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Where to Train: Shifts in the Doctoral Destination Advice Given to Asian Bioscience Students

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Abstract: Prospective Asian doctoral students in bioscience have significantly more local and regional training options today than in the past, and the destination advice their professors give them reflects this shift. Drawing from interviews with eighty-two Asian-born, Western-trained bioscientists in academia, now working in either Singapore, India, China, or Taiwan, we analyzed the doctoral training advice they give to promising science students in their current country to assess if these scientists encourage their students to look westward for their doctoral training. We found significant variation in the doctoral destination advice that interviewees give, with the modal category of destination advice being neutral rather than emphatically West-directed. We attribute this to a growing view among interviewees that the research environment in top Asian universities has improved to the point that, from a technical standpoint, it is increasingly on par with what is available in all but the top Western universities. These changes set the stage for greater variety in the migration streams of Asian scientists-in-training in the future.

Keywords: Doctoral Student Migration, High-Skilled Migration, Higher Education, Science and Technology Studies, Scientist Migration

Introduction

In 2007, China overtook the United States to become the largest producer of natural science and engineering doctorates in the world (see Table 1). The University of the Chinese Academy of Sciences reports having 146 doctoral programs with approximately 20,000 doctoral students enrolled as of 2017 (China Scholarship Council 2017). Meanwhile, the global rankings of Singapore's two oldest universities—the National University of Singapore (NUS) and Nanyang Technological University (NTU)—have been steadily rising. Several NUS departments in the sciences and engineering are now ranked in the top fifty in the world, and some are ranked the top department in Asia, according to the QS World University rankings by subject. The Indian government has also sunk substantial funds into establishing a string of research universities, the Indian Institutes of Science Education and Research (IISERs), around the country, similar to the renowned Indian Institutes of Technology, but this time focused on scientific education and research (NISTADS 2009). Taiwan and South Korea also grew their doctoral programs in the STEM fields during this period (National Science Foundation 2016; Cyranoski 2011). As a result of these changes, a prospective Asian-born doctoral student in science and engineering has significantly more local and regional training options today than s/he did in the past (Paul and Long 2016).

Asia's share of the world's research and development (R&D) investment is now also larger than that of the Americas and Europe, and it continues to grow (Grueber and Studt 2013). When combined with the increasing return of Western-trained Asian scientists (Paul and Long 2016; Jonkers and Tijssen 2008; Zhao 2002), this has led to an increase in the number of patents filed (Grueber and Studt 2013) and the number of scientific journal articles published by scientists in Asian countries (King 2004; Leydesdorff and Zhou 2005). These returning scientists serve as mentors to aspiring scientists working in their labs or taking their classes, and they can play a

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significant role in influencing the career/migration trajectories of these prospective scientists-in-training (Szelényi 2006).

Table 1: Total Natural Science and Engineering Doctorates Issued; by Country[1]

Country[2]	***Year***					***% Change from 1998 to 2012***
	1998	*2003*	*2008*	*2010*	*2012*	
USA	19,100	17,760	23,896	26,844[3]	23,160	+21%
China	5,562	11,034	26,165	29,039	30,017	+440%
Japan	6,155	6,830	6,701	6,460	6,081	-1.2%
South Korea	1,969	2,748	3,249	3,622	4,283	+118%
India	5,609	6,471	7,982[4]	NA	9,327[4]	+66%
Taiwan	727	951	1,732	2,210	2,174	+199%

Notes:
1. The above counts include the number of doctoral degrees issued in the physical and biological sciences, agricultural sciences, and engineering. The social and behavioral sciences, and mathematics and computer science are not included.
2. Data on Singapore is not available.
3. Data is from 2013 as data from 2010 was not available.
4. India data for 2008 is from the year 2006, the closest year for which data was available. India data for 2012 is from the year 2011, the closest year for which data was available.

Source: Adapted from National Science Foundation (2016).

Drawing from interviews Paul conducted with eighty-two Asian-born, Western-trained bioscientists in academia who have returned to work in either Singapore, India, China, or Taiwan, we analyze the migration/career advice they would give in the present day to a promising science student in their current country of residence. We do so to assess if these returned scientists would encourage Asian science students to look to the West for their doctoral training. This article thus operates at two levels. At the empirical level, it documents changes in the bioscience research sector in China, India, Singapore, and Taiwan that can have knock-on effects on the migration patterns of future cohorts of Asian scientists-in-training. At the theoretical level, this article adopts a Bourdieusian structural constructivist frame to highlight the socially-embedded subjectivities involved in the destination decision-making process among the highly-educated.

From our qualitative analysis of the interview transcripts, we conclude that objective improvements in the bioscience research and education infrastructure in Asia, and Asian scientists' subjective opinions about the current state and potential of Asian bioscience research, have together left the door open for more Asian scientists-in-training to be persuaded to stay in Asia for their doctoral training. There was a growing sense among interviewees that, since the turn of the twenty-first century, the research environment in Asia has markedly improved and that, from a technical standpoint, it is increasingly on par with what is available in the West. On a more practical front, these returned scientists need PhD students and postdoctoral fellows to staff their labs. This factor can also sway the advice these scientists give their students. The bifurcation of the training period for academic bioscientists into a doctoral training phase followed by a now-required postdoctoral fellowship phase also means that aspiring Asian scientists can now choose to go to the West for their postdoctoral, rather than doctoral, training. We argue that all of these changes set the stage for greater variation in the migration streams of Asian scientists-in-training in the coming decades.

