Why do foreign citizens with US Ph.D. Degrees return home?

Stuart Bretschneider
Foundation Professor of Organizational Design and Public Management
Center for Organization Research & Design (CORD)
Arizona State University | School of Public Affairs
411 N. Central Ave. Suite 480
Mail Code 3720 | Phoenix, Arizona | 85004-0687
E-mail: sbretsch@asu.edu
https://cord.asu.edu/

Yiqun Dai
Research Assistant
Center for Organization Research & Design (CORD)
Arizona State University | School of Public Affairs
411 N. Central Ave. Suite 480
Mail Code 3720 | Phoenix, Arizona | 85004-0687

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Abstract

Over the past 30 years, more and more Ph.D. graduates from US universities have come from abroad. Many of these individuals are temporary visa holders. Until recently little has been known about temporary visa holders tendencies to return home. Between 2008 and 2013 the National Science Foundation (NSF) began a process of surveying Ph.D. graduates from US universities that live abroad. Known as the International Survey of Doctoral Recipients (ISDR), this new data source provides a basis to understand the phenomena of international Ph.D. graduates from U.S. universities returning to their home countries. This paper uses data from the ISDR and its domestic counterpart, Survey of Doctoral Recipients (SDR), to model the probability such individuals will return home. Our theoretical framework identifies four categories of relevant variables: economic factors (e.g. wage and job type), factor related to connectedness with their home country (e.g. earlier higher education degrees and country effects), measures of embeddedness within professional research networks (e.g. research quality of degree program and nature of degree funding), and policy related variables. In particular we are interested in the extent to which foreign countries make returning home more attractive by increasing their science infrastructure. Findings suggest that salary, the research quality of their degree granting university, and the main funding mechanism for their degree have little effect; while, however, market conditions at home, funding from abroad for their degree, investment in science infrastructure at home and connectedness through various institutions increase the likelihood of return. Subsample analysis suggest that the policy variables and local labor market effects are being driven primarily by the large number of individuals in the sample from China.

Keyword: Return migration; STEM workforce; Science Infrastructure; Science Policy; Transnationalism

1.0 Introduction

It is often argued that one of the major engines of innovation and economic growth comes from advanced degree holders in science and engineering through creation of new ideas and technologies. More and more work on science and technology policy associated with promoting innovation and economic development has found the number of scientists and engineers is significant, both theoretically and statistically, to a wide assortment of relevant indicators of innovation such as patents, trademarks and economic growth (Nelson and Rosenberg 1993, Freeman and Soete 1997, Baumol 2004). While the US is one the world's largest producers of doctorates in the world, the US graduate higher education system is also perceived by much of the rest of the world as the best place for individuals to study and earn their doctorates. Thus over the last 40 years it has increasingly attracted more and more non-US citizens. Today almost 40% of US doctoral degrees go to non-US citizens, more than double the rate from 1970(Chang and Milan 2012) . Between 2001 and 2007 only 14% of all US doctoral graduates were living abroad but by 2012 that rate jumped to 32.5% were living abroad. This suggests that while the US continues to be the major producer of Ph.D. graduates, more and more of them are non-US citizens who are more likely to leave the US.

There is also some early evidence that growing numbers of temporary US visa holders of US doctoral degrees are returning to their countries of national origin(Chang and Milan 2012). Ongoing work by Finn (Finn 2012, Finn 2014) has focused on this question by looking at stay rates for non-US citizens with doctoral degrees. This work tracked individuals from their time of graduation by using voluntarily provided social security numbers matched by the Internal Revenue Service records to tax returns indicating US employment.

Therefore, the objectives of this paper is to develop a theoretical explanation of the decision to return and empirically test the viability of that explanation empirically. The next section of the paper reviews the literature and develops a theoretical model for explaining individual decisions to return including some testable hypotheses. This is followed by a section that describes the data sources and operational measured developed for estimation of the model. Next we present the results from the empirical estimation and general findings. Finally we conclude the paper with a discussion of policy implications, and future directions for this research.

2.0 Literature Review and Explanatory Model

2.1 Literature Review:

Motivated by concerns over so called 'brain drain' impacts, a number of scholars have begun to study why foreign scientists living and working in a host country may decide to return to their countries of origin. Thorn and Holm-Nielsen(Thorn and Holm-Nielsen 2006) provide a useful summary of current proposed theoretical explanations as well as some descriptive data analysis. They identify a number of potential push and pull factors which are then organized under three broad categories. The first is titled 'neoclassical factors' which focuses primarily on economic conditions like wage differentials and market factors. The term 'transnationalism' describes the second category of factors which include connection to home countries, such as family ties, a sense of national identity and commitments to the future developments of their home nations. The last group of forces is labeled 'social network factors' and pick up a number of contextual and institutional considerations including connections to 'invisible colleges' and research

networks. Their empirical work focused on OECD countries and was primarily descriptive of trends.

Fontes (Fontes 2007) identified several data issues in the context of foreign scientist whose origins are from countries with weaker scientific and technical systems. Using the case of Portugal, Fontes proposed an approach to identifying and studying Portuguese born scientists working in other countries. A test of their approach generated 41 detailed case studies. While the author note the empirical results are not generalizable, they are suggestive. While many of these expatriates expressed some interest in returning home specifically to make a difference, they remained unwilling to return due to awareness of 'difficulties' at home. These difficulties tended to reflect on the quality of the research environments in Portugal. Interestingly many of these respondents were part of networks that had some attachment to Portuguese scientists and/or research institutions.

Recent work by Franzoni, Scellato and Stephan (Franzoni, Scellato et al. 2012) provides a more current statistical review of mobility patterns of foreign born scientists. This work makes use of a sample of over 17,000 respondents from 16 countries and four academic fields. They found significant variation across country by both country of origin and host country. For example Switzerland had almost 57% of respondents currently living in Switzerland self-identify as foreign nationals. India, Italy and Japan had the least foreign scientists. The authors speculate that some of this variation may be the result of post-doctoral opportunities which would in part reflect the overall quality of research environments. Similarly the authors found that India was

the country with the highest rate of emigration and that Japan had the smallest. The authors also compared the unconditional estimates of the probability of returning home and found that Spanish nationals were the most likely to return and that Indians were the least likely. The most common reason provided by respondents for returning home was for family and personal reasons.

