The Effects of the Foreign Fulbright Program on Knowledge Creation in Science and Engineering

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Abstract: This paper examines the impact of the Foreign Fulbright Program -- which requires foreign students funded by the program to leave the US after completing their studies -- on the production of research in science and engineering. It does this by tracking the post-Ph.D. careers of 244 Fulbright scientists and 244 otherwise similar control scientists. We find that, on average, the Fulbright program encourages more international mobility of US-trained Ph.D. scientists. Scientists trained in the US through the Fulbright program spend more than twice as many of their post-graduation years outside the US when compared to controls. The effect is particularly large for students from countries with low GDP per capita or less well-developed science bases. Fulbrights from poorer or weak-science home countries also have lower numbers of some kinds of publications and less impact on global knowledge, while Fulbrights from richer/high-science countries with strong science bases have publication and citation records similar to comparable Ph.D.s of foreign origin without return requirements. Fulbrights from rich or high-science countries produce substantially more articles listing home country authors while Fulbrights from poorer or weaker science countries produce substantially fewer articles listing U.S.authors. Finally, for the poorer countries, the Fulbright program does appear to increase US-home country collaborations, an explicit goal of the Fulbright program.

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I. Introduction

The science and engineering workforce is becoming increasingly global. The share of S&E doctoral degrees produced outside the U.S. has grown in recent years (NSF *Science and Engineering Indicators* 2010), and some countries have increased their efforts to attract star scientists.[1] International migration of the highly skilled has become a hotly debated topic, with some experts pointing to "brain drain" (whereby the most talented citizens of a lower-income country are lured away by opportunities in countries like the United States) and others highlighting "brain circulation" (whereby individuals trained in the U.S. disseminate knowledge back to their home countries).[2] Many countries with relatively low levels of scientific activity subsidize the costs of doctoral education for their citizens in countries with cutting-edge research environments. Historically these investments have had limited success in the sense that many PhDs have not returned to their home countries. Some governments counter this tendency by requiring funded students to return home post-PhD. Alternatively, students may be encouraged to study under the US Fulbright Program which also requires students return home post-PhD.

The Fulbright Foreign Student Program,[3] established in 1946 and primarily sponsored by the U.S. Department of State, is the main U.S. government program that brings students from other countries to pursue graduate study in the United States. Since its inception, it has given scholarships to more than 125,000 foreign students to do graduate work in the U.S. The total budget of the Fulbright program was $374.4 million in fiscal year 2008.[4] The Department of State touts the Fulbright program as "our country's premier vehicle for intellectual engagement with the rest of the world." Students who receive a Fulbright Scholarship for study in the U.S. come on a J-1 student visa that requires them by law to leave the U.S. when they finish their education and to spend at least two years in their home country before they can return to live in the U.S.

Despite the long history and purported importance of this program, we could find no formal evaluation of this program done before 2005. In 2005, SRI was commissioned by the

[1] The Canada Research Chairs program and the Australian Research Council's Federation Fellowships offer incentives to attract researchers to these countries.
[2] See Saxenian (2002)
[3] Also called the Fulbright Visiting Students Program.
[4] Foreign governments contributed $74.2 million to this total, and private sources (both domestic and overseas) provided $65.9 million. The number of grants to foreign students studying in the US was approximately twice the number of grants to US students studying overseas.

Department of State to survey a group of Fulbright foreign student graduates and evaluate whether receipt of Fulbright funding had indeed fostered international understanding (SRI 2005). They did not evaluate the impact of these foreign Fulbright scholars on their home countries' intellectual environment or on their contribution to global knowledge.

More generally, little is known about whether any U.S. graduate study sponsorship requiring foreign students to return to their home countries – be it through the Fulbright Foreign Student Program or through foreign governments' programs -- has been successful in improving foreign countries' research capabilities. While the program may benefit home countries by increasing return flows of highly skilled human capital, these students may have fewer opportunities to do cutting-edge work because they are required to return to countries which have less funding for research and relatively inadequate scientific infrastructure. This may lower global knowledge creation compared to a situation without these return requirements.

Given the evidence on the importance of foreign-born scientists for research in science (Levin and Stephan, 1999 and Stephan and Levin, 2001), as well as the United States' substantial financial commitment to the Foreign Fulbright Program, it seems reasonable to ask what impact the program has on the production of scientific knowledge in the US itself. While the main objectives of the program are the furtherance of mutual understanding and foreign policy-related goals, we can also test the hypothesis that students supported by the Fulbright program and therefore required to leave the US contribute less to US-based research than otherwise similar foreign students.

Alternatively, research on knowledge flows across space has shown that connections between researchers are surprisingly persistent (Agrawal et al., 2006). With growth in the potential for brain circulation and international collaboration due to faster and cheaper international communication and travel, scientists returning to home countries may find it easy to continue to access knowledge produced in the US and at top research institutions globally. By creating links between home countries and other countries, the Fulbright program may increase rates of international collaboration and knowledge diffusion.

One of the reasons that so little empirical attention has been given to this topic is that little data is available on what happens to foreign graduate students once they leave the U.S. This paper begins to fill this void, concentrating on foreign Fulbright Ph.D. students in science and engineering (S&E). We have collected a data set that tracks the career progression of 488

Ph.D. scientists of foreign origin trained at U.S. universities. Half of the scientists in our sample received fellowship funding from the Fulbright Foreign Student program, the other half were chosen to resemble the Fulbrights as closely as possible along observable dimensions. Our data set is unique in being the only data set of which we are aware that tracks the career progression of individual U.S.-trained Ph.D. scientists, whether they leave the U.S. or not.[5] We supplement our data with descriptive statistics on the Fulbrights from the SRI (2005) study and other Fulbright Program materials and with information from PhD S&E graduates from the NSF's Survey of Earned Doctorates.

These data allow us to address the following questions:

1. Has the Fulbright program itself attracted a different foreign student body than foreign students without this funding? Has it, for instance, made it more likely for foreign students to receive U.S. PhD's in some S&E fields or from some countries, compared to those foreigners studying in the U.S. without Fulbrights?
2. Do the return requirements of the Fulbright promote mobility of US-trained Ph.D. scientists to foreign countries?
3. Do foreign S&E Fulbright students create less or more knowledge and have less or more impact on their fields compared to other foreign students?
4. In what ways do Fulbright students contribute to their home countries' scientific environment and the US scientific environment compared to comparable foreign students?

To preview our findings, we find that the distribution of Fulbright students across countries of origin is substantially different from the distribution of other graduate students. We find that the Fulbright program does encourage more mobility of US-trained Ph.D. scientists to home countries. In terms of knowledge creation and diffusion, we find that Fulbrights from richer countries and countries with strong science bases have publication and citation records similar to comparable Ph.D.s of foreign origin without return requirements, while Fulbrights from poorer or weaker science countries have less impact on global science and are less likely to run labs (as indicated by status as last author on a publication). However, the most profound effect might be on the location of article production. Fulbrights from rich or high-science countries produce substantially more articles listing home country authors while Fulbrights from poorer or weaker

[5] One can obtain information on foreign-born scientists who remain in the U.S. from the NSF's SESTAT database. Also, Michael G. Finn's (2007) research provides valuable information on the stay rates of Ph.D.s. of foreign origin.

science countries produce substantially fewer articles listing U.S. authors. Nevertheless, for these poorer countries, the Fulbright program did seem to have achieved its goal of increasing US-home country links by increasing collaboration between these countries.

Before presenting these results in detail, we give some background on the Fulbright Foreign Student Program itself.

II. Background on the Fulbright Foreign Student Program

The Fulbright Program was established by Congress in 1946 to "enable the government of the United States to increase mutual understanding between the people of the United States and the people of other countries." The Fulbright Program includes not only the Foreign Student Program, but also a U.S. Student Program that awards scholarships to U.S. citizens for study in foreign countries and a Scholars Program that sends scholars and professionals to research and lecture in other countries, both U.S. citizens abroad and foreign citizens to the U.S. It is funded primarily by annual appropriations of the U.S. Department of State and the Department of Education but also receives additional support from universities, foreign governments, foundations and corporations, with some of this support in kind – including tuition waivers, housing and stipends from some universities. The annual budget of the entire Fulbright program was over $374 million in FY2008/2009.

The Fulbright Foreign Student Program is the primary international exchange program for graduate students in the U.S. Since its inception through 2009, the Foreign Student Program has brought more than 128,146 students to U.S. graduate programs. In the last Annual Report available (2008/2009), there were 3,193 foreign students receiving Fulbright support to study in the U.S. This is a small number compared to the 283,329 international students who were enrolled in graduate programs in 08/09 (IIE 2009).[6] Fulbright-supported students were, however, the vast majority of international students sponsored by the U.S. government.

Not all of the students on Fulbrights are in doctoral programs. In fact, according to the SRI (2005) evaluation of a sample of those who received Fulbrights between 1980 and 2000, only 36% reported receiving a doctoral candidate grant, although 42% said that they produced a doctoral thesis as a result of the Fulbright program as of the SRI 2004 survey. More than 48% *had* a Ph.D by then.

[6] IIE's Open Doors Report on International Students in the U.S. 2009 (http://www.iie.org/en/Research-and-Publications/Open-Doors/Open-Doors-Data-Tables/2009/International-Students).

The IIE (Institute of International Education) administers the program for Fulbrights from most areas. Two organizations share responsibility with IIE for the Fulbright Foreign Student Program for the Americas and the Middle East/Northern Africa respectively.[7]

Foreign Fulbright students came from 139 different countries in academic year 2008/9. Since the Fulbright program's inception, students have come from 178 different countries. Only 31% of the Fulbright foreign students in recent decades studied natural sciences or engineering (excluding social science). (SRI 2005) Because we are primarily interested in the creation and diffusion of scientific knowledge, the sample that we took were limited to this 31%.[8]

Fulbright recipients are required to leave the US after completing their doctorates, since the program is intended to promote understanding of the US abroad. It is possible to apply for a waiver of the foreign residency requirement if a student falls into one of several very restrictive and quite rare categories.[9] Also, Fulbright recipients may delay their departure for a period for educational purposes e.g. for two years of a post-doc and/or for up to three years of "occupational or practical training" (OPT) on-the-job immediately following the completion of their studies.[10] Thus, in principle, a Foreign Fulbright recipient could remain in the U.S. for up to 5 years following the receipt of Ph.D. before having to leave the country. Moreover, after they spend two years their home country, the Fulbright-subsidized Ph.D. can apply for a work visa and return to the U.S. The two years in their home countries need not even be 730 consecutive

[7] America-Mideast Educational and Training Services, Inc. (AMIDEAST) administers the Program for most students applying from the Middle East and North Africa. Latin American Academic and Professional Programs (LASPAU) shares responsibility with IIE for the Fulbright Foreign Student Program for the Americas.