Definitions of Terms

In this article, we focus on scientists in the biological sciences as several governments in Asia and elsewhere have dubbed the twenty-first century the "century of biology" (Biotechnology and Biological Sciences Research Council 2013; National Research Council 2009; Wong 2005) and have invested significant funds to boost their domestic bioscience research output. By focusing on

a sub-population of scientists rather than all STEM scientists, we are following Chompalov (2006) and Ackers' (2005) suggestion that, when studying high-skilled migration, it is helpful to break such flows down to smaller, more uniform groups. That said, the biological sciences encompasses a wide range of sub-disciplines including structural biology, biochemistry, evolutionary biology, biostatistics, and ecology, and we recognize that the pressures on the doctoral destination decision will vary across these sub-disciplines. Still, we can offer a more coherent analysis of the motivations behind migration flows than if we had considered the sciences or all academic disciplines together.

We define a "bioscientist" as anyone with a PhD in the biological sciences, who engages in academic research either in a university setting or a research institute and can serve as the principal investigator on a research grant application. Scientists in industry are not included in our analysis, as they experience different expectations about training and international exposure.

When we talk about "scientists-in-training," we are referring to doctoral students and postdoctoral fellows in the biological sciences. We do so, recognizing that within the biological sciences, a multi-year postdoctoral fellowship is now considered *de rigueur* before an individual can apply for an independent position as a faculty member or principal investigator in research universities and institutes. This was not the case in the 1970s when a postdoctoral fellowship was optional before starting one's research career. However, by the late 1990s, almost 80 percent of all PhD recipients in the biological sciences in the United States reported plans to seek out a postdoctoral fellowship.[2] Within the biological sciences, there were 6,866 postdoctoral appointees in the United States in 1979; by 2015, this had increased threefold to 21,600 (including those in neuroscience).[3]

Finally, an "Asian" scientist is one who is born anywhere in East, South, or Southeast Asia. We do not count the Middle East, Russia, or other eastern members of the Commonwealth of Independent States in this category. When we talk about "Western" training for these scientists, we are referring to training that occurred in the United States, Canada, or any of the countries in Western Europe.

Having outlined the various terms we use in this article, we now discuss the existing research on doctoral student migration.

Doctoral Student Migration

The migration of doctoral students in the sciences sits at the juncture of student and scientist migration. Like other international students, most international doctoral students enter their host countries on student visas and work towards a degree. For this reason, the international student migration literature is of relevance in understanding the factors that affect whether or not aspiring doctoral students choose to leave their home country or not (King and Raghuram 2013; Li and Bray 2007; Carlson 2013). At the same time, this literature tends to focus on students pursuing their first university degree. Doctoral students, however, are significantly older than most undergraduates; they are also less likely to be influenced by their parents' aspirations and preferences, and more by those of their peers and professors (Szelényi 2006). Many programs—especially in the United States and in the STEM fields—offer scholarships or research assistantships to incoming doctoral students, even international ones. As a result, financial concerns may be less of an issue with doctoral students than they are with other categories of international student. These differences need to be taken into account when trying to apply lessons from the literature on international student migration to doctoral student migration.

[2] Accessed May 20, 2017. https://wayback.archive-it.org/5902/20150819075634/http://www.nsf.gov/statistics/nsf06319/figures/fig06-11.

[3] Accessed May 20, 2017. http://ncsesdata.nsf.gov/gradpostdoc/2015/html/GSS2012 DST28.html

At the same time, doctoral students in the sciences are expected to become scientists eventually, whether in academia or industry. The literature on scientist brain drain and brain circulation encompasses the movements of these scientists-in-training because a student migrant is more likely to stay overseas as a permanent emigrant, compared to someone without any overseas educational experience (Li et al 1996; Hamilton, McNeely, and Perry 2012; Robertson 2006). While five-year stay rates for international doctoral students in science and engineering in the United States vary significantly by country, they can be as high as 85 percent (Finn 2014). Host country governments may also recruit these highly-skilled student migrants—through special visa mechanisms or scholarships—recognizing the disproportionately large, positive impact international students can have on their host country's scientific and technological trajectories and future economic growth (Milio et al. 2012; Kapur and McHale 2005). Thus the literature on scientist migration can also contribute to our understanding of the factors that influence the migration and destination decisions of doctoral students in the sciences.

The Literature on Student Migration

Various factors in the home and destination countries drive international student migration (Altbach 1998; Li and Bray 2007; Hung 2010; Mazzarol and Souter 2002). In the home country, a shortage of university seats, and university programs of questionable quality have been found to drive students and their parents to consider an overseas college education (Mazzarol and Souter 2002; Li et al. 1996). At the same time, worries about being apart from one's family and a lack of proficiency with foreign languages may make students reluctant to leave their home country. From the destination country point of view, universities with reputations as world-class institutions, located in global cities, can draw international students who are seeking a particular experience for that stage in their lives (Raghuram 2013; Robertson 2006). Strategically-minded students may seek an overseas degree if they believe it will improve their chances for social mobility upon their return home (Xiang and Shen 2009; Hung 2010; Zweig et al. 2004) or if they hope to emigrate permanently and having an overseas qualification will make it easier for them to secure an overseas job and long-term visa (Rosenzweig 2007; Mazzarol and Souter 2002; Li and Findlay 1996; Hamiton, McNeely, and Perry). Waters and Brooks (2010), however, push back slightly against the idea of the universal "strategic international student migrant," highlighting that the British students they interviewed had chosen to study overseas largely for lifestyle reasons, riding on their privileged position as middle-class, native-English-speaking students in a Western country. While such thinking might not apply to aspiring, Asian doctoral students, the authors' argument that not all migration decision-making follows a conscious, rational-choice type model is valid.