The paper by Baruffaldia and Landoni (Baruffaldia and Landonib 2012) takes a relatively more analytic perspective and models both the choice to return and the productivity of 497 foreign researchers in Italy and Portugal. The principle finding was that for these foreign scientists both the likelihood of return and their productivity were positively related to maintaining some form of professional linkage to their home countries. These results controlled for a number of other relevant factors including research area, position and personal characteristics of the scientist.

Another analytic study conducted by Gaule (Gaule 2011) used over 1900 individual foreign scientists born after 1944 associated with a single US Ph.D. granting department in chemistry, chemical engineering, and biochemistry. This data collection strategy focused on a single institution's graduates over time was applied because of the general lack of data that follows scientist over time. The author used a discrete time hazard model for the decision to return. While the study found that only 9% of foreign faculty returned home, the most successful scientists were the least likely to do so, though they were more likely to move within the US. Interestingly, the author also found that after an adjustment period returning home seemed to have no negative effects on scientific productivity for returnees. Earlier work by Borjas and Bratsberg (Borjas and Bratsberg 1996) also found negative self-selection into return, but

negative selection occurred only at the top of the distribution and not for the average scientist. More recent work by Grogger and Hanson (Grogger and Hanson 2015) also suggest positive selection for remaining in the US.

2.2 Explanatory Model:

Labor economics and theories from organizational behavior provide a useful starting point for thinking about why individual scientists and engineers make job decisions. Yet in many situations these models provide only a partial explanation for such choices. As noted above, aggregate data analysis (Chang and Milan 2012, Chang and Milan 2014, Finn 2014) of trends for temporary US visa holders with US doctoral degrees suggest decisions to live and work abroad cannot be fully understood by wage rates alone. Certainly other factors like quality of the research environment, potential for job advancement and other work related activity matter in the return decision(Thorn and Holm-Nielsen 2006, Grogger and Hanson 2015).

Nevertheless, even science and technology workforce; performance and wages are related to how an individual fits within broader institutional and professional networks (Grogger and Hanson 2015). During the training and education process scientists and engineers become part of established networks, often through funded research. Thus it is likely the characteristics of the education process either facilitate or hinder how well connected new scientists and engineers are likely to become to such networks (Dietz, Chompalov et al. 2000, Bozeman, Fay et al. 2013). It is also likely that the degree to which new scientists and engineers are embedded into research networks will influence initial and future job decision making. Therefore, there is a potential linkage between how students are funded during their education, the degree of connection that

produces so-called ‘invisible colleges’, and in turn their initial and future decisions about jobs, particularly their willingness to either stay in the US or return home (Thorn and Holm-Nielsen 2006, Grogger and Hanson 2013).

Several empirical studies have found significant linkages between those who return home and specific ties to their home countries. Sometimes these ties are personal and familial (Franzoni, Scellato et al. 2012) and sometimes they are of a more professional nature (Baruffaldia and Landonib 2012). It is likely that differences in national cultures affect the likelihood and nature of these linkages. Several empirical studies demonstrate significant variation across nation of origin, strongly suggesting this type of connection (Chang and Milan 2012, Franzoni, Scellato et al. 2012, Chang and Milan 2014).

Next we need to consider the role of policy from both the perspective of the US and the foreign country of origin. Policy is likely to influence the individual either through financial and job related incentives or their perceptions of the research environment at the lab, university, and systemic level. In many foreign countries the quality of the system influences the perception of universities and programs. Thus national science and higher education policy is likely to be relevant (Thorn and Holm-Nielsen 2006). At the individual level grants that support a student’s education can come from their home country or the US, reflecting different policy influences. Characterizing the research infrastructure of foreign scientists’ home countries reflects how that country uses policy to affect perceptions of the quality of the research environment(Zweig and Wang 2013). This could include per capita national research and development expenditures, size of the research and development workforce, whether any of their universities are internationally

ranked (and for how long), and the existence and extent of government funds related to merit based research completion. Thus our initial theoretical framework is:

$$Pr (I=1) = F(E, O, R, P, C, t) \quad (1)$$

Where

I is a binary variable indicating that a US visa holder with a US degree returns home
E is a vector of economic variables (e.g. wages, type of work, local labor market conditions),
O is a vector of variables that reflect connectedness to country of origin (e.g. undergraduate university, country effects),
R is a vector of variables that reflect how embedded one is in professional research networks (e.g. quality of doctoral granting university and department, nature of educational funding.)
P is a vector of policy variables (e.g. funding for doctoral education including type, amount and nation of origin, science infrastructure),
C is a vector of control variable (e.g. personal and family demographics), and
t is the time since graduation.

2.3 Testable Hypotheses

Labor market theory suggests that both the wage rate and labor market conditions matter. In the context of this study, US real wage rates for high skilled Ph.D. individuals tends to be above that found in most other countries, particularly developing and middle income countries (Rosenzweig, Irwin et al. 2006, Clemens, Montenegro et al. 2008). Since relative wages are the

key to understanding how wages effect the decision process, this suggest that current wage rates for individuals in the US are likely to work against the decisions to return home. Thus we hypothesize:

H1: Wage rates reduce the likelihood an individual will leave the US and return home, all else equal.

Local market conditions effect relative wages but also individual perceptions about future opportunities for wage growth. Thus, in countries where the number of skilled science and technical workers are growing at a faster relative rate than in the US, individual who might otherwise decide to return home face issues of future downward pressure of wage growth. Thus

H2: As a home countries science and technical workforce expands, creating downward pressure of long term science and technical wage growth, individuals are less willing to return, all else equal.

This framework accounts for labor market conditions but they are not the only focus of our theory. Instead this model allows us to understand how the quality and nature of the higher education process might affect the decision to return through a process of building professional network linkages. The idea is that higher quality programs provide access to professional networks(Bound, Demirci et al. 2014, Grogger and Hanson 2015). This process is likely to be enhanced if the student is funded predominantly through research activities as opposed to teaching activities. Once an individual is embedded in these research networks the decision to

leave the US are likely to attenuate their professional relationships and their access to grant money (Black and Stephan 2007). Thus we hypothesize:

H3: As the quality of their research training increases the less likely the individual is to return home, all else equal.

Some forms of funding promote active research training over for example the teaching function. A large proportion of research funding in US universities and certainly the most prestigious are from national institutes such as NSF and NIH. The level of US research expenditures is thus related direct US government policy and indirectly through R and D tax credits(Bloom, Griffith et al. 2002). Consequently, individuals mostly funded by research grants, fellowships and research assistantships are not only likely to develop better research skills, there are more likely to become embedded in higher quality research network. Thus:

H4: Individuals whose primary source of funding for their degree focus on research training and activities are more likely to be embedded in higher quality research networks and less likely to return home, all else equal.

