Does US Science Under-invest in International Post-Doctoral Scholars? Evidence from the ECDS Preliminary Results and Outline of Research Plan

Shulamit Kahn* and Megan MacGarvie**

8/2/2021

Abstract: We investigate investment in postdoctoral researchers at US academic institutions using new data from the NSF's 2017 Early Career Doctorates Survey. We observe differences in the treatment of temporary resident postdocs compared to US citizen postdocs. The development of independent research careers among temporary residents is less supported, while their work is more closely monitored and their salaries are lower. Their activities are more likely to be related to their degrees and they do more basic research. They are more motivated to take a particular postdoc by its prestige, and less likely to take it to work for a specific person or have the opportunity to do independent research. Differences are typically larger for non-US citizens who plan to leave the US within 10 years. We describe plans to expand upon these preliminary findings in ongoing research.

The US STEM workforce is heavily reliant on skilled workers who come to the US from abroad. Prior literature has focused on the roles and impacts of foreign-born scientists who come to the US to obtain PhDs as well as those who are trained abroad and enter the US on work visas such as the H-1B to join academic institutions or for-profit firms.[1] However, there has been little research on post-doctoral scholars (or postdocs) who come to the US with a PhD from a foreign institution – a glaring omission because a large share (38%) of post-doctoral scholars in the US obtained their PhD degrees abroad.

Postdocs receive training and career development, but also supply labor in research labs led by PIs. The balance of training and work may differ across postdocs and PIs. International postdocs who come to the US are typically reliant on temporary visas tied to the employer, and a recent study found qualitative evidence that international postdocs are "exploited" due to their dependence on PIs for the renewal of short-term visas.[2] Other research has suggested broader problems with the post-doc model (Ginther, D.K. & Kahn,S. 2017; Stephan, P. 2013; Ganguli, I & Gaule, P. 2020, Sauermann, H. & Roach, M. 2016, Ganguli et al. 2021). A systematic analysis of a larger, representative dataset is needed to assess whether US PIs do indeed under-invest (i.e. provide less training and career development) in foreign postdocs – with foreign or US PhDs – and if so, identify potential explanations for this under-investment.

In addition to the possibility that temporary visa status influences the treatment of international postdocs, there are a number of other reasons why under-investment could occur. One is that foreign-trained postdocs could be perceived to have lower productivity than domestically trained post-docs, reducing supervisors' incentives to invest in them. Another is that supervisors under-invest in anticipation of a disruption in their relationship upon foreign postdoc's return to the home country and that this is more likely the case for those with foreign PhDs. A third is that postdocs trained outside the US are less well informed than US citizens about the nature of postdocs in the United States, making mismatch between postdocs and supervisors more likely.

This paper will measure under-investment in international postdocs and differentiate between candidate explanations for it, using some of the richest and most detailed data available on postdocs. The NSF's Early Career Doctorates Survey is designed to provide nationally representative statistics on recent doctorate (or equivalent) recipients working at U.S. master's degree– or doctorate-granting academic institutions (excluding medical schools and centers) and federally funded research and development centers (FFRDCs). Unlike the NSF's Survey of Doctorate Recipients, it includes doctorates who received degrees in any country. The ECDS is

* Boston University, ** Boston University and NBER.

[1] E.g., Bound, Turner and Walsh 2009, Kahn and MacGarvie 2015 and 2020, Roach, Sauermann and Skrentny 2019, Hunt and Gauthier-Loiselle 2010, Lincoln and Kerr 2010, Mayda et al 2019, etc.

[2] A Nature editorial titled "Stop exploitation of foreign postdocs in the United States" (https://www.nature.com/articles/d41586-018-07479-7) was based on Hayter and Parker (2018). The study's findings are concerning, but are based on a sample of 97 postdocs and 35 PIs. Research is needed to determine whether these findings are observed in a larger sample representative of all US postdocs.

particularly useful because it contains: (a) detailed data on postdocs' visa and citizenship status, countries of origin, location of PhD, and plans for future employment and future location plans; (b) rich information on researchers' productivity in the form of patents, publications, proceedings, and submissions and (c) survey questions describing the extent and type of supervisor mentoring, training and activities during postdocs.