[8] In recent years, the Fulbright program has increased funding for science and engineering students through the International Fulbright Science and Technology Award. However, because this scholarship was introduced at the end of our sample period, we do not have any Ph.D. recipients in our sample from this program.

[9] The first route is for the student to ask his country of origin to file a "no-objection" statement. While this approach may work for students whose J-1 status arose from scholarship funding from a foreign government, it is almost never considered grounds for waiving the foreign residence for Fulbrights whose funding comes from the U.S. government. (Conversation with BU ISSO January 2008) Waivers may also be obtained if an "Interested Government Agency (IGA)" files a request on behalf of the student, stating that the departure of the student will be detrimental to its interest and that of the public. Our conversations with experts suggest that these waivers are obtained only in rare and special circumstances. Medical doctors may also obtain a waiver if they agree to practice in a region of the U.S. with a shortage of health care professionals. A third reason for a waiver of the foreign-residency requirement is the threat of persecution, in which "an exchange visitor believes that he or she will be persecuted based on his/her race, religion, or political opinion if he/she were to return to his/her home country." Finally, applications for waivers may be filed on the basis of "Exceptional hardship to a United States citizen (or legal permanent resident) spouse or child of an exchange visitor." The State department warns "Please note that mere separation from family is not considered to be sufficient to establish exceptional hardship." http://travel.state.gov/visa/temp/info/info_1288.html (accessed February 17, 2008). Finally, years working for international organizations such as the UN or World Bank are considered equivalent to returning home. This loophole affects economists and others in policy-relevant fields more than the natural scientists in our study.

[10] OPT status allows students to work in their field of study for the purposes of obtaining on-the-job training.

days, but could be a combination of summers and/or semester-long visits abroad while spending the rest of the time in a U.S. post-doc or in OPT.

Nevertheless, the enforcement of these rules is sufficiently stringent that almost all foreign Fulbright Ph.D. recipients left the U.S. for some period of post-Ph.D. We discuss this in section V below.

In the next section, we describe Fulbrights scholarships are allocated across fields, countries and universities and how Fulbright recipients are selected.

III. Has the Fulbright program itself attracted a different foreign student body than foreign students without this funding?

Fulbrights are not a random sample of all foreign students studying in the U.S. The distribution of Fulbrights across countries of origin, across U.S. universities and across fields is not necessarily the same as the distribution of all foreign graduate students in the U.S. In this subsection, we explain the source of these differences.

Countries: Foreign students apply for Fulbright Fellowships through the Fulbright Commission/Foundation or U.S. Embassy in their home countries. If there is no Fulbright organization in the home country, students apply through the U.S. Embassy. Fifty one countries presently have Fulbright Commissions. Materials on the Fulbright website assure applicants that, "Grantees are selected through an open, merit-based competition."

Fulbright Commissions in home countries are funded jointly by the U.S. and partner governments and include half resident Americans and half home country citizens. The commissions plan and implement educational exchanges (both foreigners to the US and Americans to their country, both students and scholars) and recruit and nominate candidates for fellowships as well as do other functions such as fundraising, engaging alumni, supporting American Fulbrights in their countries etc. The U.S. based Fulbright Foreign Scholarship Board (FSB) has input into the process and has final responsibility for the approval of selected candidates. In countries with no Fulbright Commission, the U.S. Embassies and FSB play a greater role in selection.

While we do not have information on the precise kinds of considerations the commissions, embassies or the FSB presently or in the past have taken into account in their choices among candidates, we can infer some from the facts. The most recent Fulbright Annual

Report reported the number of Fulbright scholars from each country for the most recent year (AY2008/9) and over the entire 63 years since its inception. These numbers and their comparisons indicate some clear priorities. First, there is wide variation in the number from each country, ranging from 1 (from Equatorial Guinea and others) to 21,819 from Germany over the entire 63 year period.[11] The variation is clearly not random. Germany was a full 17% of the total number of students over the 63 years, but only 8% in AY2008/9, and other countries in Europe also saw their proportion of the total fall proportionately: while Europe overall sent 60% of the foreign Fulbright students from 1946-2009, by the end of that period it was sending half of that percentage.

Why so many from some countries and not from others? First, it is clear that the changing patterns by country over time reflect political relationships between the US and the sending country. Post-WWII, US foreign policy was heavily concentrated on rebuilding Europe and strengthening ties with Western European countries. Hence, while recently Fulbrights from Europe were 30% of the total, over the entire 62 years (including the post WWII years), they were 60%. Soviet bloc countries did not send Fulbrights during the entire USSR period at all. Africa has become more important over time so that in the most recent year 7.6% of Fulbright foreign students came from Africa while the 62 year average was only 4.5%. The same time trend was true of the Middle East. South America, Chile and Brazil both had notable growth percentage-wise.

Second, the U.S. and foreign governments share the cost of the program to varying degrees, and countries willing to put considerable resources into funding Fulbright students send more students. In 1990, Germany contributed 71.4% of the budget of the German bi-national commission, while Japan contributed 62% of the budget for its program. Most other higher-income countries appear to have contributed in the range of 40-50% of the budget for their country.[12] Poorer countries contribute far smaller shares of the budget, generally less than 10%.[13] Interestingly, Pakistan has recently become the single largest Fulbright program, thanks to a $90 million initiative funded by the U.S. Agency for International Development (USAID) and the

[11] The second largest was France at 6469.
[12] The UK contributes 40%, France 39%, South Korea 39%, the Netherlands 55%, etc.
[13] Pakistan contributed approximately 1% of the budget in 1990, Colombia 2%, Egypt 1.6%. (Annual Report of the Foreign Scholarship Board (FSB), 1990.)

Pakistani Higher Education Commission that began in 2005.[14] A similar initiative was recently launched to increase Fulbright funding for science and engineering students from Indonesia. These initiatives, reflective of current U.S. foreign policy goals, illustrate the extent to which the geographic emphasis of the Fulbright program can vary over time.

We also find evidence that countries with commissions send more Fulbright students than countries without commissions. Two thirds (66%-71%) of Fulbright foreign students were from countries with Fulbright commissions, yet those countries with commissions held only 16% of the population of all countries that had ever sent Fulbrights.[15] Of course, those countries with commissions will tend to have closer political ties to the US as well so it is difficult to separate the contributions of commissions. Nevertheless, the existence of an ongoing body committed to maintaining Fulbright exchanges is bound to increase those exchanges. In addition, commissions help raise funds from non-governmental sources to support grants.

Even in countries without commissions, there is a great deal of historicity in the patterns of foreign Fulbright students by country. One reason may be that some individual professors and universities are particularly enthusiastic about the Fulbright program and are likely to encourage students to apply. In the SRI (2005) survey, a full 60% said that they had received encouragement from their home university or professors to apply for a Fulbright scholarship.

Our data set includes people sponsored by the Fulbright program during the 1990's, in order allow time to track post-Ph.D. career progressions. In our data set, the Fulbrights come from 79 different countries – similar to the number of countries in the program overall in 08/09 with 10 or more students. (FSB Annual Report 2009) The distribution by country is given in Table 1. Our sample coincides with a period where many Fulbright doctoral students in Science and Engineering came from Mexico. A full 38% of our sample are from Mexico, although only 3% of all Fulbright foreign students were from Mexico in 2008/09 and only 2.4% were from Mexico on average over the 62 years. This also reflects variation across countries in the use of the Fulbright program to fund students in doctoral rather than Master's or other programs or in their tendency to send students studying S&E rather than other fields. For example, despite the fact that Germany had the largest budget for Fulbright students in 1993, all but a handful of the

[14] USAID, HEC Expand Fulbright Scholarship Program; Initiative Called "Investment In Pakistan's Future" (press release of the US Embassy in Islamabad, 04/06/05)

[15] The 66% is for 2008/9 or from the entire 62 years from numbers in Fulbright Annual Report. The 16.1 and 71.5 is from the population numbers for 93-97 for Fulbright. Note that these are countries with commissions at the end of this period. Some of these countries did not have commissions earlier on.

German Fulbrights entering Ph.D. programs in the U.S. in 1994 were enrolled in “Non-degree programs”, presumably temporary exchange programs. Of the 19 Spanish Fulbrights entering programs in 1994, only one was pursuing a doctorate in S&E, with the others enrolled in Masters’ or non-degree programs, mostly in non-scientific fields. By contrast, of the 90 Mexican Fulbrights arriving in 1994, 64 enrolled in S&E doctorates.

Universities: The Institute of International Education (IIE), headquartered in New York City, facilitates the placement of many Fulbright nominees at academic institutions and communicates with Fulbrights during their stay in the United States. For some countries (e.g. Canada, France, Germany and Australia, and formerly the UK), students apply directly to universities, in many cases applying for Fulbright funding once they have been accepted. For students from most other countries, the IIE works with the binational commission and the student to obtain a place at a university once the student has been awarded a Fulbright. The IIE also acts as a liaison with the university and often helps students obtain additional financial support from the university. In many countries, Fulbright commissions guide the Fellows towards particular U.S. universities and are sometimes influenced by the availability of supplementary fellowship funding from the university and/or the lower tuition costs of public universities.[16] Finally, the Fulbright Foreign Scholarship Board’s policies encourage geographic diversity, stating that “Every effort will be made to affiliate grantees at institutions in all geographic areas of the United States, and at all types and sizes of institutions, provided that such affiliation is not detrimental to the goal of providing the best possible academic experience for the grantee.”[17]

The SRI (2005) survey gives us a sense of how many Fulbright foreign students end up being assigned and how many choose their institutions. Of their sample of Fulbright foreign students 1980 and 2000, 47% said they knew which university they wanted to attend before applying for the Fulbright. 44% were either assigned to the university or were given a choice between two universities. The remaining 24% did not know which school they wanted to attend before applying to the Fulbright, but were not assigned.

In the dataset used in this paper, 156 students or 32% of the sample obtained degrees from universities in the Northeast, and 122 (25%) obtained degrees from Midwestern universities. 90 degrees (18%) came from Southern universities, and the remaining 120 students

[16] Conversation with IIE representative , June 2009.
[17] http://fulbright.state.gov/fulbright/become/programwork/program-structure-and-rules

or 25% of the sample received degrees from Western universities. A large share of the universities in our sample are publicly funded.

Fields: Within the S&E area, Table 2 gives the distribution by fields in our sample, using the NSF major field classifications further aggregated into 7 categories because of the small size of our sample. The distribution across fields is slightly different for Fulbrights and controls because this is the first field listed in the person's (Proquest) dissertation record. Occasionally, people listed two or more fields and our procedure for identifying controls matched on advisors and/or fields rather on order of fields. The two distributions are not significantly different from each other (the P-value of a Chi-square test is 0.965). We also matched the field division to the overall distribution across S&E fields among Fulbright foreign students 1980-2000 (SRI 2005) and found that this also were remarkably similar (P=.9999). Of all PhD's in science granted in 1996 (the year closest to our median year of degree for which data were available) 45% were in math, computer science or engineering, while the equivalent figure in our dataset is 43%.[18] 55% of all US Ph.D.s in 1996 were in the natural sciences, in contrast to 57% of our sample.