Individuals often forego economic benefits for cultural and familial reasons. Thus we expect the extent to which individuals are socially and culturally connect to their home countries it is likely to increase their likelihood of returning home. While simple to state this is very complex. It can include such diverse issues as social constructed gender roles, family demographics (e.g. marital status), and connection to social networks through prior institutional affiliations (e.g. number of

prior higher education degrees from their home country). Empirical efforts to deal with these factor are typically done through the use of numerous control variables like gender, marital status, number of higher education degrees from their home country, and country specific effects. It is important to understand in the context of the current study, the vast majority of non-US citizens graduating with US based Ph.D. degrees are from developing and middle income societies, particularly from Asia. Specifically, we hypothesize

H5: Unmarried individuals are more likely to return home than married individuals in order to better identify appropriate spouses, all else equal.

H6: Women are less likely than men to return home due to weaker social gender roles, all else equal.

H7: As an individual has higher education degrees from institutions in their home country they are more likely to return, all else equal.

Next we are interested in how science policy might affect the individual decision to return. Here we suggest several possible mechanisms. The first is direct subsidy programs offered to an individual to study abroad. If a major source of funding for non-US citizens is from foreign sources, which are most likely to be from their home country, this is likely to create either a legal requirement or at the very least increase an individual's sense of duty or loyalty to their home country. Thus:

H8: Individuals who have major foreign financing for their higher education are more likely to return home, all else equal.

Some countries have, by policy, increased investments in their science infrastructure. Here countries like China have invested in increasing their science and innovation outcomes through increase government expenditures for funding science and technology (Regets 2001, Saxenian 2002, Zweig, Changgui et al. 2004, Grogger and Hanson 2015). Consequently,

H9: Countries that have increased expenditures for science and technology relative to the US will increase the likelihood their citizens will return, all else equal.

While there have been a couple of attempts to model foreign Ph.D. scientist decisions to return home they are based on very limited and unique data sets applying relatively limited theoretical frameworks. The NSF data described by Chang and Milan (Chang & Milan, 2012, 2014) provides an opportunity to investigate this issue in the US context and apply a more complete theoretical framework.

3.0 Data and Measurements

3.1 Data sources:

The data we used are from the National Survey of Doctorate Recipients (SDR) and the International Survey of Doctoral Recipients (ISDR), which is a panel study sponsored by NSF and conducted every three years on representative cohorts of Ph.D. graduates. These data are augmented with survey data taken at the time each individual graduated with their doctoral

degree, the Survey of Earned Doctorates (SED). The SDR targets the population of Ph.D. students who received doctoral degrees in the US and were living in the US on the survey reference date, while the ISDR includes Ph.D. students who were residing outside of the US. There have only been two iterations of the ISDR, 2010 and 2013. Based on the information of citizenship and residence location, we can know whether a respondent has returned to his home country. Our analytic sample is based on the 2013 SDR and ISDR. Since the data on graduates living abroad who received degrees before 2001 is not adequate to characterize returnees due to limitations of sampling, our sample contains only graduates since 2001. The decision to use the 2013 generates the largest possible time frame since graduation, 2001-2011.

3.2 Dependent variable:

We define an individual as having returned home if in the 2013 ISDR they indicate they reside and work in their country of origin, as indicated at the time of their graduation from a US institution of higher education. Thus we use their initial declaration of their home country from the SED and their current status from the 2013 ISDR to make this determination. Students may also live in some country that is not their home country except the U.S. We only count a subject as 'returned' if they returned home, and therefore students who are residing in the U.S. or other foreign countries are defined as not returned. We use a binary variable coded 1 for return and 0 for not returned to measure their return status.

3.3 Independent variables:

Appendix A provided definitions and coding for all independent variables used in this study. Our main independent variables are the log of salary, R&D infrastructures, primary source of degree

funding, undergraduate degree granted location, whether the respondent has a master degree granted from an institution in their home country, gender, marital status, job relevancy to degree, university quality, sector of occupation, and a measure of their intention to return home filled out at the time of graduation on the SED. We also make use of information about their country of origin and their academic area of concentration. Six additional control variables are also considered; whether a subject changed jobs during last two years, number of degrees granted at institutions from their home country, whether they have a degree in a different field than they are currently employed, perspectives on job preference, age at graduation, and years since graduation.

Current salary is the first important determinant we are interested in. In our sample, the average annual salary of returnees was approximately $63,000 in 2013, and the average salary of graduates who were residing in the US was about $90,000. We take the natural logarithm for each respondent's current annual salary in USD in 2013.

We use the ratios of total research and development (R&D) researchers to the US level by year as a measure of local labor market conditions. Next we calculate the ratio of total R&D expenditures of a Ph.D.'s home country to the US level by year to capture relative investments in science infrastructure. The R&D researcher data is extracted from the World Development Indicators of the World Bank, and the R&D expenditure data came from the OECD Main Science and Technology Indicators Database. The R&D expenditure data were converted into 2005 USD to be comparable to US data. During the first decade of 21st century, there were about 3800 R&D researchers per million people in the US, and the average annual growth rate was less

than 1.5%. China by comparison, had 577 per million people in 2001, but had 1020 R&D researchers per million people in 2012, growth of 76% in 11 years. The ratio to the US R&D expenditures increased from 0.16 in 2001, to 0.35 in 2008 and then declined to 0.25 in 2012. The US has the greatest amount of R&D expenditure as well, with $328 billion in 2005. The differences in R&D expenditures with the US has been narrowing for most countries during the last decades especially China. In 2012, the amount of Chinese R&D expenditure reached 65% of that of the US.

The SED asks respondents to identify the major form of financing associated with their degree. The five main funding sources we focus on are; fellowship, grant, teaching assistantships, research assistantships, foreign country source. A sixth source of funding was used as the base case in our models: all other sources which include personal family sources of funding. We created individual binary variables for each of these. In our sample, 66% of respondents' degree funding was primarily from teaching or research assistantships. Funding sources were very different among students from different countries. 92% of Thai Ph.D. students were supported by their home country, but Chinese and Indian Ph.D. students were mostly funded by teaching or research assistantship.

There were three possible locations for a respondents' undergraduate degree granting institution: the US, their home country or some other country. We applied a similar approach to coding the location of their Master's degree granting institution. For both of these constructs we coded the US case as the reference class for estimation.