Also of particular interest are the ECDS questions that ask about the factors affecting the researcher's decision to stay in the US or return home. The latter reasons include visa and immigration barriers, a highly important topic but one about which there is little direct evidence on the actual impact of visas on location choices.[3]

Below we describe results from a pilot study, as well as a research plan. We do not have a full paper at this point, because the 2017 ECDS was only recently made available to external researchers. However, we provide below a timeline for completion of the full paper before the conference deadline.

Empirical Approach

Pilot Analysis of how postdoc experiences differ by visa status, education location and intentions to leave

During our pilot study discussed below, we use the subset of respondents to the 2017 ECDS who are currently postdocs in academia and research centers. Note that we cannot use the ECDS to learn about those in industry postdocs, because of its sampling frame. In what follows, we will examine differences in career investment between each of four groups: US citizens or permanent residents with US PhDs, US citizens/permanent residents with Foreign PhDs, Temporary residents with US PhDs, and Temporary residents with Foreign PhDs. (For simplicity, from here on we will use the term "US citizens" to include permanent residents.) Table 1 gives some summary statistics on these four groups. As this table shows, the smallest group is US citizens with foreign degrees. We do not focus on this group, since although this group varies most from citizens with US degrees, we have found that much of those differences are explained by selection and shrink considerably with controls for productivity and other factors.

Table 2 presents the signs and significance of the differences between these groups from regressions using many different ECDS variables. Figure 1 graphs percentage differences in some of these variables compared to US citizens with US degrees. Some of the dependent variables are binary, but many are measured on scales that vary from question to question. The sign and significance provides information that can easily be compared across questions. In the table, we report both significant and marginally significant results with

[3] In our prior work (Kahn and MacGarvie 2019), we found that recipients of US PhDs who were subject to longer waits for permanent residency had lower stay rates.

different notation. In the text, we note some magnitudes when they are relevant. All regressions include 27 field dummies, years from PhD, and age quartile.

Support by supervisors

The first column of Table 2 compares all temporary residents (whether with US or foreign degrees) to US citizens. The first group of variables measures the postdoc's perceptions of whether their supervisor gives them different kinds of support. We see that temporary residents perceive a lower level of support than US citizens along several dimensions. Fewer consider their postdoc supervisor as a mentor (and indeed fewer temporary residents believe that they have any mentor at all). Temporary residents also reply that their supervisors are less likely to encourage collaboration with other researchers, to encourage independence in their research, to support the publishing and presenting of their work, to provide career guidance, to provide opportunities to work on grant proposals. Temporary residents' work plans in their postdocs are less likely to reflect the postdoc's personal goals. In fact, the only kind of supervisor support that both temporary residents and US citizens perceive similarly is in appropriate recognition for their work.

The second column addresses whether any of these differences are explained by either productivity measures or by the person's intention to leave the US within the next 10 years. Overall, it is clear that neither factor is responsible for the lower level of support of temporary residents, because significant differences between citizens and temporary residents remain even after controlling for productivity and future location plans.

Interactions with supervisors

The second group of variables includes some aspects of the formal interactions between the supervisor and postdoc. Temporary residents are more likely to be subject to oversight, as measured by work plans that specify expectations and responsibilities, formal performance evaluations, and frequent meetings with their supervisor. This also dovetails with the fact that they are less likely to be doing independent work, thus more likely to be working on the supervisor's projects. However, this might also explain why they perceive less stress on the job, as shown later in this table. And indeed, we also see later in this table that fewer temporary residents took the job for the opportunity to do independent research.

Activities while in postdocs

The next group of variables models activities worked on during the postdoc. Temporary residents are less likely to have prepared grant proposals during their time as postdocs, and are less likely to attend professional workshops. These responses dovetail with the kinds of supervisor support they felt lacking that we mentioned above.

On the other hand, temporary residents' postdocs are 6% more strongly related to their degree than postdocs of citizens. The primary activity during the postdoc is more likely to be conducting basic research than US citizens. (There is no difference in the likelihood of doing empirical research.) However, this difference disappears if we control for their intention to leave. Investigating why this is, the data indicates that it is temporary residents who intend to leave the US within the next 10 years are more likely to be conducting basic research. In Kahn and MacGarvie (2019), we found that US-trained scientists who left the US and worked abroad were much more likely to be engaged in basic research. In light of this, it is reasonable that they would pursue postdocs in the US that would prepare them for their future work.