IV. Our Data Set

In order to understand whether and how Fulbrights PhD scientists' careers unfold differently than careers of other foreign students who received their Ph.D.'s in the U.S., we have collected a sample of 244 Fulbright scholars who were receiving a Fulbright foreign student fellowship to study in a Ph.D. program in a science or engineering field between 1993 & 2005. To create this sample, we took all Fulbright scholars who completed a PhD at the institution listed in the *Foreign Fulbright Fellows: Directory of Students* for whom we could identify a location post-Ph.D. and for whom we could identify a match. We wanted to match each of these Fulbrights with a non-Fulbright foreign student who was as similar as possible to the Fulbright in terms of research potential. The characteristics that we *a priori* believed to be most relevant for future research output while being easily identifiable include institution, advisor/field, date of graduation and, where possible, region of origin. Therefore, we used the *Proquest Dissertations and Theses* database to obtain information on the year of graduation and advisor and to identify a "control" student of foreign origin who did *not* have post-Ph.D. location restrictions, whose current location could also be found on the web and who was similar along the above

[18] Data on the distribution of doctorates across fields in 1996 comes from *NSF Science and Engineering Indicators 2000.*

dimensions, i.e. he/she graduated from the *same* program in the *same* year and, whenever such a student existed, with the same advisor and from the same region.[19] Since students who receive substantial funding from their home country's government often are required to return for some period, we searched Ph.D. acknowledgements for evidence of foreign governmental funding and did not include the student as a control if we found any.

When several potential control students were identified for a single Fulbright fellow, we chose the student who came from the same or similar countries as those represented in the Fulbright sample. Table 1 lists the countries of origin of our Fulbright and Control samples. It is clear that the distribution of students across countries in the treatment and control groups, while similar, is not identical. There are several reasons for this. First, the distribution of Fulbrights across countries is affected by all of those factors we discussed earlier – most notably the past and present government policies and the presence of commissions or specific individual or institutional boosters. Second, because many students from certain countries receive government funding, we were less likely to select controls from those countries. There are two cases where the differences in the numbers of Fulbrights and controls are substantial enough to be noted. There are no Fulbrights in our sample from China or India so we tried to avoid sampling controls from these countries, but when a suitable control could not be found from another country we allowed students of Chinese and Indian origin in the sample. Also, in our sample there are many Fulbrights from Mexico but few controls since most of the Mexican students in the U.S. without Fulbright fellowships are subsidized by their governments. Data Appendix A gives a more detailed description of how we identified control students, made sure that they were not getting major funding from their own government, searched for the locations of both the Fulbrights and their controls and found their publication and citation information.

It is possible that our sample differs in important respects from the population of Fulbrights or foreign students in general due to our method of collecting data. It seems likely that the students for which we are able to find location data over the internet will be more research-active than students we were unable to find, because one of our sources for location data is the publication record itself. However, it is important to note that, because we apply the same search

[19] In cases where there was no control student with the same advisor in the same year, we identified a student with the same advisor graduating within 3 years before or after the Fulbright. If no students met the latter criteria, we chose a student graduating in the same year in the same major field, but with a different advisor.

criteria for all the students in our database, any biases introduced by our procedure apply equally to Fulbrights and controls.

In the following sections, we use these data to compare mobility, publications, citations, and collaboration patterns for the 488 foreign students who received U.S. doctorates in S&E. As explained above, the sample was constructed with the aim of choosing controls that are observationally identical to the Fulbright students. Nevertheless, in the regressions we also include control variables to account for any differences that may exist between treatment and control groups. All of the analysis includes the following control variables:

Ranking of Ph.D. institution: We use the (log of the) 1995 relative ranking of the U.S. Ph.D. institution (by field) from the National Research Council (Goldberger et al. 1995) as a control for the quality of Ph.D. training. Note that a lower rank signifies higher quality.

Field dummies: Fields differ widely in the number of articles published a year and even in conventions regarding citing precedents. We categorized each student by the first field listed in their (Proquest) dissertation record. We divided fields into the seven groups listed in Table 2.[20] Since the control was chosen from the same department as the Fulbright, the distribution across fields of study should be exactly identical. There are differences, however, since often the fields specified in *Proquest* are quite narrowly defined and many dissertations list more than one field. Students of the same advisor and department may list different fields and, even if the fields listed are identical, might choose to list them in different order.

Ph.D year dummies: Ph.D. year is divided into 6 categories (<1995, 1995 & 1996, 1997 & 1998, 1999 & 2000, 2000, 2001 & 2002, and > 2002.)[21] Table 3 divides our sample by Ph.D. year and we once again see a similar but not identical distribution between Fulbrights and controls, since the control was the closest available foreign student within three years of the Fulbright's Ph.D. (although the mean and median year of graduation are the same.) Note that since our variables cover the span of time from Ph.D. until 2008, Ph.D. year also proxies for the

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[20] Because of the limited number of observations, we could not meaningfully divide the field dummies into more categories and we were unable to converge the instrumented model for most output variables. We experimented with different field groupings and qualitative results were not affected.

[21] While in principle we would have wanted to use a full set of dummies for year and years since graduation, in practice we found it difficult to estimate some of our models including a full set of dummies. We *have* estimated some regressions with dummies for each year and did not find results to differ substantially from the results using the more grouped year variables. This is likely due to the fact that our samples of controls and Fulbrights are similar in terms of Ph.D. year.

length of the period over which the person can accumulate publications, citations, and collaborations.

Gender: We obtained data on the gender of the scientist using information from web searches (e.g. photographs, the use of personal pronouns in web bios), using a web-based algorithm for identifying the probable genders of given names when no other information was available.[22]

Different analyses in the following sections also include one of these two sets of variables:

Quartiles of GDP per capita of home country (5 years before Ph.D. receipt)*:* The GDP per capita of the scientist's country of origin may affect the quality of pre-doctoral training or the average financial resources available for the student's doctoral education and may capture the standard of living in the environment of returnees. Very few (21% on average) of either the Fulbrights or the controls come from countries in the bottom half of the income distribution. We therefore combine the bottom two quartiles. In some cases, we find that people from the third quartile are very similar to those from the poorer countries and use only two income categories, bottom 75% and upper 25%.

Total number of scientific articles produced in the home country in the Ph.D. year: This is an alternative measure to the per capita GDP. In some senses, the level of development of the entire scientific infrastructure and the opportunities and funding for scientific research are more important than average income in terms of attracting people back to their home country and/or in terms of making people productive research-wise in their home country. This variable was taken from NSF (2008).[23] It is for the country as a whole and not per capita.

Besides measuring different things – income v. scientific output – the major difference in the two sets of variables is that GDP is measured in per capita terms while scientific output is the total number of articles produced by the country. Arguments can be made for both in terms of ways of measuring the country's fertility for research.[24]

Table 4 gives the average values of the control variables.

[22] The gender-guessing program is found at: http://www.gpeters.com/names/baby-names.php.

[23] We use total articles rather than articles per capita because the former is a more accurate measure of total scientific activity in the country.

[24] The distributions by quartile are quite similar for the two measures of home country environment. For articles, the bottom half represents 21.3%, the next quartile represents 45.6% and the top quartile represents 33.1% of our sample. For income per capita, the bottom half represents 25.3%, the next quartile represents 41.0% and the top quartile represents 33.7% of our sample. However, the two measures are surprisingly imperfectly correlated, with a correlation coefficient of only 41%.

V. Does the Fulbright Program promote mobility of US-trained PhD's to foreign countries?

Most Fulbrights return to their home country for some time post-Ph.D, as required. Only 12.3 percent of our Fulbright sample appeared to have remained in the U.S. continuously and thus not have fulfilled their foreign residency requirement, although even they very well could have fulfilled the requirements in short segments that we did not observe. For the other 87.7 percent of the Fulbright students in our sample, we were able to find evidence that they did spend time abroad after receiving their Ph.D.s, compared to 43.4 percent of our control group of non-Fulbrights. We observe our sample of 244 Fulbright scholars for a total of 2,499 person-years, 77.8% of these years are spent outside the U.S. In contrast, the 244 foreign-origin controls spent only 34.7% of their 2,567 observed person-years outside the U.S. This stay rate of approximately 65.3% for control students is nearly identical to the average stay rate estimated in a much larger sample by Finn (2007), who found that 67% of foreign students who received their doctorates in 1998 (close to the average Ph.D. year in our sample) were observed in the U.S. in 2003. The top row of Table 4 documents these dramatic differences in the rates of return to home countries between Fulbrights and controls.

We have empirically modeled the number of years spent either (a) outside of the U.S. (b) in the home country or (c) in a third country that is neither the US nor the home country as a function of the standard control variables listed above including Ph.D. year dummies. The main results are found in Table 5.

Each dependent variable is estimated using Poisson estimation in three different specifications related to the Fulbright variable:

1. With a single Fulbright dummy variable.
2. With two Fulbright dummies to allow Fulbright to have a different effect in countries with different income per capita. The dummies are (a) a dummy for being a Fulbright from a country in the top quartile of GDP per capita and (b) a dummy for being a Fulbright from a country *not* in the top quartile of GDP per capita. (In these specifications, the standard set of GDP dummies is also included in the list of controls.)
3. With two Fulbright dummies to allow Fulbright to have a different effect in countries with different numbers of scientific articles. The dummies are (a) a dummy for being a Fulbright from a country in the top quartile of articles and (b) a dummy for being a Fulbright from a

country *not* in the top quartile of articles. (In these specifications, the standard set of scientific dummies is also included in the list of controls.)

The results in this table indicate that Fulbrights of all income and scientific environments spend substantially less time in the US than do controls. Instead, they spend time in their home countries. The effect is largest for Fulbrights from lower-income countries, who spend approximately 6.7 times as many years in their home countries as do controls (significant at the 1% level). By contrast, Fulbrights from countries above the 75th percentile of GDP per capita spend only about twice as many years as controls in their home countries. The difference in the number of years spend in the home country is less dramatic when we divide by the number of articles rather than GDP per capita..

There is no significant difference in the number of years spent in countries that are neither the U.S. nor the home country for most groups, with one important exception. Fulbrights from countries with strong science bases (as measured in terms of the number of articles produced in the home country) are more likely to be in a third country (at the 10% level of significance.)

VII: Do foreign S&E Fulbright students create less or more knowledge and have less or more impact on their fields compared to other foreign students?

In this section, we empirically measure whether Fulbrights publish more or less than other foreign students and whether they are cited less or more. The publication and citation data that we model were taken from information on the Fulbright and Control Ph.D.s' publication histories from *ISI's Web of Science*.[25] From the *Web of Science*, we obtained information for the following publication-related variables.

Publication counts: The number of articles on which the scientist is a contributing author. This may be a noisy measure of research output when articles have many authors.