Other scholars call for greater attention to be paid to the socially embedded nature of the migration decisions of international students (Carlson 2013; Vertovec 2003; Szelényi 2006; Xiang and Shen 2009). Given their limited knowledge about various destination options, potential student migrants are sensitive to the advice of their peers and professors in their undergraduate/graduate universities in the home country. Szelényi (2006) finds that foreign doctoral students' undergraduate- and masters-level professors in their home country—in particular, the professors with foreign experience—played a significant role in encouraging and facilitating these international students' decision to pursue doctoral studies in the United States. Likewise, Hamiton, McNeely, and Perry (2012) point to the importance of overseas social networks of co-national professors and peers in the cumulative migration of international doctoral students from the same country and even the same undergraduate institution. Building on all of these authors' findings, we sought out the career and migration advice returning Asian scientists are giving their students, as these scientists' subjective impressions of the differences between Western and Asian doctoral education systems help shape their students' destination perceptions and preferences.

The Literature on Scientist Migration

Underlying most of the literature on scientist migration is the human capital theory of migration that sees it as an investment decision, with individuals moving to places where they believe they can enjoy the greatest return on their particular level of human capital (Sjaastad 1962). Differences in relative pay and working conditions between home and host countries, the role of migrant networks, life-course variations, the relative degree of autonomy and transparency available in the research institutions in each country, and the gender of the scientist, all influence scientists to permanently leave their home country (Ackers 2005; Williams, Baláz, and Wallace 2004; Mahroum 2002, 2000; Salt 1997). Female brain drain is 17 percent higher than male brain drain from developing countries (Docquier, Lowell, and Marfouk 2009), most likely because highly-skilled women find it difficult to advance their careers in more conservative/patriarchal societies and so seek to immigrate to more liberal societies.

Over the last twenty years, however, the emphasis in the scientist migration literature has shifted from talk of "brain drain" to notions of "brain circulation." A growing number of highly-skilled Asians in the West have begun returning to their home countries, bringing back with them their accumulated financial, cultural, social, and human capital to start transnational business ventures or research collaborations (Robertson 2006; Saxenian 2006, 2005; Zweig et al. 2004). Such circular migration flows are partly viewed as a strategic means of accumulating valuable human capital that can be leveraged to advance one's scientific career back home (Milio et al. 2012; Szelényi 2006; Baláz and Williams 2004). From a policy perspective, sending country governments may actively support this brain circulation as it allows for the costs of advanced scientific training to be borne by another, more developed, country (Rosenzweig 2007). Finally, as with consultants and business executives at multinational corporations, international mobility may increasingly be seen as a requirement for a scientist's career, as it encourages the accumulation of network ties with scientists in other countries and allows for the cross-pollination of ideas (Ackers 2005). With respect to prospective doctoral students, we wanted to determine if returning Asian scientists' destination advice was informed by a "brain circulation" model of migration, with these scientists imagining their students returning to Asia at the completion of their training.

Data and Methods

This article draws on data from an ongoing study of the migration and destination decision-making processes of Asian bioscientists. The primary research method involved in-depth, one-on-one interviews between the first author and Asian bioscientists who received doctoral and/or postdoctoral training in the United States, Canada, or Western Europe, and have since returned to Asia (though not necessarily their home country). Scientists were recruited from four countries: Singapore, Taiwan, China, and India. Whenever possible, scientists' spouses were also interviewed to learn more about the family decision-making process around the question of return. In several cases, spouses were also bioscientists, and they were included in the sample if they were also working in academia.

We identified potential interviewees by visiting the public websites of top bioscience research institutes and bioscience departments in highly-ranked research universities in the four country sites. These websites typically list all the faculty affiliated with the institution, along with their educational and employment histories. Scientists who possessed Asian-sounding names or had an undergraduate degree from an Asian university, followed by a PhD and/or a postdoctoral fellowship in a Western university, were sent an email that introduced the study, confirmed their eligibility, and asked if they would be willing to participate in a one-hour confidential interview. As a token of appreciation for taking part in the study, scientists were offered a US$50 Amazon.com voucher. More than 600 emails were sent out between December 2013 and June 2014, with some interviewees recruited separately through snowball sampling.

A total of eighty-two interviewees met the criteria for inclusion in this article: Born in Asia, received their PhD and/or postdoctoral training in the West, and now working as an academic

bioscientist in one of the four country sites. Table 2 provides some basic demographic statistics about the sample used for this article. Among these eighty-two scientists, 74 percent had completed their PhDs in a Western country with forty-eight of them having done so in the United States. All but eight had completed at least one postdoctoral fellowship, a phase in their careers that had lasted anywhere from one to six years, with the average being 4.5 years.

