned the merit of assessing "top researchers" based on publication counts, citations, and h-indexes. This is due partly to questions about whether people can meaningfully contribute to extremely high numbers of quality papers (the "top" author in our analysis averages 75 papers per year),[9] and partly to additional questions about bias in citation networks (well-connected researchers are more likely to cite one another and to overlook early career researchers or those from less-known institutions).[10] While we acknowledge these limitations, the AI research job market nonetheless often measures productivity, impact, and competitiveness using these three metrics. Additionally, these metrics are more easily quantifiable and comparable than are qualitative assessments of research merit.

For all top 100 AI researchers across the three different lists (217 researchers total), we collected data about their current country of residence and place of employment as of September 2022, marking affiliations with academia, the private sector, or other. We also examined whether researchers remained in the United States to work, pursued dual-country affiliations, or left the United States entirely. In some cases, researchers spent some time in a U.S. institution, conducting research and publishing papers under their U.S. institutional affiliation, and then left the United States to pursue opportunities elsewhere. In situations such as these, when evaluating their research productivity and impact, we only counted the research papers these individuals produced while affiliated with a U.S. institution. While this method may exclude AI researchers who left the U.S. after a short amount of time, but were still productive in other countries, we limit the scope of this paper to researchers who are productive within the U.S.

For the purposes of this study, the term "while publishing" indicates an author's affiliation and sector between 2010 and 2021, when data on publications, citations, and h-index was collected. Authors' publications after that time are not included in this analysis, which does not mean they did not continue to publish while at their most recent workplace. The phrase "as of September 2022" indicates the most recent career status.

As previously noted, aspiring scientists and researchers from around the world come to the United States to pursue their education and build productive careers, and many end up working in top research universities or major tech companies. For this reason, we

also sought to identify foreign-born talent among the top 100 U.S. AI researchers across the aforementioned three lists. We reviewed LinkedIn profiles, official biographies, CVs, Google Scholar profiles, affiliations listed in published papers, Wikipedia pages, media profiles, and other public sources, seeking information that indicated whether an individual was born outside the United States, attended high school outside the United States, or pursued an undergraduate, graduate, or doctoral degree outside the United States.[11] Likewise, we searched for information suggesting that an individual was present in the United States as a worker or student at any point during a career. In some cases, scholars and researchers explicitly discussed their immigration histories and mentioned their nationalities, and we relied on this information as well. Using this open information, we manually classified researchers as "foreign-born or foreign-educated," although we make no claims about the type or class of their immigration status from a legal standpoint.[12]

In our classification of foreign-born or foreign-educated researchers, we took steps to avoid false positives. In ambiguous cases where it was not possible to ascertain someone's background, we did not classify that person as foreign-born or foreign-educated. In the absence of information about citizenship, residency, or visa status, it was not possible to ensure complete accuracy, and our classification process may contain unintentional errors. The findings here are intended to represent general trends, and the reader should exercise reasonable judgment when assessing exact numbers in relation to foreign-born or foreign-educated AI talent in the United States.

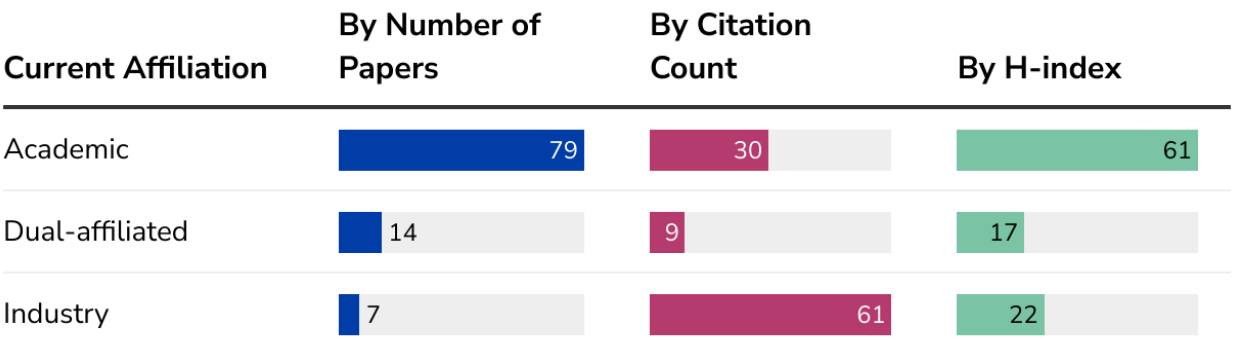
Profiling the Top 100 AI Researchers in the United States: Output, Citations, and Impact

Across our three lists of top 100 U.S. AI researchers—most-published, most-cited, and those with the highest h-index—we identified 217 distinct researchers. The absolute majority, 94 percent (203/217) of these researchers, were men. Only 6 percent (14/217) were women.[13] In 2022, when we collected and analyzed the data, about 61 percent of the male AI researchers and 72 percent of the women were in the later stages of their careers or had retired. These shared characteristics suggest that extreme productivity during the past decades was concentrated in a somewhat homogeneous set of researchers, at least when considering gender and age. The following sections examine differences and similarities in researchers' sector and institutional affiliations.

Sector Affiliations

We used institutional affiliation data to estimate the employment sectors of the top U.S. AI researchers in our dataset. Between 2010 and 2021, about 74 percent were primarily affiliated with universities, with interesting differences in sector affiliations across our three productivity and impact metrics: number of publications, number of citations, and h-index. These are illustrated in Figure 1.