Respondent indicate the extent to which their current job is relevant to their degree training as closely related, somewhat related and not related. This was coded as a single variable with corresponding values of 1, .5 and 0.

Measuring of the quality of a degree granting institution is complex and problematical. Consequently, we developed two alternative approaches. The first approach is based on faculty research activity. The data on university rank by faculty research activity come from the Data Table for the National Research Council's A Data-Based Assessment of Research-Doctorate Programs in the United States (2006), authorized by National Academy of Sciences. Our second approach used the median program's ranking as a measurement of the quality of a university. The data of federal research expenditure ranking came from the data table of "Top 200 Institutions - Federal Research Expenditures (2014)", by Center for Measuring University Performance.

Salary and market conditions vary by sector of employment. Respondents indicated which sector they were currently employed. Four categories were identified; non-profit organization, for-profit company or organization, government, and university or college. We modeled these categories using four binary variables with non-profit sector as the base case for estimation.

At the time a student graduates and fills out the SED, they are asked about their future plans. This two-part question identifies the individuals 'expectation' to either stay in the US or move some foreign country and where in the US or which foreign country they expect to go. This information is used to develop two binary variables for three categorical outcomes; leave for

home, leave for another country, or remain in the US. Remaining in the U.S. is used as the base case in our model estimation.

3.4 Control variables:

NSF categorizes academic areas of concentration into seven broad categories: biological, agricultural & other life science, computer & mathematical science, physical science, psychology, social science, engineering, and health. A series of binary variables are used to model the effects of the area of concentration as a fixed effect in our model. We use a similar strategy associated with the country of origin. Using country of origin is a bit problematic in that many of the cultural connection are likely correlated with this variable. We also consider the year of graduation and use fixed effects dummy variables to model these effects.

We also include four more controls in our model. A binary variable indicates if the respondent has changed their job during last two years. A variable also is included which counts how many degrees the respondent holds from institutions in their home country. Finally we include a binary variable to indicate if the respondent holds a degree from multiple fields. Table 1 provides summary statistics on all of our variables. The full sample drawn from the SDR and the ISDR is 6609. Since there was no data on research expenditures and STEM graduates for many of the countries sending small number of students to the US, only 4134 cases were used in estimating various models. Unfortunately this results in a problem of selection in favor of individuals coming from countries with strong levels of scientific infrastructure at home.

Table 1: Descriptive Statistics

	Mean	Std	Min	Max	N
Salary	79862.1	157037.2	0.0	7545600.0	6390
R&D infrastructure					
Ratio of researchers	0.415	0.440	0.001	2.125	5634
Ratio of expenditure	0.132	0.145	0.001	0.578	5179
Primary funding source					
Fellowship	0.176	0.381	0	1	6144
Grant	0.040	0.197	0	1	6144
Teaching assistantship	0.189	0.391	0	1	6144
Research assistantship	0.470	0.499	0	1	6144
Foreign country	0.060	0.237	0	1	6144
Others	0.065	0.247	0	1	6144
Undergraduate degree					
US	0.086	0.280	0	1	6609
Home country	0.815	0.388	0	1	6609
Other country	0.099	0.299	0	1	6609
Master degree at home	0.316	0.465	0	1	6609
Gender	0.647	0.478	0	1	6609
Marriage	0.796	0.403	0	1	6609
Job related to degree	0.850	0.272	0	1	6390
University quality					
Research activity	45.788	24.187	6.5	212	6213
Research expenditure	81.233	81.460	1	664	6577
Employer sector					
Non-profit	0.184	0.388	0	1	6390
For-profit	0.332	0.471	0	1	6390
Government	0.080	0.271	0	1	6390
University	0.393	0.488	0	1	6390
Others	0.011	0.103	0	1	6390
Expectation of return					
Return	0.298	0.457	0	1	6417
Stay in US	0.600	0.490	0	1	6417
Go to other country	0.103	0.303	0	1	6417
Job change	0.193	0.395	0	1	6609

Table 1 continued: Descriptive Statistics

	Mean	Median	Std	Min	Max	N
Salary satisfaction	0.715	0.75	0.205	0	1	6390
Year of graduation						
2001	0.072		0.259	0	1	6609
2002	0.073		0.260	0	1	6609
2003	0.079		0.269	0	1	6609
2004	0.081		0.272	0	1	6609
2005	0.101		0.302	0	1	6609
2006	0.116		0.320	0	1	6609
2007	0.116		0.320	0	1	6609
2008	0.107		0.309	0	1	6609
2009	0.101		0.302	0	1	6609
2010	0.110		0.312	0	1	6609
2011	0.045		0.208	0	1	6609
Major						
Biological, agricultural and life science	0.201		0.400	0	1	6608
Computer and mathematical science	0.116		0.320	0	1	6608
Physical and related science	0.160		0.367	0	1	6608
Psychology	0.030		0.170	0	1	6608
Social science	0.168		0.374	0	1	6608
Engeneering	0.281		0.449	0	1	6608
Health	0.045		0.208	0	1	6608
Country of citizenship						
China	0.199		0.399	0	1	6609
EU	0.119		0.324	0	1	6609
India	0.101		0.301	0	1	6609
South Korea	0.081		0.273	0	1	6609
Taiwan	0.044		0.205	0	1	6609
Canada	0.039		0.195	0	1	6609
Turkey	0.038		0.192	0	1	6609
Thailand	0.035		0.183	0	1	6609
Japan	0.021		0.144	0	1	6609
Others	0.323		0.468	0	1	6609

4.0 Estimation and Findings

4.1 Base Case:

Since the dependent variable is binary, we apply standard approaches to estimation including linear probability, probit, and logit models, which define the dependent variable as the probability of return. Table 2 presents our basic result for estimation of the linear, probit, and logit probability models. Not surprisingly the results are consistent across all three forms of the model. Each model does a reasonable job of explaining variation in individual decisions with r-square and pseudo-r-square running around 0.48 with samples over 4100 cases. The higher the wage the less likely one is to return. This is even true when taking into account the country of origin. This is due to the generally higher wage rates in the US. The actual story here is not that higher wage rates work against return but that they promote the decision to stay in the US. We also find that as the labor supply at home increases (more college graduates in STEM) it decreases the likelihood individuals will return home. Overall these results are consistent with economic theory-wages and labor market condition effecting wages matter. That said, returnees are likely to get higher wages by staying in the US than returning home. These results support both hypothesis 1 and 2.