Table 2: Characteristics of Sample Population (N = 82)

	China (n = 13)	***India (n = 15)***	***Singapore (n = 32)***	***Taiwan (n = 22)***
	Percentage of Participants (%)			
Gender				
Male	92	67	78	59
Female	8	33	22	41
Migrant Type[1]				
Return Migrant	69	53	9	82
Multistate Migrant	-	13	75	5
Return+Multistate	31	33	16	14
Decade of Departure from Home Country				
1960s/1970s	-	-	9	5
1980s	23	-	13	27
1990s	46	53	47	23
2000s	31	47	31	45
Location of PhD				
Asia	31	27	31	14
West	69	73	69	86

Notes:

1. A return migrant is one who returns to his/her origin country after some years spent in one destination country. A multistate migrant is one who engages in at least two international migration journeys, living and working/studying in at least two countries other than his/her origin country. A return+multistate migrant is one who engages in multiple migration journeys but eventually returns to his/her origin country.

Source: Data from interviews conducted by first author.

Where possible, face-to-face interviews were conducted by the first author in the interviewee's office during site visits to Taiwan, China, India, and Singapore. When in-person interviews were not possible, Skype/phone interviews were scheduled. The interviews used a life-course approach, with interviewees asked to reflect on how they first came to like science as a subject, how they decided to become scientists, why they chose to leave for the West and their subsequent decision to return to Asia. They were asked about their experiences in the various countries they had lived in, and their destination advice to a hypothetical Asian student of theirs about doctoral and postdoctoral training options. Interviews were audio-recorded with participants' permission, the audio files were transcribed, and the transcripts coded using closed and open coding techniques. This article focuses on interviewees' responses to two questions from the interviews:

1. How did you decide to go to the West to seek scientific training?
2. What advice would you give a promising science student in your current country if s/he asked you where to pursue a PhD or postdoctoral fellowship?

These two questions were designed to document how the terrain for scientific training in Asia had changed over the last one to three decades, between the time when interviewees had made their personal doctoral destination decision, and the present day when they have to give doctoral destination advice to their students. Many scientists indicated that their students in Asia had asked them for career/migration advice and that their responses to this interview question were not mere hypotheticals. We independently coded interviewees' destination advice and sorted their advice into five categories: West, Leaning West, Neutral, Leaning East, and East.

In pursuing our questions, we were motivated by Bourdieu's notion of "structuralist constructivism" (Bourdieu and Wacquant 1992; Bourdieu 1989). Bourdieu recommended a first-round mapping of the objective structures, resource distributions, and external constraints that exist outside of individual actors within a social field, followed by an explication of the lived experience of these actors as they perceive, interpret, and interact with the broader structure of their field. Other scholars have already highlighted the positive and negative structural factors influencing scientist brain drain and brain circulation in Asia; see Cao (2008), Simon and Cao (2009), Vale and Dell (2009). We extend this literature by emphasizing the *subjective* interpretations of these structural factors by the social actors involved in shaping the doctoral destination decisions of different cohorts of Asian bioscientists.

Interviewees' Doctoral Destination Decision

Within our study sample, the scientist with the oldest doctoral degree was a former Malaysian who began his graduate studies in the West in the 1960s, while the most recent doctoral degree recipient was a Singaporean who began her doctoral studies in the United States in the mid-2000s. However, the vast majority of scientists interviewed had left Asia in the 1990s and early 2000s. Likewise, the earliest returnee was a Chinese scientist who had trained in northern Europe and then moved to Singapore in 1998, while the most recent returnee was an Indian scientist who had trained in the United States and then returned to India just six months before his interview in 2013. This broad range in the decade of departure and return to Asia allowed for comparisons across three decades in the evolution of doctoral programs in various Asian countries vis-à-vis the West.

For those interviewees who pursued their doctoral training in the West in the early 2000s and earlier, a variety of macro-level factors in both their home country and abroad made the decision to pursue doctoral studies overseas rather straightforward. The most critical of these factors was the lack of any doctoral programs in their home country in their areas of research interest. One Chinese bioscientist recalled that, in the early 1980s, when he had been thinking about graduate studies in biology after finishing his undergraduate degree at the top university in his province, he was faced with the dilemma of not finding any professors at the Chinese Academy of Sciences (CAS) to supervise him. "In the mid-80s, there were very few professors who actually can advise PhD students," he explained. And so, he looked to the United States.

Even at the governmental level, there was a recognition that scientific expertise in the biological sciences was concentrated in the West. Several Asian governments had established scholarship programs to send their citizens overseas for doctoral training with the proviso that these scientists-in-training would then return home, bringing their newly-acquired scientific expertise with them. The Chinese-US Biochemistry Examination and Application (or CUSBEA) was set up in 1982, following the re-establishment of diplomatic relations between China and the United States in 1979, to enable a select group of talented science students in China to pursue doctoral training in the United States on full scholarships. Between 1982 and 1989, 422 Chinese students travelled to the United States for doctoral studies in biochemistry or structural biology under the

auspices of CUSBEA (Chang 2009). Likewise, many Singaporean interviewees pursued their doctoral training overseas on scholarships from the Singaporean government.