Figure 1. Sector Affiliations of the Top 100 U.S. AI Researchers in 2022, by Productivity and Impact Metrics



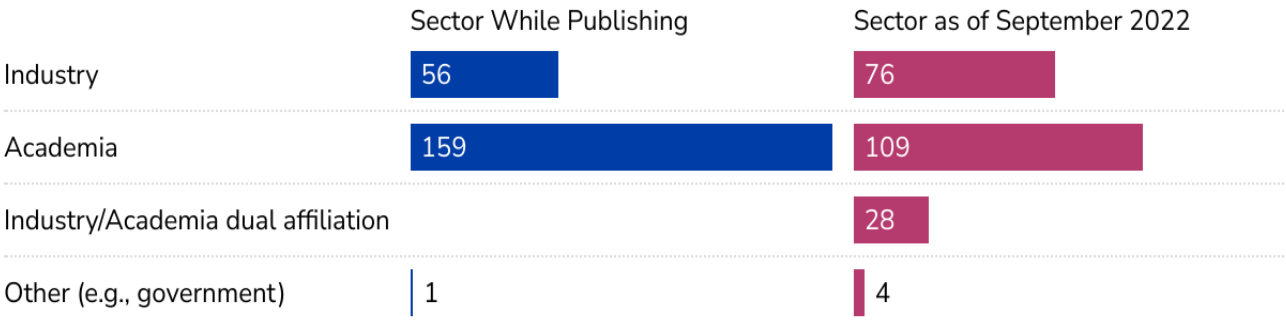
Source: CSET merged corpus.

We found that highly cited researchers were more often in industry roles than were those who ranked among the top 100 based on number of AI publications or h-index scores. Specifically, of the top 100 highly cited researchers, 61 worked in industry.

More than twice as many highly-cited researchers were in industry roles than in academia, and more highly cited researchers held industry jobs than the combined number of highly published and high-h-index researchers employed in this sector, as shown in Figure 1. This may be because canonical industry papers in AI tend to be heavily referenced. For example, a recent study finds that four of the five most-cited AI papers in 2022 were authored by researchers affiliated with leading technology companies including DeepMind, OpenAI, Meta, and Google.[14] This study also shows that research teams in companies sometimes collaborate with elite institutions such as the University of California, Berkeley, on high-impact papers, allowing them to increase their citation footprint.

When examining the affiliations of these top U.S. AI researchers over time, we found a slight shift into industry roles, as Figure 2 shows. Over 51 percent of the researchers in our dataset remained exclusively in academia and another 14 percent held a dual industry-academy affiliation. 34 percent of the researchers in our dataset currently hold only industry affiliations (as of September 2022), a slightly higher proportion than the proportion of researchers with industry affiliations while publishing AI papers identified in the CSET merged corpus between 2010 and 2021 (27 percent).

Figure 2. Sector Changes for Leading AI Researchers: Number of Researches in a Given Sector Between 2010 and 2021 (While Publishing) and 2022



Source: CSET merged corpus and manual annotation.

Institutional Affiliations

Between 2010 and 2021, 38 of the 216 leading AI researchers were affiliated with Google, 21 with the University of California system, and 17 with Stanford University, as Table 1 shows.*

Table 1. Top 10 Institutional Affiliations for the Leading U.S. AI Researchers between 2010 and 2021

Institution	Number of Leading AI Researchers
Google	38
University of California	21
Stanford University	17
Carnegie Mellon University	13
University of Texas	11
Microsoft	10
MIT	8
Johns Hopkins University	7
University of North Carolina	6
University of Washington	6

Source: CSET merged corpus.

During the past decade, 62 percent of the top U.S. AI researchers in our dataset worked at one of the 10 elite institutions listed in Table 1 (based on an estimation of

* Affiliation data was ambiguous for one researcher in the total merged list of 217 during 2010–2021, yielding 216 researchers suitable for that analysis.

affiliations between 2010 and 2021). Google and Microsoft alone employed about one-fourth of the leading U.S. AI researchers included in our analysis. As a whole, 63 of the 216 leading U.S. AI researchers—29 percent—were affiliated with companies during this period (Table 1). As previously noted, researchers employed in company roles tended to publish the work most widely cited, as Figure 1 shows.

The leading AI researchers also tended to stay within this group of elite institutions between 2010 and 2021, as well as during our 2022 analysis. Google remains the most frequent company affiliation for top researchers; several moved to Google-adjacent Alphabet subsidiaries such as DeepMind or Waymo. The University of California remains the most frequent university affiliation, followed by Stanford University.

Leading researchers are concentrated among a few elite research institutions.

The same institutions, including a handful of prestigious universities and companies, remain home to the most competitive U.S. AI researchers. As noted, 62 percent in our list of leading U.S. AI researchers worked at one of the 10 institutions listed in Table 1. Overall, our analysis of career trajectories of leading AI researchers in the United States mirrors broader trends in academia and industry: top talent goes to and stays at top universities and top companies.

This concentration may be the result of any or all of the following factors:

1. ***Elite universities and top companies have an easier time getting AI papers published and cited.*** Research shows that faculty in more prestigious institutions publish more of the scientific literature, receive more citations, more funding and awards, and train more of the faculty hired by other prestigious institutions. Different factors explain this phenomenon, including the nature of the work environment, the reputation of the institutions where researchers were trained and/or now work, and social connections, as well as meritocratic characteristics such as the skill, effort and potential of individuals and nonmeritocratic characteristics like age and gender.[15] For example, one study that modeled citation networks found that male researchers and researchers from elite institutions were referenced more frequently than women researchers and researchers from lower-ranked institutions (recall that only 6 percent of the leading AI researchers in our dataset are women).[16]

2. ***Elite universities and top companies may have more infrastructure and resources to facilitate large-scale research in science and technology.*** Elite institutions are more likely to receive research funding awards than non-elite institutions. Furthermore, a small number of institutions, including Google, Stanford University, MIT, Carnegie Mellon University, UC Berkeley, and Microsoft (closely correlated to our list of institutions employing the most productive and impactful AI researchers), hold the lion's share of computing capabilities and other resources in AI research.[17]

   In addition to research funding and other resources, studies have shown that elite universities maintain a "labor advantage" over non-elite institutions.[18] This labor advantage manifests itself as more staff, graduate students, and larger research faculty groups that yield more academic publications, and thus more citations, plus funding. All of this may result in a positive feedback loop while maintaining prestige and resources among a few institutions.