Table 2: Linear, Probit and Logit Models for Probability of Return

	Linear	Probit	Logit
1. Log of salary	-.049***	-.214***	-.426***
	(.014)	(.069)	(.145)
2. R&D infrastructure			
2.1 Ratio of researchers	-.086**	-.399*	-.642
	(.038)	(.213)	(.422)
2.2 Ratio of expenditure	.074	.484	.896
	(.074)	(.612)	(1.189)
3. Primary funding source			
Fellowship	.007	.032	.146
	(.029)	(.172)	(.321)
Grant	.004	.052	.171
	(.036)	(.223)	(.434)
Teaching assistantship	-.015	-.015	.006
	(.029)	(.173)	(.322)
Research assistantship	-.027	-.151	-.188
	(.027)	(.165)	(.309)
Foreign country	.048	.183	.344
	(.045)	(.224)	(.424)
4. Undergraduate degree			
Home country	.157***	.992***	1.859***
	(.028)	(.202)	(.396)
Other country	.085***	.459**	.895**
	(.027)	(.191)	(.373)
5. Master degree at home	.092***	.652***	1.124***
	(.022)	(.150)	(.287)
6. Gender and marriage			
6.1 Male	.019	.128	.243
	(.025)	(.141)	(.272)
6.2 Marriage	-.045**	-.345***	-.674***
	(.019)	(.119)	(.230)
6.3 Interaction	.048*	.356**	.665**
	(.027)	(.162)	(.309)
7. Job related to degree	.039**	.351***	.618***
	(.017)	(.126)	(.241)
8. University quality			
8.1 Research activity	-.000	-.000	-.002
	(.000)	(.002)	(.005)
8.2 Research expenditure	.000	.000	.001
	(.000)	(.001)	(.002)
9. Sector:			
For-profit	.039**	.127	.264
	(.015)	(.099)	(.199)
Government	.076***	.393***	.709***
	(.024)	(.129)	(.243)
University	.038**	.218**	.365**
	(.015)	(.090)	(.172)
Others	.130	.647	1.380*
	(.103)	(.442)	(.819)
10. Intention of return			
Return	.547***	1.913***	3.338***
	(.018)	(.070)	(.134)

Other counties	.083*** (.022)	.451*** (.094)	.755*** (.180)
11. Year of graduation			
2010	.027 (.020)	.231 (.162)	.492 (.320)
2009	.049** (.022)	.430*** (.165)	.881*** (.326)
2008	.073*** (.023)	.458*** (.164)	.977*** (.324)
2007	.075*** (.024)	.541*** (.169)	1.065*** (.329)
2006	.107*** (.025)	.740*** (.170)	1.486*** (.343)
2005	.095*** (.025)	.615*** (.170)	1.293*** (.341)
2004	.087*** (.027)	.565*** (.178)	1.162*** (.357)
2003	.059** (.028)	.312 (.193)	.764** (.387)
2002	.175*** (.032)	1.047*** (.194)	2.060*** (.383)
2001	.200*** (.036)	1.052*** (.204)	2.136*** (.436)
12. Interaction btw log of salary and countries			
China * log salary (obs: 1123, 27.2%)	-.126*** (.025)	-.865*** (.168)	-1.667*** (.335)
EU * log salary (obs: 625, 15.1%)	-.034 (.026)	-.186 (.127)	-.374 (.265)
India * log salary (obs: 565, 13.7%)	-.054 (.051)	-.171 (.221)	-1.005 (1.035)
Korea * log salary (obs: 468, 11.3%)	-.012 (.020)	.006 (.106)	-.036 (.263)
Canada * log salary (obs: 232, 5.6%)	.040 (.027)	.214* (.124)	.404* (.220)
Turkey * log salary (obs: 218, 5.3%)	-.091** (.036)	-.448** (.189)	-.780* (.474)
Other controls	Y	Y	Y
Country	Y	Y	Y
Major	N	N	N
N	4134	4134	4134
(Pseudo) R2	.482	.482	.483
Log pseudolikelihood		-22259.746	-22239.111
Joint test: F statistic for linear model, chi-squared statistic for probit and logit model			
Source of funding (5)	1.74	7.45	5.76
University quality (2)	.38	.03	.32
Other controls (13)	4.70***	63.42***	57.02***
Country (118)	3.57***	87.28***	78.74***
Major (6)	.63	3.29	2.62

Hypothesis 3 suggested that the research quality of their training institution might matter. The empirical results do not supported this hypothesis. The two individual measures and the joint hypothesis test on both measures together were all statistically insignificant. Hypothesis 3 attempted to link return to the extent to which individuals were embedded in research networks during their Ph.D. program. Hypothesis 4 also attempted to establish this type for a link by looking at the primary way individuals had their degrees funded. None of these variable were statistically significant individually and when a joint test was done considering all of these variables the collective effect is also insignificant.

Demographic factors do have an influence on the decision to return. While the gender variables is statistically insignificant, marital status and the interaction of marital status with gender are significant. The results support hypothesis 5 that being married decreases the likelihood of return. The main effect for gender suggested in hypothesis 6 is not supported but the interaction effect of gender and marriage does provide some support for hypothesis 7. Married men are more likely than married women to return home. A more significant demographic effect though is found with regard to an individual's association with institutions of higher education in their home countries. Having an undergraduate degree and having a Master's degree from their home country significantly increases their likelihood of return.

The final two hypotheses focus on the role of policy, specifically from the perspective of the foreign country. First hypothesis 8 is rejected, foreign funding did not seem to promote return. The final hypothesis considered the role of home country investment in science and technical

infrastructure. In each model the relevant estimated coefficients were statistically insignificant leading us to reject hypothesis 9.

Several other results from these models are worth noting. There was significant variation in return by country of origin but not by field of study. This is consistent with other work on return migration (Chang and Milan 2012, Franzoni, Scellato et al. 2012). There was also significant effects associated with year of graduation. There appears to be a trend of growing rates of return starting with 2010 graduates consistently back to 2006. The two highest years were the two earliest years represented, 2001 has 20% return and 2002 had 17.5% return.

Another result worth noting is that declared intentions to return home or leave the US at the time of graduation was highly significant. Clearly most individuals who do return home indicate this expectation early on. Since this particular variable is made at the time of graduation and the sample process does not include individuals until at least one year later this variable in not likely to be endogenous but rather acts as a leading indicator of a future decision.