First-authored publication counts: The number of articles each year on which the scientist is the first author. In science, the first author is the major contributor to the research.

Last-authored publication counts: The number of articles each year on which the scientist is the last author. In science, typically the last author will be the person running the lab, who is often

[25] Authors were matched to publications using information on post-Ph.D. locations, authors' middle names, fields of research, co-authors on other work etc.

the Principal Investigator (PI) on the research grant funding the research. This variable is an indicator of the author's ability to secure research funding.

Publications in high-impact journals: The number of each year's publications in the top 50% journals *in that field* as ranked by ISI's impact factors. We made this measure field specific because different fields have very different conventions about citations. We did this by calculating impact relative to the mean impact within each field.

First-or-last authored publications in high-impact journals: This is the select subgroup of publications for which the person was either a first or last author in a high-impact journal.

Forward citation counts: The total number of citations received as of 2008 *by articles published each year*, which proxy publication's impact on scholarship. We model citations for each of the five classes of articles described above.[26]

Table 4 displays the average levels of these publication and citation variables.

There are two general types of reasons why the Fulbrights and the controls might have different research productivity post-Ph.D. The first, and the one we are most interested in testing, is that the return requirement of the Fulbright program leads otherwise identical PhD scientists to pursue different kinds of careers and to use their scientific knowledge in different ways, leading to different publication and citation patterns. The second is that non-US residents who get Fulbright funding to study in the US are inherently different in ability or research proclivity from other non-US residents who study in the US. The first of these reasons implies a causal impact of Fulbright on productivity while the second implies differences due to heterogeneity and selection.

We constructed our match between the Fulbright and control students with the goal of choosing controls that are as similar as possible in inherent ability and proclivity for research in order to isolate the causal impact of Fulbrights scholarships, which is likely to be similar to the impact of other scholarships to study in the US that, while prestigious, also require return to the home country. The criteria we used for matching were based on our priors about the characteristics most relevant for research output -- institution, advisor/field, date of graduation and region of origin. To the extent that U.S. universities can observe the differences between students, the university admissions procedure may ensure that the Fulbrights and non-Fulbrights they admit to any specific department are likely to have equivalent abilities.

[26] Due to the extreme skewness of their distributions, citation counts are winsorized at the 99th percentile.

Nevertheless, there may remain inherent differences between controls and Fulbrights. The sign of these differences is not obvious. Since Fulbright recipients are chosen by "merit", this would lead to Fulbrights might have more research potential than others studying in the U.S. Similarly, as our earlier description suggested, Fulbrights may not be matched to the best university that would have accepted them, again leading Fulbrights to be better than controls.

On the other hand, there are reasons that Fulbrights may be worse than controls. Fulbright commissions, Embassy staff and the Fulbright Foreign Scholarship Board (FSB) may avoid funding the *most* promising students if they are believed to be less likely to spend their careers in their home country. Also, many excellent students may not pursue Fulbright fellowships if they have strong preferences to remain in the U.S. post-Ph.D. and/or can afford to avoid funding that restricts their futures and particularly if they receive funding directly from the universities. Finally, U.S. departments may lower their admission standards for graduate students with outside funding.

We have done several things in order to remove and/or evaluate possible biases due to differing inherent research potential of Fulbrights and controls. First, we control for the GDP per capita of the home country during the doctoral program or the scientific environment (measured by the number of annual articles published), since each paired Fulbright and control often come from different countries. Second, in some specifications we include as control variables three measures of students' research output while in graduate school (including the year of Ph.D. completion because of the lag between writing an article and getting it published) which we believe to be a good proxy for inherent ability. This may be over-controlling in the sense that Fulbright-control differences in pregrad publications may also be a causal effect of being a Fulbright. For instance, if Fulbrights believe that they must return home to a non-research job, they may be less committed to getting their Ph.D. research published. On the other hand, if Fulbrights are more concerned about having good chances of leaving their home country after two (or more) years of post-Ph.D. residence, they may need stronger credentials.

The specific pregrad publication variables included in these specifications are ***total articles published while in graduate school (including the year of Ph.D. completion), first-authored publications while in graduate school and high-impact first or last-authored publications while in graduate school.*** Note that first-authored articles are more prevalent during the Ph.D. year than later. In fact, 84% of articles published by our sample during this period were first-authored, probably publications from their thesis work for whom the Ph.D. student was the primary author.

Tables 6 and 7 give results of Poisson regressions of five measures of publications post-graduate school -- total publications, first-authored publications, last-authored publications, publications in high-impact journals and first-or-last-authored publications in high-impact journals – and citations to these publications. All equations include controls for field, Ph.D. year, school rank and gender. Table 6 also includes dummies for the GDP per capita of the country during doctoral education (top quartile, middle quartile and bottom half of countries worldwide.) Table 7 replaces these GDP dummies with similar dummies for scientific articles produced in the country in the PhD year (top quartile, middle quartile and bottom half).

Tables 6 and 7 list only the coefficients on the Fulbright variables. Coefficients of all control variables for one specification (Panel C of Table 7) are included as Appendix B. All other complete results are available on request from the authors.

Panels A and B include the coefficients on a single Fulbright dummy. In Table 6 Panel A (without controls for pre-grad publications), Fulbrights on average have significantly fewer last authored publications and high impact first/last authored publications, and fewer citations to high impact publications (all only significant at the 10% level). For other publication and citation measures, the coefficients on Fulbright are all negative but not significantly different from zero even at this level. In Table 7 panel A, not only are there no statistically significant differences between Fulbrights and others, but the signs vary for the different variables. When pregrad publications are added as controls for inherent research ability, results are qualitatively the same insofar as only a few output measures have significant impacts of Fulbright (mostly the same ones as earlier). Most coefficients are negative although some are positive. If this were all we had estimated, results would be very inconclusive.

A single dummy can hide very disparate effects for Fulbrights from different backgrounds. Panels C and D allow the effect of the Fulbright dummy vary by GDP per capita (Table 6) or scientific environment (Table 7). These panels indicate that the overall Fulbright-control differences are much larger than indicated in Panel A for some countries but not for others. Thus in Table 6 Panel C we see that Fulbrights from poor countries (below the 75th percentile of GDP per capita) have significantly lower levels of every single measure of publications and citations *ceteris paribus*, while in Panel C of Table 7, six of the ten research measures are lower for Fulbrights than for controls from poor scientific environments.

However, for those from rich (or high science) countries, there are no significant Fulbright-control differences and half of the signs are positive (primarily in Table 7). Controlling for heterogeneity in research ability and proclivity via pre-grad publications in Panel D, in both tables Fulbrights from poor (or science-poor) countries have significantly fewer last-authored publications, high impact citations and first- and last-authored high impact citations. In addition, Fulbrights have significantly fewer first or last high impact publications in Table 6 and fewer total citations in Table 7. Thus, while some of the lower publication/citation rates of Fulbrights from poor countries can be explained by heterogeneity in research ability, there remain significant differences. As before, Fulbrights from rich countries are not significantly different from non-Fulbrights.

To summarize results on publications and citations, research productivity and impact of Fulbrights from poor or science-poor countries is lower than the comparable non-Fulbrights in some respects – last authored publications (implying fewer PI's with their own labs) and citations to high impact publications. These scientists appear to be disadvantaged by the return requirement both in running their own labs and in getting their work noticed around the world.

VII. In what ways do Fulbright students contribute to their home countries' and the US scientific environment compared to comparable foreign students?

In this section, we examine the publication output of Fulbrights and controls to determine the extent to which the Fulbright program promotes knowledge production in different countries. We use information on the location(s) of the author(s) of the articles in our dataset as an indicator of where papers where produced. Unfortunately, the ISI did not link each institution with a particular co-author, so we are limited in the kinds of collaboration variables we can calculate. We construct the following variables based on the articles authored by the people in our sample:

1. The total number of articles listing an author in the home country.
2. The total number of articles listing an author in the United States.
3. The total number of articles listing an author in a third country (not the home country and not the US).

4. The total number of articles listing an author in the home country excluding the institution of the focal scientist.[28]
5. The total number of articles listing an author in the United States excluding the institution of focal scientist.
6. The total number of articles listing an author in a third country (not home and not US) excluding the institution of the focal scientist.
7. Total publications with an author in the home country and an author in the US.
8. Total publications with an author in the home country and an author in a third country.
9. The total number of countries listed on articles by the scientist.

Table 4 gives averages for these variables. Note that collaboration variables 4, 5 and 6 are the same as 1, 2 and 3 except that the later ones exclude the student's own institution from the count. The measure including the scientist him/herself is a useful measure of the extent to which the Fulbright program promotes the creation of knowledge in a particular location, either through collaboration or through scientists' locations. The second variable allows us to ask whether Fulbright recipients are more likely to collaborate with other scientists in the home country, U.S. or third country respectively.

We begin, in the first panel of Table 8, by examining the average effect of the Fulbright program on knowledge production in the home country, controlling for the GDP per capita of the home country and other covariates but not controlling for pre-grad research output. We find that Fulbrights produce significantly more articles that list an author in the home country than do controls (at the 10% level, col.1), an expected result given the location restrictions of Fulbrights. Fulbrights also produce 35% fewer articles than controls with a US author (significant at the 5% level, col.2). Fulbrights do not, on average, author more articles that list an address in a third (non-home, non-US) country (col.3). Neither do they produce more articles from the home country after excluding the author's own affiliation (col. 4). This latter finding implies that, despite being vastly more likely to be in the home country, Fulbrights do not on average increase publication counts of home-country scientists besides themselves (or, more accurately, people at other institutions. See footnote 28.) Excluding the author's own institution does not change the qualitative results as we move from column 2 to column 5, or from column 3 to column 6, not

[28] We would have preferred to use the total number of articles co-authored by someone else from the home country, whatever institution they were at. This was not possible to calculate using our data.

surprisingly since the latter versions include the Fulbrights themselves, few of whom live in the US or in a third country.

Fulbrights produce more articles that list both a home-country author and a US author (col. 7) or a home-country author and a third-country author (col. 8, latter difference significant at the 10% level only). In other words, the return requirement does lead to more collaboration between the home country and other countries. Fulbrights do not, on average, collaborate with authors in a larger number of countries over the course of their careers (col. 9).

Controlling for pre-graduation research (in panel B of Table 8) renders several of the aforementioned coefficients more rather than less significant. In fact, being a Fulbright approximately doubles the total number of publications with a home-country author (col. 1).

The results from regressions that use the total number of scientific articles published in the home country as a control (Table 9) are broadly similar to the regressions using GDP per capita with one major exception: The impact of Fulbrights on Total publications with any US author other than oneself is not significantly different from zero.