It was not only education structures that encouraged Asian-born aspiring scientists to look Westward for their doctoral training. The immigration policy structures of Western countries like the United States made entering as a doctoral student both cheaper and easier to accomplish than other entry strategies. For degrees lower than a PhD, most international students would have had to pay their tuition fees out-of-pocket, while postdoctoral fellowship opportunities for overseas applicants were less common before the 2000s. Securing a faculty/principal investigator position with a non-Western PhD was also rare. As one Indian-born, US-educated researcher interviewed in Singapore explained, "This was one window of opportunity for me that would close if I did not avail of it. So this is my one chance." At the time, the PhD moment was the only one when funding and a student visa to the United States would be readily available to this interviewee, once he secured a place in a US-based doctoral program. Trying to gain access to the United States at other points in his career trajectory would not have been so straightforward. Applying for a tenure-track position in the West on solely Asian qualifications was unheard of, while applying for undergraduate programs in the West could be done but financial aid was rarely available.

For other students, the West was not their only option, but it was viewed as the best. Up until the 2000s, Western universities, especially American ones, represented the furthest reaches of technological and scientific innovation in most interviewees' minds. The oldest Chinese interviewee in the sample, who had been born in the 1950s, had trained as a medical doctor in mainland China before being accepted into a PhD program in Europe. He explained what China's scientific reawakening had felt like after Deng Xiaoping came to power in 1978 and how the West had appeared to Chinese students in his generation:

> In the '80s, China started opening the door to see the Western education. Then we start to know the journals like Lancet or the New England Journal of Medicine. Lancet, we will say, "This is the best of the best." […] And then, China just open[ed] in 1980 in that moment and then people they go out and say, "Wow! Outside, the medical science was so good, and then the equipment, knowledge, and everything."

Similar thoughts were going through the minds of aspiring bioscience students in other Asian countries in the 1980s and 1990s. An Indian neuroscientist who had completed her PhD in the United States and then pursued postdoctoral work in Europe explained why she had never considered joining a doctoral program in India:

> I knew I definitely wanted to do a PhD in neuroscience and I was interested in vertebrate neuroscience and there wasn't much in the '90s [in India]. This is 1992, 1991. I looked around the country and knew [India] was at that state that it made sense for me to go abroad to do my PhD because the kind of work I was interested in just wasn't available to me in the country.

Interviewees also revealed the critical role played by their social networks in shaping their career aspirations and destination decision-making. In the absence of concrete information about the relative merits of particular institutions, interviewees relied on hearsay and suggestions from peers and professors. These network contacts fostered a general culture of westward migration. As a female scientist in one of the premier bioscience research institutes in Bangalore, India, recalled: "I was told that I should go to the US to do a PhD," as soon as she finished her master's degree in 1992. None of her teachers suggested that she complete her doctoral studies in India and she had unquestioningly followed their advice, applying only to doctoral programs in the United States. Another bioscientist in Taiwan had pursued her PhD at Cambridge University in the United Kingdom. When asked why, she explained that she and her husband had applied to both Cambridge

and Oxford, the only universities they knew of in the United Kingdom. When both universities had offered them a place, they had to make a choice:

> At that time, we [didn't] know how to choose. Both [were] fine. Then my husband just ask[ed] his supervisor [in Taiwan]. His supervisor look[ed] at the brochure for these two schools and said, "This one. It looks more beautiful." That is Cambridge Department of Biochemistry. Just because of that thought, we went to Cambridge.

The Taiwanese supervisor who had suggested Cambridge over Oxford had no knowledge of the relative merits of the biochemistry programs in these two universities. However, the interviewee and her then-boyfriend had no information either, and so they followed their advisor's recommendation.

Interviewees' accounts also highlighted how an entrenched culture of migration to the West pervaded the top undergraduate science programs in each of the country sites. This culture of westward migration swept up aspiring scientists in Asian countries and discouraged them from considering any other possibilities for their doctoral education. One Korean scientist, who had completed his doctoral and postdoctoral training in the United States before returning to Asia, clarified why he had only applied to doctoral programs in the United States and nowhere else:

> It's kind of the preference from peers and people around me. Somehow, I was kind of thinking that the degree in the US is the best. […] I don't know how correct I am but that was my impression. So I just applied [in the] US.

A different researcher from India put it even more succinctly. "It's like a train," he said. "It's like you want to be on that train."

Interviewees' Doctoral Destination Advice

Moving to the present day, the interviews highlighted how the situation faced by ambitious science students in Asia in the 2010s is very different from what interviewees had faced when they were deciding to pursue a PhD. Interviewees did have ongoing complaints about the absence of an entrenched culture of scientific inquiry, the ongoing bureaucracies that plagued their places of work, or a lack of transparency when it came to granting funding in Asia, and this affected the advice they gave their best students about where to train (Paul 2017). There was also the acknowledgment that Asian science still lacked the prestige associated with research conducted in the West, independent of the value of the work (Paul 2017; Xiang and Shen 2009). Upon their return to Asia, many interviewees felt slightly cut-off from influential, Western-centric networks. However, they also recognised the generous funding opportunities now available in several high-income Asian countries.

While the highest proportion of interviewees still advised their students (either strongly or more moderately) that the West was the best place to go for a doctoral degree, a significant number gave more neutral doctoral destination advice (see Figure 1). These latter scientists argued that the decision about where to go for one's doctoral training should be dependent on the particular institutions/programs which accept the student, and that the top PhD-granting institutes in Asia were on par with all but the very best universities in the West. There were even a small handful of interviewees who went so far as to actively lean towards recommending their students stay in Asia for their PhD.