Job characteristics and salary

In terms of other primary activities during the postdoc, it is not surprising that temporary residents are less likely to be doing management and administration, since they are less likely to have independent research of their own to manage. Nor is it surprising that they are less likely to be doing professional services, since some of this may be explained by postdocs who are MD/PhDs and not licensed to practice in the US.

Both US citizens and temporary residents are equally likely to have attended some training workshops or courses, holding other factors constant. (The actual average is slightly higher for temporary residents, 57.3% v. 56.4%.) However, the topic of this training differs. Temporary residents are more likely to have attended training on publishing, and less likely to have attended training on teaching or on research ethics. The latter may be due to US citizens being more likely to be supported by federal funds (and particularly fellowships) than temporary residents (75% v. 67%) that require research ethics training.

Salaries are 6.2% lower for temporary residents and US citizens. The gap is somewhat (but statistically significantly) smaller for those with US degrees (4.7%) than with foreign degrees (7.4%). The differences are not erased by controls for productivity or by the intent to leave. Instead, it may reflect the fact that US citizens have higher opportunity costs since they can easily have taken industry jobs, while temporary residents are precluded from doing so by their visas. We will test this hypothesis in our finished paper.

Reasons for taking the current position

The ECDS also includes questions about the respondent's reasons for accepting the current position. These are different for temporary residents and US citizens. Temporary residents are less motivated to work with specific researchers or departments than are US citizens. They are also less likely to be doing the postdoc for the compensation, or for the geographic location of the position. Instead, temporary residents are more motivated by the prestige that a US postdoc will bring them. This is true both for those with US or foreign degrees.

Column 3 of Table 2 describes any significant differences between temporary residents with US degrees and temporary residents with foreign PhDs. This column is based on regressions that include productivity

controls, but results are qualitatively similar when we do not include these controls. Column 3 shows there are very few significant differences between these two groups. This is somewhat surprising because we expect there to be important differences between these groups in networks formed during the PhD program, familiarity with US research practices, and the supervisor's information about the postdoc's expected productivity.

The few differences here are interesting to note. Those with US degrees are less likely to require frequent meetings than those with foreign degrees. Those with US degrees are more likely to have acted as a reviewer and to work on – and get trained on – grants. The salary penalty for temporary residents is smaller for those with US degrees (-4.7% v. -7.4%). Geographic location (e.g. being in the US) is more important to those with US degrees, although geography remains less important to these temporary residents than to US citizens.

The fourth column of Table 2 divides people based on future plans rather than location of doctoral education. Specifically, it compares non-US citizens who plan to stay in the US within the next 10 years to those who plan to leave. There are many more significant differences between temporary residents who plan to stay and non-US citizens who plan to leave than there were when we compared individuals based on where their degrees were earned. The lack of support for independent research careers and the increased oversight differs a lot more for leavers than stayers, although even stayers remain disadvantaged in these dimensions compared to US citizens. Similarly, temporary residents who plan to stay are much more satisfied with their jobs than both US citizens and those who plan to leave. The difference in activities seen between US citizens and temporary residents is larger among those planning to leave, sufficiently so that US citizen and temporary resident stayers are only marginally different in terms of being primarily engaged in management/administration and professional service. Leavers are less likely to do applied research than temporary resident stayers, and there is some suggestion ($p=.118$) that they do less applied research than US citizens as well. Moreover, the differences in motivations for choosing the postdoc are more exaggerated for leavers, to the point that both US citizens and temporary resident stayers are equally likely to choose their postdoc for the opportunity to do independent research.

To sum up the findings from our pilot study, we observe differences in the treatment of temporary resident postdocs compared to US citizen postdocs. The development of independent research careers among temporary residents is less supported, while their work is more closely monitored. Their activities are more likely to be related to their degrees and they do more basic research. They are more motivated to take a particular postdoc by its prestige, and less likely to take it to work for a specific person or have the opportunity to do independent research. Differences are typically larger for non-US citizens who plan to leave the US within 10 years, but along almost all dimensions, even those non-US citizens who plan to stay in the US are treated differently by supervisors and do different activities than US citizens.

Many differences are also likely explained by differences in the pre-existing networks of citizens and temporary residents. Wei et al. (2012) found that US postdocs were more likely than international postdocs to

use personal networks to find a job. This may result in better matching between citizen postdocs and supervisors.