While these regressions are informative about the effects of the Fulbright program in general, Panel C provides more information by distinguishing between Fulbrights from countries of origin above and below the 75th percentile of GDP per capita. In Table 8, we see that the positive effect on home-country publications (col. 1, 4) is mainly apparent for Fulbrights from rich countries and, as before, refers to publications written by Fulbrights located in the home countries since it appears in column 1 but not in column 4. The Fulbright program may also stimulate more home-country/third-country collaborations for those from rich countries (col. 4). In contrast, the negative effect on US publications comes mainly from Fulbrights from poorer countries of origin. However, the Fulbright program does stimulate more home-country-US collaborations for people from these poorer countries (col. 7). These results are also evident when Fulbright is divided by scientific environment in Table 9, and in fact in Table 9 the Fulbright-control differences are larger and more significant.

Controlling for pre-graduation output results in more similar coefficients for Fulbrights from rich and poor countries in column 1 and 2 of Panel D in both Tables 8 and 9. This suggests that a substantial part but not all of the difference between rich and poor Fulbrights from panel C is explained by variation across regions of origin in students' pre-graduation research productivity (our proxy for inherent research potential.) One surprising fact, however, is that in column 5 of Table 8, the Fulbright coefficient is no longer significant for the poorer countries but becomes significant for the richer ones. This suggests that Fulbrights from richer countries are less likely than controls to co-author with Americans, but not from poorer countries. Neither is significant in Table 9, casting some doubt on the robustness of this result. Finally, controlling for pre-grad publications increases the magnitude and significance of the result that the Fulbright program increases the incidence of home country-US coauthorship (col 7).

The largest difference between the Tables 8 and 9 is in publications by third country authors. Fulbrights from countries of origin above the 75th percentile of national scientific articles produce significantly more publications listing an author in a third country, and more publications from a third country excluding oneself. In both Tables, however, the Fulbright program stimulates more collaboration between richer home countries and third countries.

To summarize the main findings of the regressions displayed in Tables 3 and 4, we find that Fulbrights from rich (or science-rich) home countries on average stimulate more articles authored in the home country and more home country-third country collaboration. Fulbrights who come from countries with strong science bases also have more articles listing authors from non-US, non-home countries. Fulbrights from poor (or science-poor) home countries on average stimulate fewer articles being authored in the US but do stimulate more home country-US collaborations.

A particularly striking result from this analysis is what we don't observe. We would have expected that given their location restrictions, Fulbrights from high-income countries would produce fewer articles listing a US author than controls. We do not find a significant difference.

This last result suggests that for high-income countries, the Fulbright program promotes knowledge production in home countries and maybe third countries without reducing knowledge production in the US. However, students from lower-income countries produce fewer articles with ties to the US without producing more home-country knowledge than the control scientists who are not subject to location restrictions.

VIII. Conclusion

The Foreign Fulbright program imposes a legal requirement that students funded by the program return to their home countries before applying for a work visa in the United States. The program has a major impact on the post-graduation location choices of US-trained, foreign-born scientists, with Fulbrights spending more than twice as many post-graduation years abroad. The effect is particularly large for students from countries with low GDP per capita or less well-developed science bases, which are not otherwise attractive destinations for Ph.D. recipients in Science and Engineering. It can be argued that this flow of highly-trained human capital to lower income countries, which would not otherwise have occurred, is likely to benefit those countries substantially.

One might ask, however, what the effects are for the progress of science in general of this relocation of scientists away from the countries with the most fertile environments for research and towards countries farther from the scientific frontier. If the environment in which one does science really matters, one might expect that Fulbright-funded scientists from less-science-rich environments and environment with fewer resources would be less productive in their subsequent careers than otherwise similar scientists whose location choices were not constrained. We find that, on average, Fulbrights are from these countries are typically have less of an impact on global science and are less likely to be independent PI's.

We also see impacts on the the location of article production and collaboration across borders. Fulbrights from rich or high-science countries produce substantially more articles listing home country authors while stimulating similar or only slightly lower levels of articles listing US authors and similar or higher levels of articles in third countries. This suggests that return requirements not only have positive impacts on home country scholarship and other non-US scholarship, but do not significantly hurt US scholarship.

For those from poorer or weaker science environments, however, the return requirement of the Fulbright program seems not to have stimulated additional home country or other non-U.S. scholarship while substantially decreasing scholarship in the US. It might be better for the students themselves and for the U.S. scientific community to do away with return requirements to poor countries, and our findings suggest little or no cost to scholarship in the home country. Nevertheless, the Fulbright Foreign Students does seem particularly good at achieving its explicit objective, at least with these students from poorer countries. It stimulates more articles reflecting home country-US collaborations. And finally, the presence of Fulbright scientists in their home countries may have large benefits to home-country science (e.g., through teaching and mentoring, advising governments and firms, editing journals etc.) that not measured well by the publication variables we consider here.

References

Agrawal, Ajay, Iain Cockburn, and John McHale (2006). “Gone but not forgotten: Knowledge Flows, Labor Mobility, and Enduring Social Relationships.” *Journal of Economic Geography* 6(5), 571-91.

Bound, John, Sarah Turner, and Patrick Walsh. *forthcoming*. “Internationalization of U.S. Doctorate Education.” In Richard Freeman and Daniel Goroff (eds.), *Brainpower, Science and Engineering Careers in the United States*. Chicago: University of Chicago Press.

Finn, M. G. (2007), “Stay Rates of Foreign Doctorate Recipients from U.S. Universities, 2005”, Working paper, Oak Ridge Institute for Science and Education.

Freeman, Richard (2006). “Does Globalization of the Scientific/Engineering Workforce Threaten U.S. Economic Leadership?” in Adam Jaffe, Josh Lerner and Scott Stern editors. *Innovation Policy and the Economy.* Cambridge MA: NBER/MIT Press.

Goldberger, Marvin L., Brendan A. Maher, and Pamela Ebert Flattau, Editors; (1995), *Research Doctorate Programs in the United States: Continuity and Change*, Committee for the Study of Research-Doctorate Programs in the United States. National Research Council. National Academy of Sciences: Washington, D.C.

Institute for International Education (1993) *Foreign Fulbright Fellows: Directory of Students1993-94*. New York, NY: IIE Foreign Fulbright Programs Division.

Institute for International Education (1994) *Foreign Fulbright Fellows: Directory of Students1994-95*.New York, NY: IIE Foreign Fulbright Programs Division.

Institute for International Education (1995) *Foreign Fulbright Fellows: Directory of Students1995-96*.New York, NY: IIE Foreign Fulbright Programs Division.

Institute for International Education (1996) *Foreign Fulbright Fellows: Directory of Students1996-97*.New York, NY: IIE Foreign Fulbright Programs Division.

Levin, S. and P. Stephan (1999), “Are the Foreign Born a Source of Strength for U.S. Science?”**,** *Science* 20 August 1999: Vol. 285. no. 5431, pp. 1213 - 1214

National Science Foundation, Division of Science Resources Statistics (2006). *Science and Engineering Indicators 2010.* Arlington, VA (NSB 10-01).

National Science Foundation, Division of Science Resources Statistics (2008). *Science and Engineering Indicators 2008.* Arlington, VA (NSB 08-01).

Saxenian, Annalee (2002). "Brain Drain or Brain Circulation: How High-Skill Immigration Makes Everyone Better Off." *The Brookings Review*, Winter 20(1), 28-31.

Stephan, P. and Levin, S., (2001), "Exceptional contributions to US science by the foreign-born and foreign-educated", *Population Research and Policy Review*, 20: 59-79, 2001

Stephan, Paula and Sharon Levin (1992). *Striking the Mother Lode in Science: The Importance of Age, Place, and Time.* New York and Oxford: Oxford University Press.

SRI International (2005), *Outcome Assessment of the Visiting Fulbright Student Program*, Report,W June 2005.

United States., J. William Fulbright Foreign Scholarship Board (2009), *Annual Report 2008-09*, Washington, DC

United States., J. William Fulbright Foreign Scholarship Board (1991), *Annual Report 1991-90*, Washington, DC

United States., J. William Fulbright Foreign Scholarship Board (1994), *Annual Report 1993-94*, Washington, DC

Wooldridge, Jeffery M. (2002). *Econometric analysis of cross section and panel data.* Cambridge MA: MIT Press.

Table 1: Distribution of Controls and Fulbrights by Country of Origin

Country of Origin	Controls	Fulbrights	Total	Country of Origin	Controls	Fulbrights	Total
Argentina	3	4	7	Kenya	0	2	2
Armenia	1	0	1	Korea	8	0	8
Australia	0	4	4	Lesotho	0	1	1
Austria	3	3	6	Lithuania	0	1	1
Bangladesh	2	0	2	Macedonia	1	0	1
Belgium	1	3	4	Malawi	1	1	2
Bolivia	0	1	1	Malaysia	1	0	1
Botswana	0	1	1	Mexico	9	93	102
Brazil	11	0	11	Morocco	0	2	2
Bulgaria	1	0	1	Netherlands	4	5	9
Canada	8	0	8	Nigeria	2	0	2
Chile	3	0	3	Norway	2	6	8
China	18	0	18	Pakistan	2	0	2
Colombia	4	8	12	Panama	1	1	2
Costa Rica	0	3	3	Peru	2	2	4
Cote D'Ivoire	0	2	2	Philippines	3	2	5
Croatia	1	1	2	Poland	1	1	2
Cyprus	1	0	1	Portugal	2	19	21
Czech Republic	3	1	4	Romania	5	1	6
Denmark	2	4	6	Russia	9	0	9
Ecuador	1	0	1	Singapore	1	0	1
Egypt	2	0	2	Solomon Islands	0	1	1
Ethiopia	2	2	4	South Africa	0	7	7
Finland	2	5	7	Spain	6	7	13
France	2	0	2	Sri Lanka	1	0	1
Germany	10	0	10	Swaziland	1	0	1
Ghana	0	2	2	Sweden	2	3	5
Greece	4	7	11	Switzerland	3	1	4
Guatemala	1	1	2	Taiwan	7	0	7
Haiti	0	1	1	Tanzania	1	1	2
Hungary	3	1	4	Thailand	5	5	10
Iceland	2	7	9	Togo	0	2	2
India	25	0	25	Trinidad & Tobago	1	1	2
Indonesia	4	0	4	Turkey	11	1	12
Iran	1	0	1	UK	2	4	6
Iraq	1	0	1	Uganda	1	2	3
Ireland	2	1	3	Ukraine	5	0	5
Israel	3	6	9	Venezuela	2	1	3
Italy	5	3	8	Yugoslavia	3	0	3
Japan	5	0	5	Zimbabwe	1	0	1
Jordan	1	0	1	Total	244	244	488

Table 2: Distribution of Controls and Fulbrights, by first-listed field of study

	Controls	Fulbrights	Total
agric sci	30	34	64
biol sci	47	53	100
engineering/comp sci	86	82	168
earth/air/ocean	21	17	38
math/stats	21	22	43
phys sci	27	23	50
environment	12	13	25
Total	244	244	488

Table 3: Distribution of Controls and Fulbrights, by year of Ph.D.