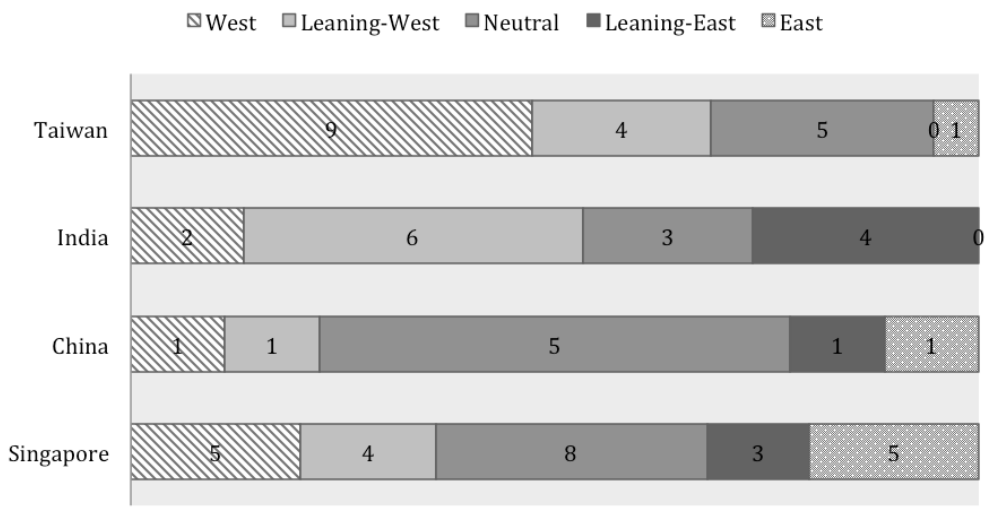

Figure 1: Distribution of Migration Advice for Doctoral Studies, by Country of Residence of Interviewee
Source: Data from interviews conducted by first author.

Westward Advice

For a quarter of interviewees, their doctoral advice was the same as what they had received when they were doctoral students: "Go West." One scientist in Taiwan was even more geographically specific, insisting that his students should train in the United States and nowhere else:

> Without a doubt, I would tell them that for [my field], they should go to the US. It's just simply the leading country right now for this field. […] No one comes close to addressing the sheer diversity of research topics that they're doing and the skill and also the depth of it.

Unlike this scientist, however, most other scientists who recommended doctoral training in the West provided justifications that did not emphasize the technical skills that doctoral students would gain there, but rather the cultural and social capital their students could acquire only in the West. There was a sense that the top research universities in countries like India and China, and specifically the top labs in these universities could provide as much technical rigor as what was available at all but the top universities in the West. Instead, it was the general attitude towards scientific inquiry and a peer culture passionate about research that interviewees thought their students could only find in the West. A US-trained Indian geneticist in Singapore argued that "the kind of intellectual curiosity that exists [and] the way they ask questions" in the West made all the difference.

Other scientists' arguments emphasized the principle that brain circulation is a necessary component of a scientist's career trajectory, especially one in Asia, and that this was why some exposure to the West—through years spent training there—would be helpful. An evolutionary biologist in India who had completed her PhD and a postdoctoral fellowship in the United States before returning to a top research institute in Bangalore had this to say:

> I've told all of these people that for the kind of work you want to do, India is getting to be a better and better place, so I don't think you would be at any major disadvantage if you were working here, especially if you were in a good lab where your supervisor is known to people in general, so that you don't hamper your chances of landing a good postdoc or any good job afterwards because you're in India and not outside. […] And so, you don't really lose anything by being here, by being in a lab here. But yeah, I would

> still encourage them to have some exposure. […] I think it's good for them. Sometimes, it's good for them because they have already become the smartest kid in their lab or in their environment and that's not good for them. It's good for you to sort of move around a little bit and say, there's smarter fish out there that you should at least interact with at some point.

Other interviewees raised reasons that had less to do with questions of skills or know-how, and more to do with the symbolic capital associated with a Western degree. A Singaporean scientist who had completed his doctoral and postdoctoral training in the United States before securing a tenure-track position in Taiwan insisted that doctoral training in Asia would stunt one's career:

> I've seen too many people being shortchanged because they did their PhD here [in Taiwan]. Typically a university would not hire someone who graduated from their own system. […] Someone comes to us having graduated from National Taiwan University and someone comes to us having—in terms of a PhD—having graduated from Illinois or, okay, Harvard or Berkeley. You don't think [about which to hire]. You don't have to think! [...] So that's why, for that reason—it's utilitarian, but I wouldn't encourage the student to do a PhD here.

Another scientist in Taiwan pointed to the importance of linguistic capital, explaining that since English was still the *lingua franca* of the scientific world, she encouraged her students to go to the West:

> You have to be able to write in English. You have to communicate in writing or orally, and here, we cannot just provide you the right stimulus and environment for you to do that. So you have to go to that kind of place. If now, if the science language is Chinese, then I will not say so.