   However, some studies suggest this status quo has certain drawbacks. For instance, researchers using grant-funding data found that prestigious universities were 65 percent more likely to receive awards, and that those awards were 50 percent greater than those at less-prestigious universities. Yet the prestigious institutions used the money less effectively, as the "less-prestigious institutions produced 65 percent more publications and had a 35 percent higher citation impact per dollar of funding." In other words, "implicit biases and social prestige mechanisms" likely affect grant funding and productivity.[19] Such findings raise questions about the optimal distribution of research funding across different types of institutions, and about how to ensure that less-prestigious institutions with demonstrated productivity and success under serious resource constraints can continue building robust academic AI and research programs.

3. ***Elite universities and top companies attract top AI research talent.*** It is possible that highly prolific researchers self-select into elite institutions and companies. Elite universities tend to pay higher salaries, and, as noted, often provide superior resources in the form of computing power, labor, and other work benefits. A 2022 study found that more than 80 percent of U.S. professors were trained at only 20 percent of universities. This study also found that most faculty had attended more prestigious universities than the one where they

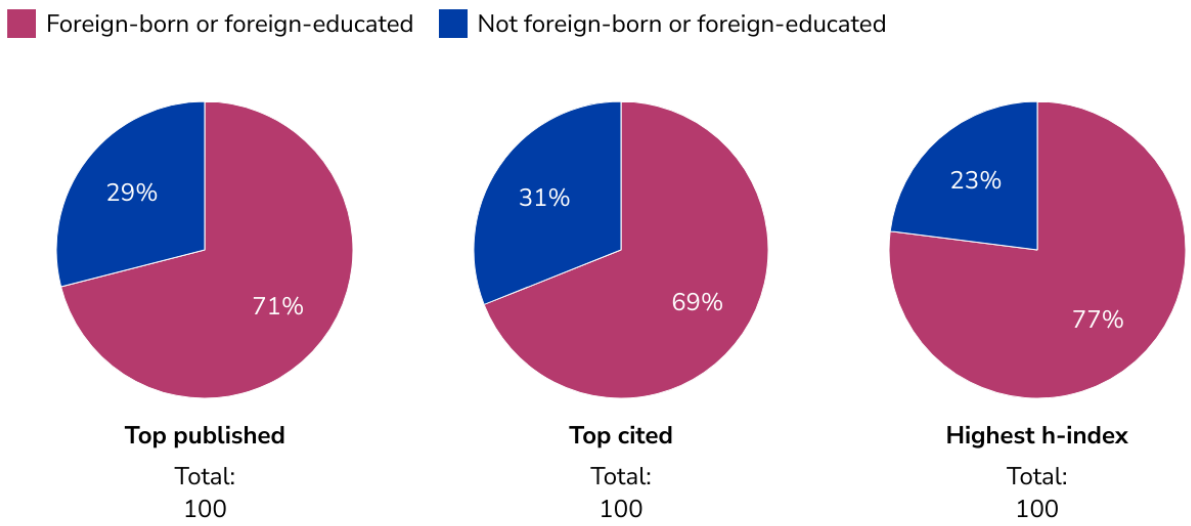
currently worked, leading to what has been termed “prestige bubbles” in academic hiring.[20]

To summarize, while a comprehensive review of the reasons behind these patterns is beyond the scope of this paper, possible explanations include the high concentration of resources, opportunities, and benefits within elite universities and companies; as well as factors such as reputation, prestige, and broader and systemic socioeconomic and commercial forces favoring the continued predominance of these institutions across the science and technology ecosystem.

Assessing International AI Talent among the Top U.S. AI Researchers

Our analysis shows that at least 152 out of the total 217 most-published, most-cited, and most-impactful AI researchers in the United States between 2010 and 2021 were born or educated outside of the United States and developed their research portfolios and careers at U.S. institutions.

Figure 3. Foreign-Born or Foreign-Educated AI Researchers among Leading U.S. AI Researchers



Source: CSET merged corpus and manual annotation.

As Figure 3 indicates, 71 of the 100 U.S.-based researchers who produced the highest number of AI research papers during the past decade were either born or educated outside the United States. When looking at the top 100 U.S. AI researchers by number of citations credited to AI papers, we found that 69 were born or educated outside the

United States. Finally, our assessment of the top U.S.-based AI researchers by h-index scores showed that 77 of 100 were born or educated outside the United States—a slightly higher share than the list of top scholars ranked by number of AI papers or citations.

Foreign-Born or Foreign-Educated Leading AI Researchers in the United States: Countries of Origin

Previous research found that India and China were the most common countries of origin for foreign-born or foreign-educated employees and students in AI-relevant fields who were working or studying in the United States, and that computer science and engineering PhDs from those two countries had some of the highest stay rates after graduation.[21] Our findings show that these trends are also present when looking at the most prominent group of AI researchers in the United States.

Figure 4. Estimated Countries of Origin for the 217 Leading AI Researchers in the United States

	Estimated Area of Origin	Number of Researchers	Percentage of Researchers
1	United States	65	30%
2	China	50	23%
3	India	14	6%
4	United Kingdom	11	5%
5	Taiwan	9	4%
6	Greece	7	3%
7	Canada	7	3%
8	France	5	2%
9	Italy	4	2%
10	Germany	4	2%
11	Spain	3	1%
12	Portugal	3	1%
13	Ukraine	2	1%
14	South Korea	2	1%
15	Russia	2	1%
16	Netherlands	2	1%
17	Moldova	2	1%
18	Iran	2	1%
19	Bulgaria	2	1%
20	Australia	2	1%
21	Other	19	9%

Source: CSET merged corpus and manual annotation.