Year of PhD	Controls	Fulbrights	Total
1991	1	0	1
1992	2	0	2
1993	7	5	12
1994	15	17	32
1995	11	23	34
1996	31	27	58
1997	45	36	81
1998	38	40	78
1999	33	34	67
2000	28	22	50
2001	13	22	35
2002	9	10	19
2003	7	6	13
2004	2	1	3
2005	2	1	3
Total	244	244	488
Average	1997.881	1997.897	1997.889

Table 4: Summary Statistics on Controls and Fulbrights

Number of post-Ph.D. years spent in the U.S. (Controls)	244	6.865	4.862	0	17
Number of post-Ph.D.years spent in U.S. (Fulbrights)	244	2.275	3.689	0	15
Number of post-Ph.D. years spent at home (Controls)	244	3.000	4.738	0	17
Number of post-Ph.D.years spent at home (Fulbrights)	244	6.648	4.818	0	16
Gender	488	0.250	0.433	0	1
Rank of PhD program	488	37.819	34.614	1	175
ln(home country GDP per capita)	488	8.809	0.880	5.817	10.220
Home country GDPpc above 75th percentile	488	0.328	0.470	0	1
Home country GDPpc below 50th percentile	488	0.254	0.436	0	1
Home country GDPpc between 50th & 75th percentile	488	0.418	0.494	0	1
Total Number of Scientific Articles Produced in Home Country in year of graduation	488	6711.16	10154.268	0	57228
Home country articles between 50th & 75th percentile	488	0.457	0.499	0	1
Home country articles above 75th percentile	488	0.332	0.471	0	1
# articles published before graduation	488	2.352	3.434	0	27
# first-authored articles published before graduation	488	1.322	1.972	0	18
# high-impact first- or last-authored articles published before graduation	488	0.590	1.146	0	9
Total number of articles published	488	8.678	14.935	0	154
First-authored articles	488	3.545	5.494	0	54
High-impact articles	488	4.441	9.253	0	90
Last-authored articles	488	2.096	5.066	0	50
High-impact, first- or last-authored articles	488	2.545	5.173	0	51
Total forward citations	488	107.287	235.651	0	1256
Total forward citations to first-authored articles	488	46.980	107.357	0	677
Total forward citations to last-authored articles	488	16.242	55.800	0	408
Total forward citations to high-impact articles	488	73.486	181.631	0	1008
Total forward citations to first- or last-authored high-impact articles	488	38.740	96.809	0	598
Total publications with a U.S. author	488	5.652	10.202	0	82
Total publications with a home-country author	488	3.074	10.644	0	137
Total publications with a non-US, non-home-country author	488	2.256	5.943	0	68
Total publications with a home-country author excluding self	488	1.467	6.345	0	114
Total publications with a US author excluding self	488	3.881	8.116	0	74
Total publications with a non-US, non-home country author excluding self	488	2.012	5.684	0	69
Total publications with an author in the home country AND an author in the US	488	1.080	3.395	0	36
Total publications with an author in the home country AND an author in another non-US country	488	0.836	4.218	0	68

Table 5: Effect of Fulbright on Location

Estimation method: Poisson

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:	Years in the US			Years in the home country			Years in a third country		
Fulbright	-1.081*** (0.112)			0.769*** (0.104)			0.399 (0.264)		
Fulbright from lower 75% GDP h.c.		-2.110*** (0.311)			2.040*** (0.293)			0.495 (0.437)	
Fulbright from top 25% GDP h.c.		-0.721** (0.350)			0.740** (0.357)			0.377 (0.404)	
Fulbright from lower 75% articles			-1.645*** (0.266)			1.747*** (0.270)			0.426 (0.369)
Fulbright from top 25% articles h.c.			-1.515*** (0.436)			1.174*** (0.415)			0.818* (0.461)

See text for list of control variables included. Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Effect of Fulbright on Publications and Citations
Controls: GDP per Capita of home country during graduate school

	1	2	3	4	5	6	7	8	9	10
	Total Publications	First-Authored Publications	Last-Authored Publications	High-Impact Publications	High-Impact First/Last Pubs	Total (forward) Citations	Cites to First-Authored pubs	Cites to Last-Authored pubs	Cites to High Impact pubs	Cites to Hi-Imp 1st /Last Pubs
Panel A: Average Impact of Fulbright										
Fulbright	-0.11	-0.053	-0.322	-0.430*	-0.384*	-0.318	-0.094	-0.363	-0.385*	-0.366
	(0.166)	(0.147)	(0.205)	(0.243)	(0.213)	(0.198)	(0.204)	(0.297)	(0.226)	(0.232)
Panel B: Average Impact of Fulbright with Pregrad Publication Controls										
Fulbright	-0.017	0.03	-0.284	-0.360*	-0.378**	-0.279	-0.074	-0.286	-0.383*	-0.375*
	(0.157)	(0.133)	(0.196)	(0.196)	(0.174)	(0.176)	(0.177)	(0.265)	(0.214)	(0.210)
Panel C: Coefficient on Fulbright * GDP Interactions										
Fulbright from top 25% GDP h.c.	0.264	0.23	0.215	0.033	0.025	0.048	0.237	0.107	0.08	0.049
	(0.255)	(0.242)	(0.333)	(0.300)	(0.317)	(0.281)	(0.267)	(0.393)	(0.304)	(0.308)
Fulbright from lower 75% GDP h.c.	-0.446**	-0.336*	-1.226***	-0.637**	-0.841***	-0.739**	-0.573**	-0.935**	-0.922***	-0.937***
	(0.210)	(0.173)	(0.288)	(0.293)	(0.242)	(0.290)	(0.283)	(0.443)	(0.335)	(0.324)
Panel D: Coefficient on Fulbright * GDP Interactions with Pregrad Publication Controls										
Fulbright from top 25% GDP h.c.	0.117	0.109	0.038	-0.167	-0.177	-0.149	0.015	-0.048	-0.122	-0.183
	(0.21)	(0.21)	(0.26)	(0.25)	(0.26)	(0.26)	(0.24)	(0.36)	(0.30)	(0.30)
Fulbright from lower 75% GDP h.c.	-0.141	-0.05	-0.884***	-0.392	-0.605**	-0.435	-0.203	-0.593	-0.697**	-0.645*
	(0.22)	(0.18)	(0.30)	(0.31)	(0.25)	(0.30)	(0.29)	(0.46)	(0.34)	(0.34)

See text for list of control variables included. Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7 : Effect of Fulbright on Publications and Citations
Controls: Country Scientific Environment (Articles)

	1	2	3	4	5	6	7	8	9	10
	Total Publications	First-Authored Publications	Last-Authored Publications	High-Impact Publications	High-Impact First/Last Pubs	Total (forward) Citations	Cites to First-Authored pubs	Cites to Last-Authored pubs	Cites to High Impact pubs	Cites to Hi-Imp 1st /Last Pubs
Panel A: Average Impact of Fulbright										
Fulbright	0.075	0.082	-0.193	-0.115	-0.173	-0.117	0.079	-0.155	-0.17	-0.151
	(0.194)	(0.148)	(0.264)	(0.222)	(0.218)	(0.232)	(0.251)	(0.330)	(0.260)	(0.284)
Panel B: Average Impact of Fulbright with Pregrad Publication Controls										
Fulbright	0.046	0.081	-0.254	-0.211	-0.275*	-0.196	-0.007	-0.183	-0.287	-0.263
	(0.168)	(0.138)	(0.199)	(0.197)	(0.162)	(0.196)	(0.204)	(0.284)	(0.234)	(0.244)
Panel C: Coefficient on Fulbright * Articles Interactions										
Fulbright from top 25% articles h.c.	0.45	0.253	0.392	0.2	0.149	0.416	0.626**	0.539	0.454	0.551
	(0.314)	(0.237)	(0.378)	(0.345)	(0.369)	(0.317)	(0.310)	(0.428)	(0.342)	(0.366)
Fulbright from lower 75% articles	-0.187	-0.032	-0.644***	-0.317	-0.385*	-0.502**	-0.415	-0.645*	-0.603**	-0.714**
	(0.204)	(0.179)	(0.219)	(0.271)	(0.225)	(0.255)	(0.273)	(0.346)	(0.288)	(0.295)
Panel D: Coefficient on Fulbright * Articles Interactions with Pregrad Publication Controls										
= 1 if Fulbright in top 25% articles in country	0.224	0.089	0.085	-0.165	-0.234	0.092	0.259	0.245	0.059	0.138
	(0.278)	(0.223)	(0.317)	(0.283)	(0.252)	(0.312)	(0.302)	(0.409)	(0.369)	(0.385)
= 1 if Fulbright in bottom 75% articles country	-0.077	0.076	-0.512**	-0.239	-0.3	-0.407*	-0.243	-0.484	-0.525*	-0.576**
	(0.195)	(0.172)	(0.210)	(0.264)	(0.217)	(0.243)	(0.262)	(0.341)	(0.276)	(0.286)

See text for list of control variables included. Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Effect of Fulbright on Location of Articles and Collaboration
Controls: GDP per Capita of home country during graduate school

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total pubs with any home country author	Total pubs with any US author	Total pubs with any 3rd country author	Total pubs with any home country author excl self	Total pubs with any US author excl self	Total pubs with any 3rd country author excl self	Total pubs with authors in home AND US	Total pubs with authors in home AND 3rd coun.	Number of collab. countries
Panel A: Average Impact of Fulbright									
Fulbright	0.554*	-0.428**	0.201	0.313	-0.382**	0.216	0.557*	0.645*	-0.011
	(0.305)	(0.173)	(0.215)	(0.342)	(0.194)	(0.226)	(0.314)	(0.368)	(0.091)
Panel B: Average Impact of Fulbright with Pregrad Publication Controls									
Fulbright	0.696**	-0.355**	0.356	0.524	-0.293*	0.366	0.632**	0.914**	0.014
	(0.333)	(0.145)	(0.225)	(0.416)	(0.164)	(0.242)	(0.308)	(0.440)	(0.086)
Panel C: Coefficient on Fulbright * GDP Interactions									
Fulbright from top 25% GDP h.c.	0.875**	-0.155	0.558*	0.634	-0.281	0.557	0.459	0.868*	0.178
	(0.408)	(0.275)	(0.339)	(0.420)	(0.314)	(0.371)	(0.418)	(0.490)	(0.151)
Fulbright from lower 75% GDP	0.219	-0.652***	-0.106	0.057	-0.465*	-0.065	0.655	0.369	-0.164
	(0.426)	(0.221)	(0.335)	(0.517)	(0.249)	(0.343)	(0.473)	(0.615)	(0.114)
Panel D: Coefficient on Fulbright * GDP Interactions with Pregrad Publication Controls									
Fulbright from top 25% GDP h.c.	0.745*	-0.328	0.444	0.504	-0.475*	0.434	0.179	0.788*	0.154
	(0.403)	(0.219)	(0.297)	(0.447)	(0.247)	(0.326)	(0.396)	(0.470)	(0.135)
Fulbright from lower 75% GDP	0.644	-0.379*	0.277	0.542	-0.136	0.306	1.067**	1.088	-0.099
	(0.476)	(0.209)	(0.370)	(0.589)	(0.228)	(0.388)	(0.448)	(0.733)	(0.114)