Neutral Advice

While a quarter of interviewees were adamant in their westward destination advice, a greater proportion of interviewees were more neutral in their responses. As an indication of the advances that have occurred in Asian science, especially since the mid-2000s, several interviewees said that, in determining the appropriate destination advice to give, they would weigh the merits of the specific universities their students were accepted into, rather than make sweeping comparisons at the country level. One Indian bioscientist, who had pursued his PhD in a very-high-research-activity public university in the United States, then been awarded a postdoctoral fellowship at an Ivy League university, and then received a generous grant to establish his laboratory in a leading bioscience research institute in India, explained:

> Now if you still get admitted to a good university abroad, I would say that's good mainly because the community there is still quite big. So, as a scientist, I think you would grow faster mainly because you get exposed to a lot more things than you get in India. But again, if you're in the Indian Institute of Science or the National Centre for Biological Sciences […], I would say if you're in one of these two institutions in India, then you would probably have a much broader perspective on your field, mainly because we get so many visitors here. It's crazy how many foreign visitors we have, how many workshops are run, and what kind of people we're able to attract here for these workshops and seminars.

Along these lines, another Indian scientist said that he advises his students to first try to gain admittance into one of the top science institutes in India for their PhD, and only "if you don't get into the very good institute, then try abroad."

Like the above Indian scientist, we recognize that significant variation exists in the quality of doctoral training provided by universities in each of our four Asian country sites. By only recruiting from the top research institutes in each country, we ended up with a skewed sample of the best-resourced bioscientists in each location. Still, their opinions are instructive because they highlight just how good the very best science training in Asia can be. Along these lines, a plant biologist who finished his PhD in India in the early 2000s and then went on to complete two successive postdoctoral fellowships in top laboratories in the United Kingdom and Europe spoke of how comprehensive his Indian training had been:

> I would always say, even when I was in Cambridge, that my PhD in [India] was better than any PhD in Cambridge. […] When I came out after my PhD, I was probably as good as any trained postdoc. Not just in the lab work, but also in any administrative work. [As a result, during my postdoctoral fellowship in Cambridge] I could write grants for my boss; I could go and present his grant when there is a meeting; take care of guests; train a lot of people. Even as a PhD student in India, I already was taking care of other PhD students. That was the norm in our lab. And because there are no postdocs in India—because those who did PhD [in India], they all went aboard to do postdoc—so the senior-most PhDs, they take care of the junior PhDs. And all that is really like a complete training.

We note that, in this scientist's case, he completed his doctoral studies in 2005, when research conditions in top institutes in India were already rapidly improving. Likewise, another plant biologist who had completed both his PhD and his first postdoctoral fellowship in China in the 2000s before spending six years in the United States on two additional fellowships, argued that the best science education in China was as good as what was available in the United States: "I sometimes talk to my students and say, 'You should do a PhD here in China because, for the scientific level, now we are good. […] We can do better than them, especially most of the US labs." This scientist insisted that it was better for Chinese scientists-in-training to complete their PhD in a place like CAS because of the rigor of the scientific training and the resources available to them at the Chinese Academy.

Eastward Advice

A handful of interviewees insisted that Asia was the best place to pursue a doctoral degree regardless of institution. Their arguments encompassed not only the quality of the training but also some very pragmatic reasons to stay at home. In China, these interviewees insisted that aspiring scientists who want to return should spend their doctoral training years in a top research university/institute in China to build ties with Chinese academicians who could help them in their *China-based* scientific careers. Interviewees argued that a patronage-based and *guanxi*-driven culture continued to exist in China's scientific circles, especially when it came to the awarding of grant monies, and so it was prudent for young scientists to build relationships with senior Chinese scientists. Once equipped with a doctoral degree from China, these scientists-in-training could then apply for postdoctoral positions in the West so as to also build their Western networks.

Completing their doctoral training in their home country also meant that these students could avoid studying for and taking the English language tests and other examinations that are often required when applying for PhD programs in the West. For students from non-English-speaking countries such as China and Taiwan, this could be seen as a huge boon, especially since such tests are not required when applying for postdoctoral positions. Waiting until the postdoctoral phase of

their training to go to the West could thus enable these individuals to circumvent some of the more irksome barriers of entry to the West.

Several Asian scientists in Singapore also pushed doctoral programs in Asia (and specifically Singapore) as being on par with Western doctoral programs. These scientists—several of whom were not Singaporean themselves but had chosen to relocate to Singapore because of the promise of pursuing cutting-edge research in Asia—wanted the best students they could find to staff their labs. They were actively trying to convince their best students to stay in Singapore as this directly affected their research productivity. As one Indian bioscientist who had worked in the United States before relocating to Nanyang Technological University (NTU) in Singapore said:

> We have gone out of our way in NTU. At least I have. When I get these students to finally do a project with me, I am discouraging them to leave Singapore. [I want them to] stay back and continue their PhD here so that, you know, the government vision will at least in some place succeed.

Discussion and Conclusion

The varying doctoral advice described above highlights the dynamic changes underway in Asian bioscience. Structural factors that had encouraged the Westward migration flows of Asian doctoral students in the past are starting to shift or have already shifted. In conjunction with these changes, Asian scientists' subjective opinions about the quality of Asian doctoral training are also in the process of shifting. For instance, even as they advised their students to pursue doctoral studies in the West, several interviewees admitted how torn they were. Having returned to Asia with ambitious plans of furthering their research agenda with labs staffed by top-quality doctoral students and postdoctoral fellows, these scientists were hard-pressed to let their best and brightest students decamp for the West. Some interviewees insisted that they encouraged their students to seek Western doctoral training even though it hurt their research output. A US-trained scientist in Taiwan recalled how difficult it was for her to advise her graduate students to apply to the West:

> I tell that to my own graduate students—they're master students and they want to do a PhD: "It's really selfish if I tell you to stay here and do a PhD. […] I don't want to lose you; you're so good at this and I have to train a new person all over again. It's too tiring." But I know that if they stay here, it's really not good [for them].