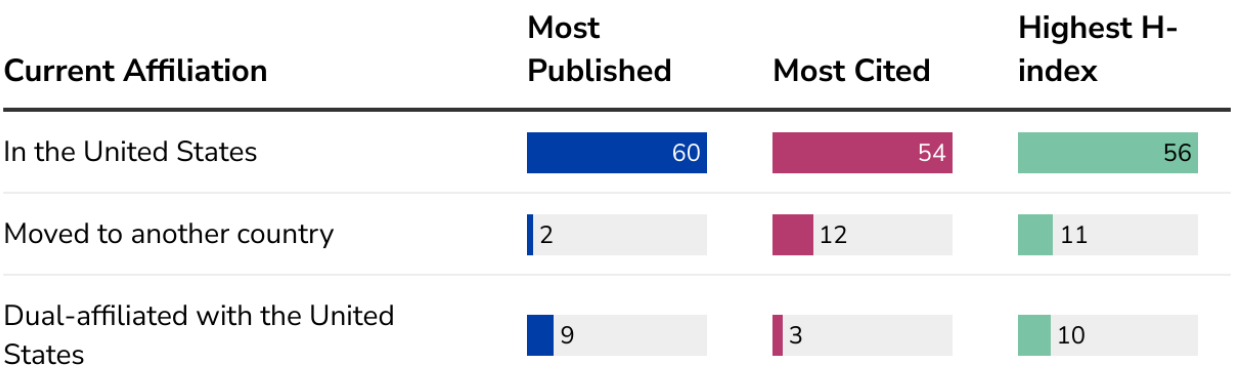
As Figure 4 shows, China and India are the most common countries of origin for foreign-born or foreign-educated top AI researchers in the United States, across all three productivity and impact metrics in this analysis, i.e., the most-published, most-

cited, and highest-h-indexes in AI research.[22] Other common places of origin include Taiwan, the United Kingdom, Canada, and Greece. There were only three researchers from Latin America in our analysis, and none from Sub-Saharan Africa.[23] Additional countries of origin, grouped in Figure 4 under "Other," include several European Union nations, Japan, and Israel, among others.

Stay Rates

Nearly 87 percent of America's foreign-born or foreign-educated top AI researchers remain in the United States, with a small proportion maintaining a dual affiliation with institutions abroad along with their U.S. institution. Only a few have permanently left the United States as of September 2022.[24] Figure 5 shows the current status of the leading foreign-born or foreign-educated U.S. AI researchers along with their U.S. institutional affiliation.

Figure 5. Current Status of Leading Foreign-Born or Foreign-Educated U.S. AI Researchers by Productivity and Impact Metrics, As of September 2022



Note: We classified researchers as having "moved" if they did not have a U.S. employment affiliation *and* had a non-U.S. employment affiliation (for example, by working at a university in Denmark) as of September 2022.

Source: CSET merged corpus and manual annotation.

Our findings indicate that as of September 2022, a large majority (77 to 84 percent) of the foreign-born or foreign-educated top AI researchers in the United States had remained in the country and continued to work exclusively for U.S. institutions. Stay rates were highest among the most-published AI researchers: 60/71 individuals (85 percent) in this category continued to work exclusively for a U.S.-based institution. Stay rates for the most-cited and highest-h-index categories for AI researchers were also high. Of the most-cited foreign-born or foreign-educated AI researchers, 54/69 (78

percent) had remained in the United States as of September 2022, working for American companies and other U.S. institutions. Finally, among the most impactful researchers based on h-index scores, 56/77 (73 percent) foreign-born or foreign-educated individuals had remained in the United States and continued to work and publish with a U.S. institutional affiliation. These findings are consistent with previous CSET research showing high stay rates among international students and scholars who earned AI-related degrees from U.S. institutions.

The Increasingly Complex Path to Immigration for AI Researchers

Foreign-born and foreign-educated researchers account for the majority of the top-tier AI researchers in the United States, and their contributions have proved essential for cutting-edge AI research produced by the leading U.S. universities, companies, and research institutions. As measured in our analysis, a substantial proportion of leading AI researchers in the United States may be first-generation immigrants who moved to the country on visas, such as student visas followed by the Optional Practical Training (OPT) program and/or the H1B skilled worker visa.[25] Some may have pursued the O-1 visa option for persons with extraordinary abilities, visited as J1 visa scholars, or applied for employment-based green cards. It is likely that many moved to the United States before 2010, as most of the foreign-born or foreign-educated researchers included in this study were mid- to-late-career professionals over 45 (as were U.S.-born researchers in our dataset) who published papers with an American institutional affiliation between 2010 and 2021.

When most of these elite researchers moved to the United States, they had access to options that differed from those available today. Some immigration pathways have improved since 2010, including increased clarity on O-1 visa guidance for talented foreign individuals and an expansion of the OPT program for STEM graduates. However, several visa processes have become more complicated or have worsened over this same period, for example the competitive H-1B visa for skilled employees, which now has numerical caps far below labor market demands.

The path to permanent residency in the United States is also not easy to navigate, especially for potential immigrants from India and China—which, according to our analysis, constitute the top countries of origin for leading AI researchers in the United States.[26] Wait times for permanent resident status (a green card) can be long; for instance, a Chinese AI professional applying for an EB-2 green card (employment-based permanent worker visa with an advanced degree or exceptional ability criteria) must wait about four years for their application to be processed. The processing

timeline for EB-2 green card applicants from China has remained steady over the past decade, but for those from India it has stretched out significantly. EB-2 green card applicants from India whose applications were reviewed in November 2010, for instance, had waited at least four years. But Indian applicants in this same category whose applications were reviewed in November 2022 had at that point waited a minimum of 11 years.[27] With a worsening backlog in processing applications, wait times continue to increase. The CATO Institute estimates that Indian EB-2/EB-3 applicants who entered the line in 2018 are projected to wait 54 years for their green card applications to be processed.[28] Such backlogs carry significant personal, financial, and professional costs for prospective immigrants—for instance, applicants cannot switch jobs or get promoted while in this queue. The difficulty of certain immigration pathways may over time make it more difficult to retain foreign talent residing in the United States, and make the United States a less attractive destination for ambitious AI researchers.