4.2 Endogeneity of Salary

One serious concern in our model is the salary variable is likely to be endogenous. There are a number of sources of endogeneity here. First, return and salary are likely co-determined. That is ones decision to return may not be caused by the wage rate offered but the wage rate offered may be effected by the decision to return. Empirically there are systematic differences in wages by country and even within country differences related to inducing high skilled citizens living abroad to return. Another important source of endogeneity is a known missing variable bias

problem. Prior empirical work suggest an adverse selection problem related to productivity (Borjas and Bratsberg 1996, Gaule 2011, Grogger and Hanson 2015). Thus, lower performing individuals less able to compete in the US are more likely to return. Since, we lack a good measure of productivity it is an omitted variable likely to be correlated with salary.

In order to consider the possible effects of endogeneity and bias in estimation we also applied an instrumental variables approach to estimation. Each respondent was asked a number of questions about how important a variety of job attributes were to them. Each question had respondents indicated on a four point likert scale how important each job characteristic was to them. There were nine characteristics; salary, benefits, job security, job location, opportunities for advancement, intellectual challenge, level of responsibility, degree of independence, and contribution to society. We coded the scale as1 for "very important", 0.75 denotes for "somewhat important", 0.5 denotes "somewhat unimportant", and "0.25" denotes "not important at all". Two of these attributes were used as instruments, salary and contribution of job to society.

Table 3 presents the results of estimating both a linear probability and probit form of the model using one and then two instruments for the log of salary. Estimation results in the first two columns are based on using a single instrument-importance of salary, and the second two columns present results based on two instruments –importance of salary and importance of a job's contribution to society. Test for exogeneity of log of salary are rejected and first-stage F-test suggest the instruments are strong. Not surprisingly, these models do not fit as well as the

base models. Most of the substantive findings from the base model remain the same with four important changes in result.

Table 3: Endogenous Linear and Probit Models of Return

	(1)	(2)	(3)	(4)
	IV Linear	IV Probit	IV Linear	IV Probit
1. Log of salary	.046	.211	.041	.195
	(.044)	(.214)	(.043)	(.216)
2. R&D infrastructure				
2.1 Ratio of researchers	-.116***	-.507***	-.116***	-.512***
	(.040)	(.195)	(.040)	(.197)
2.2 Ratio of expenditure	.176**	.865*	.176**	.877*
	(.072)	(.461)	(.072)	(.463)
3. Primary funding source				
Fellowship	.004	.018	.004	.021
	(.031)	(.154)	(.031)	(.155)
Grant	.006	.043	.007	.049
	(.037)	(.193)	(.037)	(.194)
Teaching assistantship	.006	.069	.005	.067
	(.031)	(.158)	(.031)	(.159)
Research assistantship	-.022	-.126	-.021	-.124
	(.029)	(.147)	(.029)	(.148)
Foreign country	.114**	.506**	.112**	.505**
	(.055)	(.246)	(.054)	(.246)
4. Undergraduate degree				
Home country	.176***	.964***	.176***	.970***
	(.028)	(.195)	(.028)	(.195)
Other country	.070**	.360**	.070**	.365**
	(.028)	(.183)	(.028)	(.182)
5. Master degree at home	.130***	.741***	.130***	.742***
	(.025)	(.136)	(.025)	(.136)
6. Gender and marriage				
6.1 Male	.023	.124	.023	.124
	(.027)	(.134)	(.027)	(.134)
6.2 Marriage	-.039*	-.260**	-.039*	-.261**
	(.021)	(.119)	(.021)	(.119)
6.3 Interaction	.020	.198	.022	.202
	(.030)	(.161)	(.030)	(.162)
7. Job related to degree	.022	.218	.024	.224*
	(.018)	(.124)	(.018)	(.123)
8. University quality				
8.1 Research activity	-.000	-.000	-.000	-.000
	(.000)	(.002)	(.000)	(.002)
8.2 Research expenditure	.000	.001	.000	.001
	(.000)	(.001)	(.000)	(.001)
9. Sector:				
For-profit	-.013	-.083	-.013	-.083
	(.021)	(.110)	(.021)	(.111)
Government	.060**	.293**	.060**	.295**
	(.027)	(.131)	(.026)	(.131)
University	.072***	.357***	.071***	.354***
	(.019)	(.084)	(.019)	(.084)
Others	.113	.453	.114	.459
	(.097)	(.364)	(.097)	(.369)
10. Intention of Return				
Return	.601***	1.876***	.599***	1.882***

	(.023)	(.117)	(.022)	(.115)
Other counties	.097*** (.023)	.429*** (.090)	.096*** (.023)	.426*** (.090)
11. Year of graduation				
2010	.013 (.021)	.111 (.139)	.013 (.021)	.114 (.140)
2009	.019 (.025)	.203 (.159)	.020 (.025)	.210 (.160)
2008	.056** (.025)	.319** (.160)	.056** (.025)	.323* (.160)
2007	.040 (.027)	.291* (.171)	.041 (.027)	.297* (.172)
2006	.072*** (.027)	.447*** (.173)	.073*** (.027)	.456*** (.174)
2005	.047 (.031)	.290 (.187)	.048 (.030)	.300 (.188)
2004	.036 (.031)	.246 (.189)	.037 (.031)	.256 (.190)
2003	.028 (.031)	.176 (.182)	.029 (.030)	.181 (.182)
2002	.138*** (.035)	.717*** (.218)	.139*** (.035)	.725*** (.219)
2001	.152*** (.037)	.694*** (.228)	.153*** (.036)	.707*** (.228)
Other controls	Y	Y	Y	Y
Country	Y	Y	Y	Y
Major	N	N	N	N
N	4134	4134	4134	4134
(Pseudo) R2	.394		.399	
Log pseudolikelihood		-125605.47		-125612.73
Instruments	Satisfaction for salary		Satisfaction for salary, Importance of contribution to society	
Test of exogeneity	13.190***	7.59***	12.636***	7.07***
Test of overidentification			.951	3.728*
First-stage F test	61.902***		32.541***	
Joint test: chi-squared statistic				
Source of funding (5)	10.50*	14.22**	10.43*	14.08**
University quality (2)	1.64	1.16	1.59	1.11
Other controls (13)	70.27***	79.01***	70.45***	79.14***
Country (118)	163.67***	170.39***	165.07***	170.87***
Major (6)	6.26	7.81	6.08	7.63

First, two policy related effects now emerge as statistically significant. Funding provided for an individual's degree program by a foreign country increases the probability of return. Growing expenditures for scientific and technical infrastructure in the home country also increases the likelihood of return. The gender effect evident in the base model through its interaction with

marriage is no longer statistically significant. Finally, the wage variable is also no longer statistically significant. This last change is of course a little surprising but consistent with the idea that as an endogenous variable the results in the base model would be biased.