See text for list of control variables included. Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 9: Effect of Fulbright on Location of Articles and Collaboration

Controls: Country Scientific Environment (Articles)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Total pubs with any home country author	Total pubs with any US author	Total pubs with any 3rd country author	Total pubs with any home country author excl self	Total pubs with any US author excl self	Total pubs with any 3rd country author excl self	Total pubs with authors in home AND US	Total pubs with authors in home AND 3rd coun.	Number of collab. countries
Panel A: Average Impact of Fulbright									
Fulbright	0.803**	-0.283	0.476*	0.573	-0.203	0.480*	0.693**	1.063**	0.097
	(0.383)	(0.181)	(0.252)	(0.408)	(0.198)	(0.278)	(0.345)	(0.483)	(0.103)
Panel B: Average Impact of Fulbright with Pregrad Publication Controls									
Fulbright	0.818**	-0.330**	0.458**	0.629	-0.256	0.453*	0.624**	1.065***	0.087
	(0.348)	(0.145)	(0.230)	(0.408)	(0.160)	(0.252)	(0.305)	(0.401)	(0.095)
Panel C: Coefficient on Fulbright * Articles Interactions									
Fulbright from top 25% articles h.c.	1.576***	-0.019	1.009***	1.011*	0.023	1.066***	1.063*	1.662***	0.346
	(0.569)	(0.311)	(0.371)	(0.592)	(0.348)	(0.412)	(0.573)	(0.641)	(0.219)
Fulbright from lower 75% articles	0.301	-0.451**	0.094	0.316	-0.353*	0.062	0.436	0.535	-0.056
	(0.368)	(0.192)	(0.301)	(0.511)	(0.207)	(0.319)	(0.344)	(0.546)	(0.105)
Panel D: Coefficient on Fulbright * Articles Interactions with Pregrad Publication Controls									
Fulbright from top 25% articles h.c.	1.352**	-0.277	0.820***	0.79	-0.264	0.863**	0.597	1.488***	0.264
	(0.534)	(0.253)	(0.308)	(0.606)	(0.296)	(0.345)	(0.584)	(0.532)	(0.202)
Fulbright from lower 75% articles	0.501	-0.364**	0.205	0.542	-0.251	0.166	0.641*	0.74	-0.022
	(0.346)	(0.179)	(0.293)	(0.456)	(0.188)	(0.311)	(0.328)	(0.456)	(0.102)

See text for list of control variables included. Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix A: Data Appendix

Fulbright Data

The names of Fulbrights were obtained from volumes of *Foreign Fulbright Fellows: Directory of Students* published annually by the Institute for International Education (IIE) from 1993 to 1996.

Identifying Controls and Location Search Procedure

First, we entered data from the IIE volumes on the Fulbright Student's name, graduate institution, field of study, and country of origin. Then, we searched for these students in the *Proquest* database (described below) to find their date of graduation (for those who completed their studies) and advisor name. For those Fulbrights successfully completing their programs, we then performed searches on Google, Google Scholar, LinkedIn, and/or Web of Science to obtain as much information as possible on all the student's post-Ph.D. locations and affiliations. The search time was limited to 20 minutes. If a student was not found at all on the web within 20 minutes, the searcher moved on to the next name.

For the students found on the web, we then searched for controls. We searched for controls obtaining Ph.D.s in the same year, with the same advisor, at the same institution as the Fulbright. Click on the name of the student's advisor. If this step failed (i.e. there are no foreign students with the same advisor graduating in same year), we looked for a student with the same advisor graduating within 3 years of the Fulbright. When choosing controls, we alternated students graduating before the Fulbright with those graduating after the Fulbright so that on average controls graduate at the same time as Fulbrights. If this step failed, we choose a control graduating in the same year in the same field of study (e.g. Biochemistry) at the same university.

We searched for the person's location on Google, Google Scholar, LinkedIn, and/or Web of Science, the combination of which allowed us to find both academics and non-academics.[29]

[29] Many academics had C.V.'s posted on the web. Nonacademics were more likely to be found on Linked In, conference or meeting programs, alumni associations, local news articles or civic/religious organizations websites. One person was even located via a DUI arrest. We made sure that the person we located had more than just their name in common with the student we knew (e.g. the Ph.D. location or a previous employer might be mentioned.)

Since it tends to be easier to find academics on the web than others, we no doubt under-sample non-academics. However, this under-sampling applies equally to Fulbrights and controls.

When someone was included in our sample but, after continued, we could not identify the location either of the Fulbright or the control for more than half of the years since Ph.D.even after interpolating, we dropped the Fulbright-control pair. This led us to drop 4 pairs.

For schools listing prior degrees or biographical information in the dissertation, we used this information to infer the student's country of origin (see below). For schools that did not list prior degrees, if we found a potential control student, we looked them up on the web. If we could find their current location and evidence that they came from a foreign country (i.e. foreign undergraduate degree or biography), we recorded their name, year of Ph.D., current location, and estimated country of origin.

Proquest Dissertations and Theses

The *Proquest Dissertations and Theses* database is a database of almost all dissertations filed at over 700 U.S. universities. We obtained information from this database on students' full names, advisors, fields of study, Ph.D. completion dates, and undergraduate institution and/or country of birth. Starting in the1990's, ProQuest began publishing online the full text of the first 24 pages of the dissertation.

Several universities require students to list biographical information in the front matter of the dissertation. Table A1 lists these universities, which were identified by checking dissertations filed at the universities that are major producers of scientists and engineers in the United States. At some universities, the information includes a full biographical sketch (e.g., Ohio State, NC State), but in most cases, the information is limited to a list of previous degrees. Figures A1 and A2 present examples of this information drawn from dissertations filed at the University of Illinois and the Ohio State University.

The biographical information contained in these dissertations can be used to identify the country of origin of the student. Under the assumption that most students attend undergraduate programs in their country of origin, we treat the country of undergraduate degree as the country of origin. Using this information as a proxy for the nationality of the student will of course introduce some error, since not all students receiving undergraduate degrees do so in their country of origin. However, evidence from the NSF's *Survey of Earned Doctorates* suggests that the country of undergraduate degree is a very good proxy for the country of origin. For students completing doctorates in 2003 and 2004, the *SED* lists the country of undergraduate degree. For 84.9% of students, the country of undergraduate degree is the same as the country of citizenship. However, there is considerable heterogeneity across countries in the extent to which students pursue undergraduate studies outside their countries of origin. Table A2 presents, for a selected list of countries, the share of students responding to the *SED*'s questions who remained in their home country for undergraduate study. Students from Germany and Japan have the lowest rates of staying at home among the major producers of U.S. graduate students (73% and 74%, respectively). However, the countries that send the most students (China, India, Taiwan, Korea, and Canada) have high stay-at-home rates for undergraduate study (98%, 93%, 89%, 76%, and 82%, respectively). Furthermore, counts of the number of doctoral recipients by country of origin, university and year computed from a ProQuest sample have a correlation of 0.948 with analogous counts obtained from the *SED*.

The data on country of origin is only available beginning in the late 1990's when universities began submitting digital copies of dissertations to be posted on the web by ProQuest. However, by 1996 or 1997 almost all dissertations are available in digital format.

Publication Data

We obtained publication histories from *ISI's Web of Science*. Authors were identified using information on post-Ph.D. locations, authors' middle names, and fields of research. For each publication by an author, we obtained all information available on the publication record itself, including publication year, title, co-author names, author locations, complete backward citations, counts of forward citations, publication source, abstract, specific field (for example, Marine & Freshwater Biology), and keywords.

It should be noted that our information on the number of forward citations received by an article includes self-citations. The median backward citation lag also includes self-citations. In future work, we intend to remove these citations. However, this requires downloading bibliographic data on each specific citing article, which is a very time-consuming process.

The *ISI Web of Science* database does not cover every scientific journal published worldwide. It lists articles from 6,650 scientific journals. Among Thomson's criteria for including a journal in the index are "The journal's basic publishing standards, its editorial content, the international diversity of its authorship, and the citation data associated with it."[30] Journals must typically publish on-time, implying a substantial backlog of articles forthcoming. They must publish bibliographic information in English, and must include full bibliographic information for cited references and must list address information for each author. Thomson also looks for international diversity among contributing authors, but regionally focused journals are evaluated on the basis of their specific contribution to knowledge. The number of citations received by the journal is a key factor in evaluation for inclusion in the index, with preference going to highly cited journals or journals whose contributing authors are cited highly elsewhere.

The ISI selection procedure is designed to select the most relevant scientific journals, independent of the location of their editorial offices. Since such a large share of cutting-edge science research takes place in the U.S., there will inevitably be a high share of journals in this index based in the U.S. Journals that do not publish bibliographic information in English are less likely to be included, so articles written abroad and published in low-profile regional journals with limited readership beyond the region (as evidenced by a failure to publish bibliographic information in English) will be excluded from our data. As a result, our publication data should be viewed as information on scientists' participation in the international scientific community, rather than raw article counts. Still, the large number of journals included, and the special consideration given to regionally-focused journals means that most of the relevant journals in which our scientists publish will be included. We examined the publication records of some of our scientists located outside the U.S., and found that even what might seem like relatively obscure journals (e.g. *Revista Chilena de Historia Natura*, *Revista Brasileira de Ciência do Solo*, *Acta Pharmacalogica Sinica*, etc.) were all included in the ISI index. While it is possible that ISI data is less comprehensive for articles published in non-Roman alphabets, it should be noted that only a very small number of scientists in our sample are located in Asian countries (0.36% of our observations are on scientists located in China, 0.55% in Japan, 0.87% in Korea, 1.03% in

[30] "The Thomson Scientific Journal Selection Process" http://scientific.thomson.com/free/essays/selectionofmaterial/journalselection/ (accessed March 11, 2008)

Taiwan and 1.5% in Thailand). Furthermore, these are scientists who began their careers in the United States and are thus likely to continue publishing in English-language journals.

To verify more rigorously that our sample of publications is not biased towards finding articles by U.S.-based researchers, we performed the following test. We had a research assistant collect data on the number of articles listed on scientists' C.V.s and the number of articles we obtained from ISI. We computed the share of a scientist's articles from the C.V. that were listed in the ISI database, and performed a t-test of difference in means between scientists outside the U.S. and those inside the U.S. The average share of articles found on Web of Science was 0.705 for those in the U.S. and 0.651 for those outside the U.S. We cannot reject the hypothesis of no difference in means (with a t-statistic of 0.788 and p-value of 0.433 for a two-tailed test).[31] We thus do not feel that a systematic U.S. bias is introduced by restricting our attention to journals included in the ISI index.