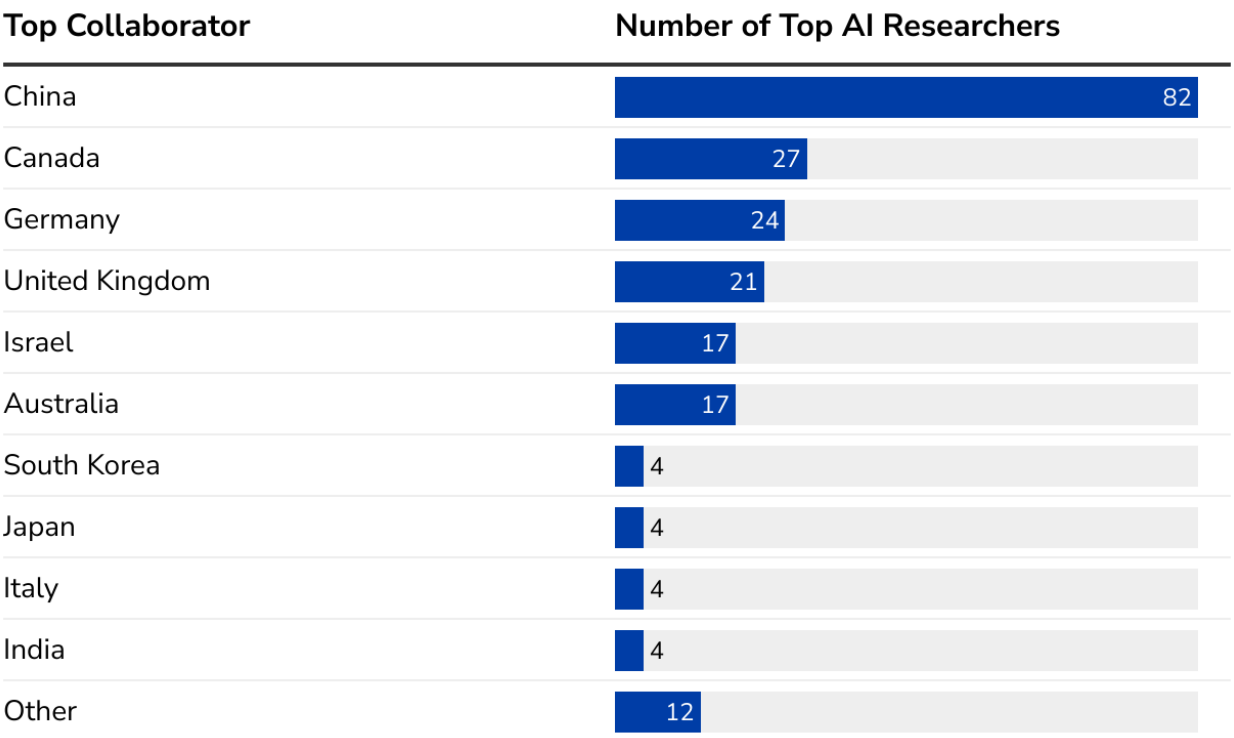
Assessing International Research Collaboration among the Top U.S. AI Researchers

Previous CSET reports have shown that AI researchers in the United States tend to collaborate more often with researchers in other countries, by comparison with the international collaboration rates of their counterparts in countries such as China and India.[29] Overall, the top 100 U.S. AI researchers in the most-published (45 percent), most-cited (47 percent), and highest-h-index (49 percent) categories did not differ meaningfully from one another in their average rates of international collaboration on AI papers. Moreover, the top U.S. AI researchers' rates of international collaboration are similar to the overall U.S. rates of international collaboration on AI papers (48 percent).[30]

From 2010 to 2021, the leading U.S. AI researchers—regardless of background or country of origin—collaborated most frequently with researchers from China, as shown in Figure 6. More specifically, 82 of the 217 top AI researchers in the United States (38 percent) coauthored at least one paper with counterparts in China between 2010 and 2021. These high rates of collaboration between the leading U.S. AI scholars and researchers from China reflect broader trends in U.S.-China AI research collaboration and are perhaps not particularly surprising, given that China is a top AI research producer globally by volume of AI papers. Indeed, since 2010, China has published more than 2.5 times as many AI papers as any other country in the world.[31] Although to a lesser extent than collaboration with Chinese counterparts, top U.S. AI researchers

have also collaborated relatively often with scholars from Canada, Germany, the UK, Israel and Australia.

Figure 6. Most Common International Research Collaborator Countries for Top U.S. AI Researchers, 2010–2021



Source: CSET merged corpus and manual annotation.

Previous studies have indicated that foreign-born researchers have larger international networks and collaborate more globally, especially with scholars from their countries of origin.[32] To examine whether this trend holds for the most productive and impactful U.S. AI researchers as defined in this study, we examined collaboration rates separately for foreign-born or foreign-educated AI researchers and U.S. born/educated AI researchers in our dataset.

Our findings indicate that among this select group of leading U.S. AI researchers, foreign-born or foreign-educated researchers collaborated more often with other scholars outside the United States than did their counterparts who had not been born or educated abroad. Across all three lists of most productive and impactful U.S. AI researchers, the average rate of international collaboration for foreign-born or foreign-educated researchers was 50 percent and above.[33] In contrast, the average rate of

international collaboration for the U.S. born/educated AI researchers in our dataset was under 38 percent.[34]

Foreign-born or foreign-educated researchers were generally more likely to collaborate with researchers from their estimated countries of origin than if they had no ties to those countries. Overall, 40 percent of the leading foreign-born or foreign-educated AI researchers in the United States collaborated most often with scholars from their estimated countries of origin.