4.3 The Case of China

We also considered one additional form of sensitivity analysis. The single largest country by far to be represented in our sample is from China. In the full sample of 6609 cases Chinese individuals represent 19.9% of the cases. In the estimation sample Chinese individuals make up 27.2% of the cases. We re-ran the exactly identified endogenous forms of the LPM and the Probit Model for the sample after excluding individuals from China. Table 4 presents the original models from Table 3 along with the new estimates. The main difference in results is the role of investments in R&D. The other significant effect remain including the role of foreign funding of graduate education. These results suggest that China alone is driving the effect associated with building up their domestic science infrastructure.

Bretschneider and Dai (2016) reviewed the trend in the rate of return for this same population between 2001 and 2011. They found the overall rate of return dropped from approximately 28% to 20% and the rates for the 10 countries contributing the model foreign students to the US also dropped with one exception, China. For the 2001 cohort from China, approximately 9% returned home but by 2011 this had climbed to nearly 14%. Also during the decade from 2001 to 2011 the relative economic situation dramatically changed as a result of the Great Recession. This may have led to a perception that the relative economic advantage of returning home to China had improved though there are no corresponding changes in relative salaries between the US and

China during this time period. While it is possible that the Chinese case is unique, it does suggest that it is possible for a country to effect the relative attractiveness of returning home for their high skilled citizens trained abroad.

Table 4: Endogeneous Models (Exactly Identified) with and without Chinese Cases

	Full sample		Sub-sample without Chinese obs.	
	(1)	(2)	(3)	(4)
	IV Linear	IV Probit	IV Linear	IV Probit
1. Log of salary	.046 (.044)	.211 (.214)	.065 (.050)	.258 (.204)
2. R&D infrastructure				
2.1 Ratio of researchers	-.116*** (.040)	-.507*** (.195)	-.065 (.045)	-.213 (.211)
2.2 Ratio of expenditure	.176** (.072)	.865* (.461)	-.195 (.191)	-1.306 (1.049)
3. Primary funding source				
Fellowship	.004 (.031)	.018 (.154)	.022 (.037)	.094 (.162)
Grant	.006 (.037)	.043 (.193)	.013 (.043)	.071 (.202)
Teaching assistantship	.006 (.031)	.069 (.158)	.023 (.038)	.134 (.166)
Research assistantship	-.022 (.029)	-.126 (.147)	-.019 (.035)	-.119 (.157)
Foreign country	.114** (.055)	.506** (.246)	.128** (.062)	.510** (.242)
4. Undergraduate degree				
Home country	.176*** (.028)	.964*** (.195)	.189*** (.035)	.911*** (.200)
Other country	.070** (.028)	.360** (.183)	.060* (.031)	.347* (.183)
5. Master degree at home	.130*** (.025)	.741*** (.136)	.158*** (.033)	.699*** (.151)
6. Gender and marriage				
6.1 Male	.023 (.027)	.124 (.134)	.025 (.031)	.132 (.140)
6.2 Marriage	-.039* (.021)	-.260** (.119)	-.040 (.025)	-.228* (.124)
6.3 Interaction	.020 (.030)	.198 (.161)	.021 (.036)	.148 (.169)
7. Job related to degree	.022 (.018)	.218 (.124)	.033 (.023)	.250** (.128)
8. University quality				
8.1 Research activity	-.000	-.000	.000	.001

	(.000)	(.002)	(.000)	(.002)
8.2 Research expenditure	.000 (.000)	.001 (.001)	.000 (.000)	.001 (.001)
9. Sector:				
For-profit	-.013 (.021)	-.083 (.110)	-.017 (.025)	-.071 (.114)
Government	.060** (.027)	.293** (.131)	.079** (.036)	.328** (.150)
University	.072*** (.019)	.357*** (.084)	.050** (.023)	.217** (.094)
Others	.113 (.097)	.453 (.364)	.011 (.084)	.046 (.341)
10. Intention of Return				
Return	.601*** (.023)	1.876*** (.117)	.596*** (.024)	1.816*** (.141)
Other counties	.097*** (.023)	.429*** (.090)	.108*** (.026)	.479*** (.096)
11. Year of graduation				
2010	.013 (.021)	.111 (.139)	.027 (.027)	.171 (.157)
2009	.019 (.025)	.203 (.159)	.008 (.031)	.123 (.171)
2008	.056** (.025)	.319** (.160)	.042 (.031)	.220 (.168)
2007	.040 (.027)	.291* (.171)	.034 (.034)	.281 (.188)
2006	.072*** (.027)	.447*** (.173)	.077** (.034)	.429** (.187)
2005	.047 (.031)	.290 (.187)	.069* (.038)	.360* (.197)
2004	.036 (.031)	.246 (.189)	.043 (.036)	.282 (.194)
2003	.028 (.031)	.176 (.182)	.032 (.038)	.188 (.198)
2002	.138*** (.035)	.717*** (.218)	.172*** (.041)	.770*** (.224)
2001	.152*** (.037)	.694*** (.228)	.146*** (.042)	.642*** (.230)
Other controls	Y	Y	Y	Y
Country	Y	Y	Y	Y
Major	N	N	N	N
N	4134	4134	3011	3011
(Pseudo) R2	.394		.391	
Log pseudolikelihood		-125605.47		-89699.343
Instruments	Satisfaction for salary		Satisfaction for salary	
Test of exogeneity	13.190***	7.59***	10.141***	6.30**
Test of overidentification				
First-stage F test	61.902***		40.769***	
Joint test: chi-squared statistic				
Source of funding (5)	10.50*	14.22**	10.33*	16.15***
University quality (2)	1.64	1.16	3.17	3.75
Other controls (13)	70.27***	79.01***	49.72***	60.05***
Country (118)	163.67***	170.39***	141.90***	141.26***
Major (6)	6.26	7.81	5.43	5.20

4.4 Overall Results

From a policy perspective these results suggest several key points. First the quality of their educational experience and the funding mechanism for graduate education does not sufficiently embed individuals into research network so as to mitigate the likelihood they will return. In other word the idea that the educations and 'invisible college' networks hold people or reduce the cultural and social connections forged earlier in a person's life does not seem to hold. The one exception is that foreign funding does increase the likelihood of return. It also seems that cultural connections are strong forces in attracting non-US citizens with US Ph.Ds. to return to their home countries. This takes several forms. For example, unmarried individuals are likely drawn home to find more suitable marriage partners. Also, connections to high education institutions in their home country also exerts a force for return. This effect is actually compounded as individuals have more and more degrees from home. Finally, countries can effect individual Ph.Ds. perception of opportunities by enhancing the quality of their science and technical infrastructure. Countries that continue to invest more in those infrastructures improve the probability their citizen with US Ph.Ds. will return, though the evidence suggest that this is primarily applicable to China.