Going forward, we will analyze questions about expectations. Although their overall levels of satisfaction are similar, preliminary analysis suggests that temporary residents are less likely to say that their expectations about independent research, collaboration, and involvement in grant writing were met. It is possible that temporary residents are less well informed about the positions they take.

Next Steps

This pilot study has identified some intriguing differences in investment in the careers of US citizen and temporary resident postdocs. Although we have advanced some candidate explanations for the differences we observe, we will spend the next few months fleshing out the patterns and rigorously testing hypotheses about these patterns and verifying their robustness. We will first add in the postdocs captured in the 2015 wave of the ECDS to expand the sample. We will investigate whether we can use information on respondents who are not currently in a postdoc but completed one recently, since the ECDS does ask similar questions about previous (first) postdocs.[4] We will then test hypotheses that the under-investment we have measured in the preliminary results is explained by:

1. Networks and information
2. Visa mobility constraints and Leave/stay intentions
3. Productivity differences

Specifically, we will do the following:

1. To better measure the role of both networks and the ex-ante information that the people had before they chose to enter their postdocs, we will incorporate information on the relationships between the postdoc's PhD-granting institution and their current postdoc, for instance:
    - Whether the postdoc is at the same institution that granted the respondent's doctorate
    - The intensity of collaboration by field and institution for the respondent's doctoral institution and the current institution. This data will be collected from SciVal.

    The information that people had before entering their postdocs might also be reflected in (a) their motivations for taking the postdoc (which our preliminary analysis suggested are different between citizens and temporary residents); and (b) variables on what the people expected from the postdoc and the degree to which their expectations were met. We will therefore also investigate how these relate to the network links between the doctorate and postdoc positions.

[4] One possible problem in including these individuals is that it would be a selected sample of people holding previous postdocs, since those who did not enter academia or research institutes would not be in this sample.

2. To investigate the role of visa restrictions on unequal treatment by supervisors and wages, we will compare groups of students with different visa constraints, including:
    - Students on J-1 visas, who are legally required to return to the home country. The ECDS includes a question about the specific type of visa, a rarity in such surveys. We have used a version of this instrument in prior research (Kahn and MacGarvie 2015).
    - Students from China and India, which have much longer wait times for permanent residency than other countries (Kahn and MacGarvie 2019). This may increase their reluctance to change employers relative to other foreign postdocs.
    - Students from Canada and Mexico, who have access to the TN visa, which can act as an alternative to the H-1B, and will make them less tied to the employer than students from other countries.

    We will investigate whether these visa restrictions can also be used to more accurately explore the causal impact of the leave/stay decision on the different dimensions of supervisor support during the postdocs and on work activities during the postdocs, using them as instruments in IV analysis.

    We will also ask whether the different reasons people have for saying they will leave the US (e.g. people who leave for family-related reasons v. for career-related reasons, different current family variables) impact treatment by supervisors and wages.

3. Our analysis to date (some of which is described above) suggests that these productivity measures do not explain much of the observed differences in investment. However, we will investigate this more deeply. For instance, we will investigate whether productivity affects supervisors differently for those with non-US degrees and those with US degrees, for those intending to remain v. leave, etc.

Other ways we may expand this study are:

4. We plan to investigate other dimensions of postdocs, such as hours of work, funding sources, etc.
5. We will ask how differences in access to funding affect their experiences while a postdoc and plans for their future careers.
6. We will further investigate patterns among US citizens with foreign PhDs.
7. We will investigate whether the differences depend on English as 1st language
8. We will investigate whether differences are the same for those in fields where a postdoc is deemed necessary.

Timeline for Completion

August 2021:

- Extend analysis to the 2015 wave of the ECDS
- Produce tables and figures documenting differences between citizen and temporary resident postdocs
- Complete literature review and formulation of hypotheses
- Collect data on collaboration networks from SciVal

Late August-September 2021:

- Perform and write up analyses that investigate alternative explanations for the differences.

October 2021:

- Finalize analyses and complete writing of the paper.