Conclusion

The United States is home to the top universities in the world as well as the most innovative and successful technology companies. But as the geopolitical competition for leadership in AI intensifies, so does the competition for top AI talent. Thus, this paper has sought to develop a more comprehensive and nuanced understanding of a particularly important group driving AI innovation, development and commercialization—the top-tier AI researchers in the United States, classified based on their publication record and impact as estimated by citations and h-index scores. Although these individuals are by no means the only ones responsible for seminal breakthroughs and progress in AI, their contributions are significant, and the market demand for their particular skillset is high.

Overall, we identified 217 leading AI researchers who were affiliated with U.S. institutions between 2010 and 2021. The absolute majority were men, and most were in the late stages of their careers or had already retired as of September 2022. The majority (74 percent) of the most productive and impactful AI researchers in the United States held or had held positions at universities, though some spent time at companies such as Google and Microsoft. Interestingly, the top-cited AI researchers most often worked for companies rather than universities. As a whole, the leading AI researchers in the United States remain concentrated in a handful of elite universities and top companies that tend to have more resources, opportunities, and benefits.

Our research also shows that foreign-born or foreign-educated AI researchers account for about 70 percent of the top U.S. AI researchers across the three metrics we used to proxy research productivity and impact: overall research output, number of citations, and h-index score. Given the demographic profile of the researchers in our dataset, most of these individuals likely arrived in the United States before 2010. China and India were the top countries of origin, although many others came to the United States from the United Kingdom, Taiwan, Canada, the European Union, and other regions.

While we cannot comment on their specific immigration experiences, trajectories, and status, the pathways for continued and stable employment and permanent residency in the United States have become harder to navigate during the past decade. Over time, these obstacles and hardships can become a deterrent for leading AI researchers looking to begin or continue careers in the United States. This situation undermines the ability of the U.S. to attract and retain top-tier tech talent.

Finally, we examined international collaboration rates for the leading U.S. AI researchers, finding that those who had been born or educated abroad collaborated with international counterparts at higher rates than U.S. AI researchers in general, as well as the U.S. born/educated top U.S. AI researchers in our dataset. Foreign-born or foreign-educated researchers were more likely to collaborate with counterparts from their estimated countries of origins, presumably leveraging their networks to secure more funding and produce high-caliber research. That said, China was the top research partner for the leading U.S. AI researchers in our dataset, regardless of background or origin.

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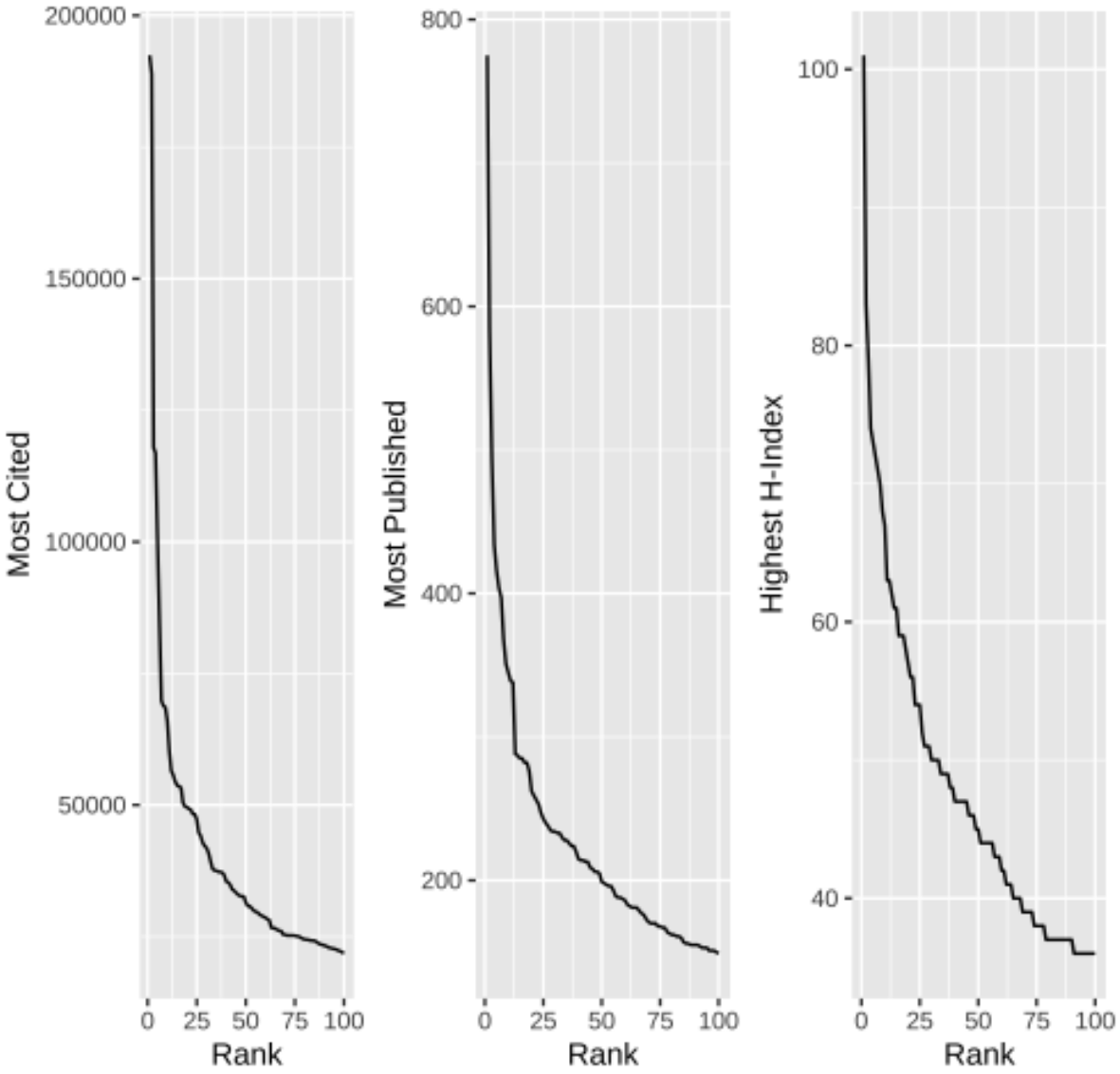
Appendix

Figure A1 plots the number of papers, number of citations, and h-index of the top 100 U.S. AI researchers and presents high values for the top 25 across the three measures. The values drop dramatically after approximately rank 25, with a declining trend as the ranks progress, approaching a long tail of average values.