5.0 Discussion and Conclusions

This paper has developed a theoretical framework for understanding why non-US citizens who earn US Ph.Ds. return home. The framework includes elements from both classical labor economics and transnational cultural connections to one's homeland to explain the decision to return home. It also considers the role of linkages to professional networks and aggregate policies at home associated with enhancing science and technical infrastructure. To understand

the overall results it is useful to focus on the single most powerful predictor of return-intention of return given at the time of graduation. This suggests that, in a causal sense, the main forces that effect the decision to return are in place before the student actually returns. Thus it is not surprising that the dominant factors are what we have referred to as the connectedness of individuals to their home countries. Indirect measures of this are having college and graduate degrees from institutions within their home country before coming to the US, marriage status, and country fixed effects.

The role of economic forces like wages are more difficult to understand. When viewing wages as exogenous, higher paying jobs in the US clearly work against the decision to return but when treated as endogenous this effect becomes insignificant. This is consistent with the idea that return is motivated by culture and connectedness conditions established before completion of the degree. It is also consistent with other empirical results. For example, we hypothesized that higher quality training could embedded foreign scholar in more prestigious research networks and that would mitigate interest in returning home. Our result did not support that hypothesis suggesting that even high quality training and potential membership in elite research networks do not compensate for these prior connections to their home country.

The two policy results found in the model assuming an endogenous effect of wages also provide results consistent with the connectedness model. Foreign funding of ones graduate education clearly strengthens the connection during the education abroad process to one's home country. It also occurs before graduation and can be a factor in forming or at least solidifying their intention to return home. The growing investment at home in science and technical infrastructure has an

independent positive effect and along with a growing supply of skilled scientific and technical work force at home having a negative effect fits with rational choice notions. The positive effect of investments only shows up in the endogenous model and based on our sensitivity analysis, and thus is likely is confined to China. This suggests it is likely a secondary force at work in the final decision to return home.

There are a number of limitations associated with this work. First the actual measure of return looks at a condition measured from a single iteration of a panel survey. While we know how long it has been since they graduated we do not know exactly when they returned. For example, an individual graduating in 2002 may have returned in 2003 or 2009. Similarly, we do not know if those counted as returnees are permanent or temporary returnees. Analysis of changes between the 2010 and 2013 iterations of the ISDR suggest the vast majority of individuals are permanent in that if they were returnees in 2011 they were 90% likely to be returnees in 2013. Nevertheless, timing matter especially with regard to relative wage rates that changed during the time period. As with any field study there are also always potential issues of omitted variable bias and selection. We do try to account for some of this with alternative estimation approaches and the use of a number of control variables but this is only a partial solution. Despite these concerns the main results seems to hold over a number of different model estimations and forms which provides some measure of confidence in the results.

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Appendix: Measurements and Resources of Variables

Variable	Format	Definition	Source
Log of salary	Continuous	Logarithm of basic annual salary on the principal job before deductions	SDR, ISDR (2013)
Ratio of R&D researchers	Continuous, [0,1]	Ratios of R&D researcher density of home country to the US	The World Development Indicators of World Bank
Ratio of R&D expenditures	Continuous, [0,1]	Ratios of R&D expenditures of home country to the US	The OECD Main Science and Technology Indicators Database (2014)
Primary funding source	Categorical	Primary source of support: fellowship, grant, teaching assistantship, research assistantship, foreign country, or some other source (base case)	SED (1990-2013)
Undergraduate degree	Categorical	Undergraduate degree granted location: US (base case), home country, or some other country	SED (1990-2013)
Master degree at home	Binary	Received a master degree at home country, 1=yes, 0=no	SED (1990-2013), SDR, ISDR (2013)
Male	Binary	Gender, 1=male, 0=female	SDR, ISDR (2013)
Marriage	Binary	Marital status, 1=married or in a marriage-like relationship, 0=not married	SDR, ISDR (2013)
Job relevancy to degree	Binary	Extent that principal job is related to doctorate degree, 1=closely related, 0=not related at all	SDR, ISDR (2013)
University quality by research activity	Integer, [1, 2, …]	The rank of US university by faculty research activities	A Data-Based Assessment of Research-Doctorate Programs in the United States (2006), by the National Academies
University quality by research expenditure	Integer, [1, 2, …]	The rank of university by federal research expenditure	The Data Table of Top 200 Institutions - Federal Research Expenditures, by Center for Measuring University Performance
Job sectors	Categorical	Current employer type: non-profit organization (base case), for-profit company, government, or university.	SDR, ISDR (2013)
Expectation of return	Categorical	Expectation of postgraduate location: stay in the US (base case), back to home country, or go to some other country	SED (1990-2013)
Country of citizenship	Categorical	Citizenship in the graduation year	SED (1990-2013)
Field	Categorical	Field of major: biological, agricultural & other life science, computer & mathematical science, physical science, psychology, social science, engineering, or health	SDR, ISDR (2013)
Job change	Binary	Ever changed jobs during last 2 years, 1=yes, 0=no	SDR, ISDR (2013)
Number of degrees granted at home country	Integer, [0, 1, 2, …]	Number of degrees granted at home country	SED (1990-2013), SDR, ISDR (2013)
Degree in other fields	Binary	Have another degree in different fields, 1=yes, 0=no	SDR, ISDR (2013)
Perspectives on job preference – 9 variables	[0.25, 0.5, 0.75, 1]	Perspective on what is important for a job: salary, benefit, job security, job	SDR, ISDR (2013)

		location, opportunities for advancement, intellectual challenge, level of responsibility, degree of independence, and contribution to society. 1=very important, 0.75=somewhat important, 0.5=somewhat unimportant, 0.25=not important at all.	
Age when graduated	Integer	Age in the graduation year	SDR, ISDR (2013)
Years since graduated	Integer, [0, 1, 2, …]	How many years since graduation	SDR, ISDR (2013)