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Table 1: Summary Statistics on Current Postdocs in the 2017 Early Career Doctorate Survey

Mean values of selected variables

	US Citizens & Permanent Residents		Temporary Residents	
	US Doctorate	Foreign Doctorate	US Doctorate	Foreign Doctorate
Years since Doctorate	2.222	4.712	1.790	2.641
ln(Current Salary)	10.913	10.859	10.880	10.835
Accepted Publications	5.292	10.123	5.826	7.424
Submitted Articles	5.906	10.288	6.482	7.775
Proceedings	2.013	4.856	2.424	3.130
Patents	0.094	0.203	0.149	0.220
Presentations	4.412	7.466	4.609	4.981
D(has a mentor)	0.906	0.822	0.851	0.838
Work Plan incorporates goals	2.567	2.390	2.446	2.489
Career Advice	4.238	3.822	4.091	4.042
Collaboration	4.414	4.144	4.409	4.264
Grant proposals	3.978	3.814	3.949	3.795
Independence	4.438	4.127	4.308	4.257
Support for publishing	4.646	4.297	4.612	4.465
Recognition	4.373	4.144	4.388	4.321
Work/Life Balance	4.013	3.822	3.920	3.986
Stress	2.939	2.763	2.757	2.721
Observations	689	118	276	591

Accepted Publications = number of publications submitted and accepted since doctoral receipt. Submitted Articles = number of publications submitted since doctoral receipt. Proceedings = number of publications in conference proceedings since doctoral receipt. Patents= number of patent applications since doctoral receipt. Presentations= number of papers presented at conferences since doctoral receipt.

D(has a mentor) = 1 if respondent has any mentors, 0 otherwise.

Work Plan incorporates goals = How much does your work plan reflect your personal career development goals? (1=not at all, 2=somewhat, or 3=a great deal?)

Extent of agreement with the following statements (1=Strongly disagree…5=Strongly agree). Career Advice = your supervisor provides career guidance. Collaboration = your supervisor encourages collaboration. Independence your supervisor encourages increasing independence in your research or work. Grant proposals= your supervisor provides opportunities to work on grant proposals? Support for publishing = your supervisor supports publishing papers or presenting your work. Recognition = your supervisor provides appropriate recognition for your work. Work/Life Balance = your supervisor encourages work/life balance.