Figure A1. Plotting H-index, Citation Counts, and Publication Counts of Leading AI Researchers



Source: CSET merged corpus.

Endnotes

[1] See Tiernan Ray, "Google Says 'Exponential' Growth of AI Is Changing Nature of Compute," *ZDNet*, November 1, 2018, https://www.zdnet.com/article/google-says-exponential-growth-of-ai-is-changing-nature-of-compute/.

[2] "Report Shows United States Leads in Science and Technology As China Rapidly Advances," *ScienceDaily*, January 24, 2018, https://www.sciencedaily.com/releases/2018/01/180124113951.htm. See also Remco Zwetsloot, "Winning the Tech Talent Competition" (Center for Strategic and International Studies, October 2021), https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/211028_Zwetsloot_Talent_Competition.pdf?VersionId=qedFwg9sJ5kx3bJw4u3kQL.6X5dj56et.

[3] International students accounted for 54 percent of STEM master's degrees and 44 percent of STEM PhDs at U.S. universities in 2017. The share of international students in postsecondary STEM degrees in the United States grew by 315 percent (from 27,470 to 114,092) from 1989 to 2017: Congressional Research Service, *Foreign STEM Students in the United States* (Washington, D.C.: CRS Report, November 1, 2019), https://crsreports.congress.gov/product/pdf/IF/IF11347.

[4] For example, a majority (more than 66 percent) of Forbes's list of the "most promising" U.S.-based AI startups had at least one immigrant founder. See Tina Huang, Zachary Arnold, and Remco Zwetsloot, "Most of America's 'Most Promising' AI Startups Have Immigrant Founders" (CSET, October 2020), https://doi.org/10.51593/20200065; Shai Bernstein, Rebecca Diamond, et al., "The Contribution of High-Skilled Immigrants to Innovation in the United States," Stanford Business School, Working Paper 3748 (December 2022), https://www.gsb.stanford.edu/faculty-research/working-papers/contribution-high-skilled-immigrants-innovation-united-states.

[5] For other reports that also examined America's "top researchers" using different methodologies, see Ishan Banerjee and Matt Sheahan, "America's Got AI Talent: US' Big Lead in AI Research Is Built on Importing Researchers" (Macro Polo, 2020), https://macropolo.org/americas-got-ai-talent-us-big-lead-in-ai-research-is-built-on-importing-researchers/?rp=m; See also J. F. Gagne, "Global AI Talent Report 2020" (jfgagne, accessed June 1, 2023), https://jfgagne.com/global-ai-talent-report-2020/.

[6] For more information on how we generated the merged corpus of scholarly literatures, see section 2.1 in Ilya Rahkvosky, Autumn Toney, et al., "AI Research Funding Portfolios and Extreme Growth," *Frontiers in Research Metrics and Analytics* 6 (2021): 11.

[7] For how CSET classifies AI papers, see James Dunham, Jennifer Melot, and Dewey Murdick, "Identifying the Development and Application of Artificial Intelligence in Scientific Text," arXiv preprint. arXiv:2002.07143 (2020). See also Margarita Konaev and James Dunham, "Russian AI Research 2010 to 2018" (CSET, October 2020), https://doi.org/10.51593/20200040; and Husanjot Chahal, Sara Abdulla,

Jonathan Murdick, and Ilya Rahkovsky, "Mapping India's AI Potential" (CSET, March 2021), https://doi.org/10.51593/20200096. Many CSET reports use the CSET merged scholarly corpus.

[8] H-index is the maximum number of publications with that same number of citations. For example, if a researcher has three publications with three or more citations, then that researcher has an h-index of 3. See "What's Your Impact? Calculating Your H-index," McGill University Health Centre, Accessed June 1, 2023, https://www.muhclibraries.ca/training-and-consulting/guides-and-tutorials/whats-your-impact-calculating-your-h-index/#:~:text=Your%20h%2Dindex%20is%20based,have%20N%20or%20more%20citations.%20for%20more%20details.

[9] Additionally, because highly cited industry papers may be cited tens of thousands of times, graduate students or researchers who contribute to early stages may earn authorship and inadvertently become "top-cited" authors, thus "leading researchers" even if they only author a handful of papers during a master's degree or otherwise work in research for a very short period. We found a handful of these cases in our data.

[10] See Stuart Macdonald, "The Gaming of Citation and Authorship in Academic Journals: A Warning from Medicine," *Social Science Information* 61, no. 4 (2023), 457–80, https://journals.sagepub.com/doi/abs/10.1177/05390184221142218?journalCode=ssic; See also Fengyuan Liu, Talal Rahwan, and Bedoor AlShebli, "Non-White Scientists Appear on Fewer Editorial Boards, Spend More Time under Review, and Receive Fewer Citations," *Proceedings of the National Academy of Sciences* 120, no. 13 (March 28, 2023), e2215324120, https://www.pnas.org/doi/10.1073/pnas.2215324120.

[11] Previous CSET work has used similar methods. See, for example, Zachary Arnold, Roxanne Heston, Remco Zwetsloot, and Tina Huang, "Immigration Policy and the U.S. AI Sector: A Preliminary Assessment" (CSET, September 2019), https://doi.org/10.51593/20190009.

[12] Previous CSET work found high correlation between foreign-born status and attendance at a foreign high school: Arnold, Heston, Zwetsloot, and Huang, "Immigration Policy and the U.S. AI Sector: A Preliminary Assessment."

[13] We did not find information indicating whether researchers were transgender or non-binary.