We made sure to collect information on Fulbright and Control publications at the same time, ideally on the same day. We did this to avoid biasing the data to include more pubs and cites for one of the groups because they were collected later and had more time to appear in the database.

[31] We also tested the hypothesis that this depended on the number of years abroad by regressing the share of articles on ISI on the number of years abroad, and the coefficient on this latter variable was -0.001 with a standard error of 0.006 (insignificantly different from zero).

Table A1: Universities listing biographic info in thesis

AUBURN
BOSTON U
CALIFORNIA STATE U
CLARK
CORNELL U
FLORIDA INSTITUTE OF TECHNOLOGY
FORDHAM
GEORGE WASHINGTON U
GEORGETOWN U
KANSAS STATE
LOUISIANA STATE U
NC STATE
OH STATE
OK STATE
SYRACUSE
TEXAS A&M
U ARKANSAS
U CALIFORNIA
U CINCINATTI
U COLORADO
U CONNECTICUT
U FLORIDA
U ILLINOIS
U MAINE
U MASSACHUSETTS

U MASSACHUSETTS AT
AMHERST
U MISSOURI
U NEVADA
U OREGON
U PITTSBURGH
U SOUTH ALABAMA
U SOUTH CAROLINA
U VIRGINIA

Table A2: Share of Ph.D. students at U.S. universities who received undergraduate degrees in their countries of citizenship

AUSTRALIA	85.00%
BRAZIL	96.02%
CANADA	82.51%
CHINA	98.35%
EGYPT	96.38%
FRANCE	82.05%
GERMANY	73.05%
GREECE	80.51%
INDIA	92.71%
IRAN	88.33%
ISRAEL	88.46%
JAPAN	73.51%
MEXICO	89.19%
NIGERIA	60.61%
PHILIPPINES	87.23%
SOUTH KOREA	76.33%
TAIWAN	89.19%
THAILAND	87.28%
TURKEY	95.57%
U.K.	63.64%
Weighted average across these countries	89.50%
Weighted average across all countries	84.79%

Figure A1

ALGORITHMS AND ARCHITECTURES FOR SOFT-DECODING REED-SOLOMON CODES

BY

ARSHAD AHMED

B.E., Regional Engineering College, Trichy, 1998
M.E., Indian Institute of Science, Bangalore, 2000

DISSERTATION

Submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Electrical Engineering
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2006

Urbana, Illinois

Figure A2

VITA

January 31, 1973	Born – Da-An, Jilin Province, China
September 1989 – July 1993	Bachelor of Science in Electrical Engineering, Nanjing University of Science and Technology, Nanjing, China
September 1993 – April 1996	Master of Science in Electrical Engineering, Nanjing University of Science and Technology, Nanjing, China
Septmeber 2002 – present	Ph.D student, Analog VLSI Laboratory, Department of Electrical and Computer Engineering, the Ohio State University, Columbus, Ohio
Since June 2006	RFIC design engineer, Freescale Semiconductor Inc., Boca Raton, Florida

PUBLICATIONS

Research Publications

P. Zhang, and M. Ismail "A New RF Front-End and Frequency Synthesizer Architecture for 3.1–10.6 GHz MB-OFDM UWB Receivers", *Proc.* 48^{th} *Midwest Symposium on Circuit and System*, vol.2, pp.1119–1122, August 2005.

C. Garuda, X. Cui, P. Lin, S. Doo, P. Zhang, and M. Ismail "A 3–5 GHz Fully Differential CMOS LNA with Dual-gain Mode for Wireless UWB Applications", *Proc.* 48^{th} *Midwest Symposium on Circuit and System*, vol.1, pp.790–793, August 2005.

Y. Yu, L. Bu, S. Shen, B. Jalali-Farahani, G. Ghiaasi, P. Zhang, and M. Ismail "A 1.8V Fully Integrated Dual-band VCO for Zero-IF WiMAX/WLNA Receiver in 0.18μm CMOS", *Proc.* 48^{th} *Midwest Symposium on Circuit and System*, vol.1, pp.187–190, August 2005.

Appendix B: Full Regression Results for Selected Regressions (corresponds to panel C of Table 7)

	1	2	3	4	5	6	7	8	9	10
	Total Publications	First-Authored Publications	Last-Authored Publications	High-Impact Publications	High-Impact First/Last Pubs	Total (forward) Citations	Cites to First-Authored pubs	Cites to Last-Authored pubs	Cites to High Impact pubs	Cites to Hi-Imp 1st /Last Pubs
Fulbright from top 25% GDP h.c.	0.117 (0.213)	0.109 (0.207)	0.038 (0.256)	-0.167 (0.251)	-0.177 (0.257)	-0.149 (0.256)	0.015 (0.238)	-0.048 (0.359)	-0.122 (0.302)	-0.183 (0.298)
Fulbright from lower 75% GDP	-0.141 (0.221)	-0.05 (0.176)	-0.884*** (0.297)	-0.392 (0.309)	-0.605** (0.247)	-0.435 (0.299)	-0.203 (0.288)	-0.593 (0.457)	-0.697** (0.338)	-0.645* (0.336)
Student from top 25% GDP h.c.	0.065 (0.187)	0.142 (0.166)	0.256 (0.256)	0.121 (0.269)	0.34 (0.236)	0.478** (0.227)	0.473** (0.229)	0.56 (0.397)	0.564** (0.279)	0.669** (0.299)
Student from h.c. at 50-75% GDP	-0.027 (0.175)	-0.237 (0.149)	0.259 (0.304)	0.121 (0.225)	0.22 (0.234)	0.298 (0.250)	-0.092 (0.267)	0.607 (0.452)	0.578* (0.298)	0.431 (0.333)
Articles published before Ph.D.	0.072*** (0.027)	0.014 (0.029)	0.038 (0.039)	0.043 (0.035)	0.002 (0.036)	0.094*** (0.024)	0.058** (0.027)	-0.009 (0.059)	0.062** (0.029)	0.004 (0.036)
First-authored articles published before Ph.D.	0.076 (0.063)	0.175*** (0.058)	0.128* (0.074)	0.031 (0.080)	0.087 (0.068)	-0.006 (0.055)	0.107** (0.052)	0.136 (0.106)	-0.009 (0.059)	0.111* (0.065)
First-authored, high-impact articles before Ph.D.	-0.053 (0.077)	-0.034 (0.065)	-0.015 (0.080)	0.200** (0.086)	0.246*** (0.077)	0.038 (0.078)	-0.023 (0.066)	0.139 (0.114)	0.181* (0.096)	0.170* (0.093)
Biological sciences	0.284 (0.302)	0.244 (0.261)	0.640* (0.361)	0.033 (0.407)	0.229 (0.332)	1.047*** (0.268)	0.979*** (0.285)	1.200** (0.523)	1.067*** (0.311)	1.083*** (0.332)
Engineering & Computer Science	-0.229 (0.302)	-0.019 (0.263)	0.318 (0.341)	-0.253 (0.383)	0.075 (0.310)	-0.047 (0.333)	-0.125 (0.366)	0.429 (0.591)	0.294 (0.360)	0.324 (0.408)
Earth/Air/Ocean Sciences	-0.364 (0.367)	0.133 (0.324)	0.145 (0.499)	-0.37 (0.444)	0.145 (0.363)	-0.028 (0.440)	0.403 (0.483)	0.812 (0.625)	0.256 (0.551)	0.622 (0.553)
Mathematics & Statistics	-0.146 (0.340)	0.587 (0.370)	0.609* (0.347)	0.223 (0.452)	0.831* (0.431)	-0.689* (0.419)	-0.193 (0.520)	0.282 (0.648)	-0.28 (0.477)	0.205 (0.529)
Physical Sciences	-0.12 (0.400)	-0.125 (0.347)	-0.033 (0.461)	0.258 (0.487)	0.226 (0.385)	0.908** (0.376)	0.244 (0.353)	0.77 (0.605)	1.100*** (0.407)	0.576 (0.412)

Environmental Science	0.073 (0.360)	0.663** (0.318)	0.502 (0.417)	0.015 (0.454)	0.477 (0.379)	0.673 (0.427)	0.925** (0.406)	0.576 (0.711)	1.004** (0.487)	1.062** (0.467)
Received Ph.D. in 95-96	0.722*** (0.262)	0.822*** (0.240)	1.488*** (0.386)	0.453 (0.353)	0.670** (0.303)	0.942** (0.455)	1.489*** (0.272)	2.396*** (0.635)	0.801* (0.412)	1.223*** (0.303)
Received Ph.D. in 97-98	0.519** (0.259)	0.458** (0.215)	1.241*** (0.377)	0.284 (0.327)	0.318 (0.258)	0.42 (0.448)	0.865*** (0.261)	1.620** (0.643)	0.311 (0.415)	0.598** (0.301)
Received Ph.D. in 98-99	0.133 (0.261)	0.199 (0.203)	1.010** (0.406)	-0.094 (0.343)	0.191 (0.270)	-0.239 (0.497)	0.032 (0.270)	1.542** (0.680)	-0.266 (0.451)	0.052 (0.311)
Received Ph.D. Post-02	-1.168*** (0.360)	-0.826* (0.431)	-1.551** (0.755)	-1.625*** (0.576)	-1.177* (0.610)	-2.901*** (0.560)	-2.333*** (0.496)	-2.138* (1.176)	-3.231*** (0.759)	-3.394*** (0.727)
Received Ph.D. pre-95	0.807*** (0.281)	0.761*** (0.244)	1.914*** (0.400)	0.403 (0.352)	0.669** (0.301)	1.024** (0.495)	1.473*** (0.352)	2.879*** (0.656)	1.003** (0.466)	1.516*** (0.351)
ln(Rank of Ph.D program)	-0.05 (0.056)	-0.006 (0.064)	-0.076 (0.076)	-0.003 (0.081)	0.025 (0.088)	-0.098 (0.087)	0.026 (0.095)	-0.179 (0.129)	-0.046 (0.091)	-0.013 (0.105)
1 if female	-0.16 (0.159)	-0.128 (0.140)	-0.778*** (0.244)	-0.063 (0.206)	-0.330* (0.176)	-0.058 (0.224)	-0.179 (0.250)	-0.932*** (0.294)	-0.085 (0.263)	-0.374 (0.270)
Constant	1.541*** (0.409)	0.283 (0.435)	-0.907 (0.563)	0.928 (0.567)	-0.188 (0.570)	3.454*** (0.659)	1.870*** (0.633)	0.062 (1.055)	2.685*** (0.679)	1.666** (0.722)
Observations	488	488	488	488	488	488	488	488	488	488
Pseudo R-squared	0.29	0.23	0.3	0.24	0.26	0.44	0.48	0.35	0.37	0.4

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%