Stress = position is 1=Not at all stressful…5=Extremely stressful

Figure 1

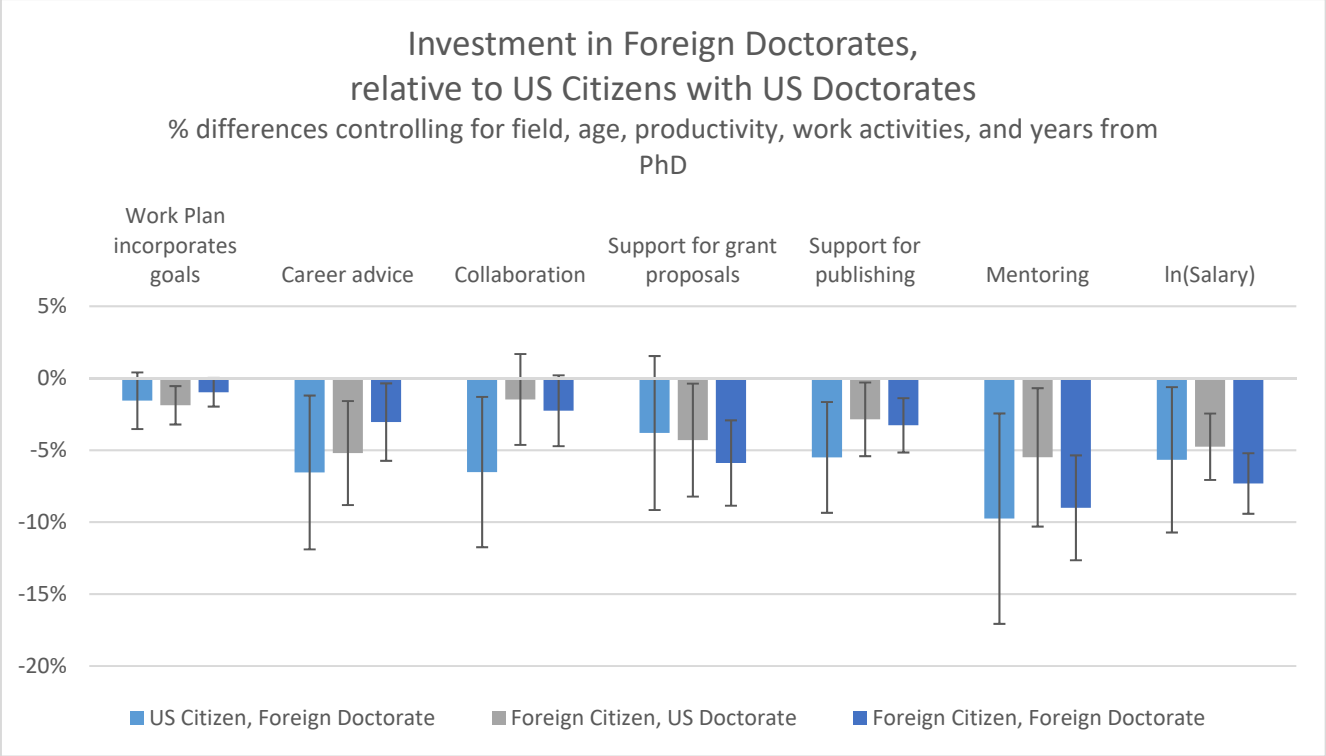

Investment in Foreign Doctorates,
relative to US Citizens with US Doctorates
% differences controlling for field, age, productivity, work activities, and years from PhD
Work Plan incorporates goals
Career advice
Collaboration
Support for grant proposals
Support for publishing
Mentoring
ln(Salary)
5%
0%
-5%
-10%
-15%
-20%
US Citizen, Foreign Doctorate
Foreign Citizen, US Doctorate
Foreign Citizen, Foreign Doctorate

Table 2: Sign and Significance of differences between groups in regressions of:	Difference of temporary residents from US citizens		Difference among temporary residents between US PHDs and foreign PhDs.	Difference among non-US citizens who plan to stay v. plan to leave
Dependent Variable	Table gives sign and significance of difference, with *** denoting p<.01, ** p<.95, * p<.90, and ? denoting p>.8 and p<.9, 0 denoting p>.8			
	with base controls	New sign and significance if any change with productivity &/or leave	with base and productivity controls	
Support of Supervisors				
Has a mentor	- ***	- ** iff also control for stay/leave	+ ?	+ *
Considers the supervisor their mentor	- ***		0	+ ?
Supervisor encourages collaboration with other	- ***		0	+ ***
Supervisor encourages independence in research	- **		0	+ *
Supervisor supports your publishing and presenting	- ***		0	0
Supervisor provides career guidance	- ***		0	0
Supervisor provides opportunities to work on grant proposals	- ***		0	+ **
Work plan refects your personal career development goals	- **	- ? If control for productivity	- ?	+ **
Supervisor provides recognition for your work	0	+ ? iff also control for stay/leave	0	+ ***
Oversight of Supervisors				
Work plan that outlines the expectations & responsibilities of position	+ ***		+ *	0
Frequency of meetings with supervisor	+ ***		- ***	+ ***
Have formal performance evaluation	+ *	+ ? if control for productivity	0	0
Activities during Postdoc				
During postdoc, attended professional conferences	- **		0	0
During postdoc, acted as a reviewer	0	- ?	+ ***	0
During postdoc, prepared grants with you as PI or co-PI	- ***		+ *	0
During postdoc, prepared grants that you weren't PI nor co-PI	- ***		+ ***	+ **
Works most on basic research	+ **	+ * adding prod'ty, 0 if also leave	0	- **
Works most on applied research	0		0	+ *
Works most on management or administration	- **		0	+ *
Works most on teaching	0		0	0
Works most on professional services	- **		0	+ *
Job is closely related to PhD	+ ***		0	0
Training during Postdoc				
During postdoc, attended some training (i.e. workshops or courses)	0		0	0
During postdoc, attended training on publishing	+ ***		0	0
During postdoc, attended training on grant writing	0		+ **	0
During postdoc, attended training on research ethics	- ***	- **	+ ?	0
During postdoc, attended training on project management	0		0	0
During postdoc, attended training on supervising others	0		0	0
During postdoc, attended training on teaching	- ***		+ ***	+ ?
Salary	- ***		+ **	+ ?
Emotions				
Feel stress at job	- ***	- *	0	- *
Overall satisfaction with job	0		- ?	+ ***
Why took job				
To work with an individual person or dept	- ***		0	0
To increase knowledge in field	0		0	+ *
To increase training outside field	- ?	0	- *	+ ?
For opportunity for independent research	- ***		0	+ ***
For prestige	+ ***		0	0
For the compensation	- ***		- ?	0
For geographic reasons	- ***		+ **	0