While admitting that they had slightly selfish reasons for wanting their master's students to stay with them for another four years or so, other interviewees argued that their students would not regret the decision to stay put. A plant biologist in Beijing who had completed his PhD in CAS before going to the United States for a postdoctoral fellowship explained his thinking in this manner:

> For me, if I trained a student and they left, that would be a big loss for me. Because I trained them as a master's student, they are well-trained, so they can do probably better than the other PhD students because I trust them. I trained them myself. But if they leave, that's a big loss for me, that's one thing. But for them, I will say they should do PhD here because I think we can do maybe exactly same as they do in the US or in Europe. And even, we can do much better than them. […] We have the good training, we know how to do science, and I believe even now our students can do much better than US students.

The above contrasting accounts highlight how individual biases and preferences can creep into the advice or information that an aspiring scientist's professors provide. Given the influential role played by professors in the decision-making process for aspiring scientists, we need to take into account these subjectivities when we study doctoral student migration streams. As more Asian-born, Western-trained scientists return to Asia to start (or continue) their research careers, their need for high-quality doctoral students and postdoctoral fellows to staff their labs will only grow and this will inevitably put pressure on future doctoral migration flows to and from Asia.

In deciding where to locate themselves for their doctoral training, Asian bioscience students have an increasing number of local (and regional) alternatives to consider, in addition to the Western options that have existed for the last fifty plus years. Rather than focusing only on changes in the push-and-pull factors that influence this doctoral destination decision, we look at the socially-embedded subjectivities that drive the advice aspiring doctoral students receive from their advisors and mentors in their home country. In particular, we focused on the doctoral destination advice returned Asian scientists give their most promising students. These scientists serve as mentors and role models to future cohorts of Asian researchers, and so the advice they give can have a significant effect. From the interviews, we found a discernible shift in how Asian scientists view the state of bioscience education and research in Taiwan, India, China, and Singapore. Interviewees espoused greater confidence about the rigor of the training and the breadth of the exposure available at the top research universities and institutes in Asia. These improvements have not resulted in a complete redirection in Asian-based bioscientists' advice to their aspiring student-scientists. But they have opened the door for more diverse patterns of doctoral student migration, rather than the more straightforward westward flows prevalent in the twentieth century. An aspiring scientist in Asia can now choose to complete their doctoral training at home, in another Asian country, or in the West.

A critical structural factor contributing to this dynamism in migration flows is the bifurcation of the training process for bioscientists so that it now encompasses a doctoral training period followed by a significant postdoctoral training period. While interviewees were divided on the best place to pursue a doctoral degree, they were united in their advice that the West was the place to go for one's postdoctoral training (Paul 2017). The consensus was that, while Asian doctoral programs had improved significantly over the last few decades, postdoctoral training programs were still weak regarding their remuneration and support structures. Some interviewees explained that they were more willing to recommend their students stay in Asia for doctoral training precisely because they knew their students could still acquire Western training and exposure later on during their postdoctoral training period.

Reflecting on our findings, we recognize that we have made broad generalizations about the relative standing of Asian scientific research and training infrastructures as a whole. Doing so masks significant intra-Asian differences. The varying demographic, economic, and scientific profiles of each of our four country sites influence the career and migration aspirations of scientists-in-training in each country, and the advice they receive from scientist-mentors. Interviewees in Taiwan were much more insistent that aspiring scientists should pursue doctoral training in the West. This advice could stem from the fact that Taiwan's bioscience sector is still relatively nascent, its economy has stagnated in recent years, and it has a long-standing tradition of sending most of its young to the United States for a graduate education (Wong 2005; Chang 1992). In contrast, Chinese interviewees expressed robust confidence about how China's research output has exploded in recent decades. This likely fed into the lower rate of westward-leaning advice they gave their students. In the case of India, there are still only a small handful of well-respected research universities/institutes in the biosciences and interviewees recognized that these were oases in a sea of ongoing bureaucratic dysfunction. The IISERs were too new to assess. As such, Indian interviewees were optimistic about their research prospects in India, but half still recommended the West to their students. Singapore, meanwhile, is seeking to establish its reputation as a world-class research hub and this has involved seeking not just Singaporean scientists but also researchers from the region to choose the island nation as their base. Within our Singapore sample, we had

scientists of Chinese, Indian, Korean, and Malaysian origin (in addition to several Chinese Americans). The non-Singaporean Asian scientists we interviewed in Singapore indicated that they largely saw Singapore as more "Western" than their home countries in its approach to research. This may have encouraged several of them to recommend that Asian students consider staying on in Asia (but, in Singapore, rather than their country of birth).

Having conducted these interviews with returned Asian scientists, another round of research must be undertaken with current undergraduate and masters students in Asia to better understand the doctoral destination-making process from the perspective of these student migrants themselves. We need to assess the destination option set aspiring doctoral students are considering, their evolving destination preferences for doctoral training, and the extent of the influence returned scientists have on their students' destination decisions. These are all productive avenues for further research in this area as we predict increasing dynamism and diversity in Asian scientist migration flows in the coming years.

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