[14] Sergei Castella i Sape, "Must Read: The 100 Most Cited AI Papers in 2022," Zeta Alpha. March 2, 2023, https://www.zeta-alpha.com/post/must-read-the-100-most-cited-ai-papers-in-2022.

[15] Samuel F. Way, Allison C. Morgan, Daniel B. Larremore, and Aaron Clauset. "Productivity, Prominence, and the Effects of Academic Environment," *Proceedings of the National Academy of Sciences* 116, no. 22 (2019): 10729–10733, https://www.pnas.org/doi/abs/10.1073/pnas.1817431116.

[16] See Buddhika Nettasinghe, Nazanin Alipourfard, Vikram Krishnamurthy, and Kristina Lerman, "Emergence of Structural Inequalities in Scientific Citation Networks," arXiv preprint arXiv:2103.10944 (2021), https://arxiv.org/abs/2103.10944. Another study finds that female researchers were

disproportionately negatively affected in publishing during the COVID-19 pandemic: Molly M. King and Megan Frederickson, "The Pandemic Penalty: The Gendered Effects of COVID-19 on Scientific Productivity," *Socius* 7 (April 13, 2021), https://doi.org/10.1177/23780231211006977. According to Molly M. King, Carl T. Bergstrom, et al., approximately 10 percent of citations are self-referential, and between 1990 and 2011, men cited themselves 70 percent more often than women. Women were also less likely to cite themselves at all: "Men Set Their Own Cites High: Gender and Self-citation across Fields and over Time," *Socius* 3, 1–22 (2017), https://journals.sagepub.com/doi/pdf/10.1177/2378023117738903.

[17] For details on the unequal distribution of compute, see Nur Ahmed and Muntasir Wahed, "The De-Democratization of AI: Deep Learning and the Compute Divide in Artificial Intelligence Research," arXiv preprint, arXiv:2010.15581 (2020). The White House also cited this inequality as a national issue in U.S. universities: Lynne Parker. "Bridging the Resource Divide for Artificial Intelligence Research," The White House, Office of Science and Technology Policy, May 25, 2022, https://www.whitehouse.gov/ostp/news-updates/2022/05/25/bridging-the-resource-divide-for-artificial-intelligence-research/. Finally, CSET researchers recently cast doubt on the notion that computing capability is actually the limiting factor for AI research and related innovation: Micah Musser, Rebecca Gelles, et al., "'The Main Resource Is the Human'" (CSET, April 2023), https://cset.georgetown.edu/publication/the-main-resource-is-the-human/.

[18] Sam Zhang, K. Hunter Wapman, Daniel B. Larremore, and Aaron Clauset. "Labor Advantages Drive the Greater Productivity of Faculty at Elite Universities," *Science Advances* 8, no. 46 (2022), https://doi.org/10.1126/sciadv.abq7056.

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[21] National Science Foundation, "Survey of Earned Doctorates," Data Tables, Table 2-8, accessed June 16, 2023, https://ncses.nsf.gov/pubs/nsf23300/data-tables#group2.

[22] Paul Mozur and Cade Metz, "A U.S. Secret Weapon in AI: Chinese Talent," *The New York Times*, June 9, 2020, https://www.nytimes.com/2020/06/09/technology/china-ai-research-education.html.

[23] A 2020 economic analysis revealed that International Mathematical Olympiad champions from low-income countries were significantly less likely to go on to conduct major research than were their high-income counterparts. While a deep-dive analysis on the economic and geopolitical dynamics of international AI talent from low-income countries is beyond the scope of this paper on U.S. AI researchers, it is of note that the most productive researchers in the United States rarely emigrate from these low-income countries, other than India and select East Asian countries. See Ruchir Agarwal and Patrick Gaule, "Invisible Geniuses: Could the Knowledge Frontier Advance Faster?" *American Economic Review: Insights* 2, no. 4 (2020): 409–24, https://www.aeaweb.org/articles?id=10.1257/aeri.20190457.

[24] Our methodological choice to include only publications (and corresponding citations) from work published while authors were affiliated with U.S.-based institutions accounts in part for this potentially high figure. Had we included foreign-born or foreign-educated researchers who left the United States and went on to be equally or more productive at foreign institutions than the researchers in this analysis, the total may have been lower than 87 percent.

[25] We infer this from our data by observing the number of researchers who pursued at least an undergraduate degree abroad. Across the three lists, less than six researchers are listed as immigrants because they were born, but not educated abroad. The others had at least an undergraduate degree from another country.

[26] See Catherine Aiken, James Dunham and Remco Zwetsloot, "Immigration Pathway and Plan of AI Talent" (CSET, September 2020), https://cset.georgetown.edu/research/immigration-pathways-and-plans-of-ai-talent/.

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[29] Husanjot Chahal, Ngor Luong, Sara M. Abdulla, and Margarita Konaev, "Quad AI: Assessing AI-related Collaboration between the United States, Australia, India, and Japan" (CSET, May 2022), https://doi.org/10.51593/20210049.

[30] Chahal, Luong, Abdulla, and Konaev, "Quad AI: Assessing AI-related Collaboration between the United States, Australia, India, and Japan."

[31] Husanjot Chahal, Jennifer Melot, et al., "Country Activity Tracker (CAT): Artificial Intelligence" (CSET, Emerging Technology Observatory, updated January 31, 2023), https://cat.eto.tech/?countries=China+%28mainland%29.

[32] Giuseppe Scellato, Chiara Franzoni, and Paula Stephan, "Migrant Scientists and International Networks," *Research Policy* 44, no. 1 (2015): 108–20, https://www.sciencedirect.com/science/article/abs/pii/S0048733314001358.

[33] The immigrant foreign-born or foreign-educated collaboration rate for the top researchers listed by number of papers was 51 percent, for citations 50 percent, and for h-index 52 percent.

[34] The non-immigrant foreign-born or foreign-educated collaboration rate for the top researchers listed by number of papers was 32 percent, for citations 39 percent, and for h-index 38 percent.