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Should I Stay or Should I Go ... North? First Job Location of U.S. Trained Doctorates 1957-2005

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Abstract:

Based on a survey of graduating PhD students in the U.S., we study the determinants of location of their first jobs. We consider how locating in Canada versus the U.S. for all graduates is influenced by both their background and time-varying factors that affect international mobility. We also study the choice of European graduates between North America and returning to Europe. We find that in many cases macro factors have the expected effect of choices after controlling for biases for home, which depend upon background variables in expected ways.

JEL Classification: J6, J44, I2

Keywords: Doctoral Education, International Mobility, Brain Drain

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1. Introduction

This paper studies the location of first jobs after receiving a doctorate from a U.S. university since 1957. This critical transition in the complex international flow of human capital has received limited attention. Rates of return of foreign graduates are known (see [Finn 2007](#)), but basic questions remain unaddressed. Is the decision of international graduates to stay related to the background of the student? Is the relative economic situations of the home country important? Is the countervailing flow of American graduates taking jobs in other countries affected by similar issues? Are non-economic policies and attitudes important?

New PhDs are usually minted at a point in the lifecycle with a high degree of mobility, both geographic and economic. The credential is universally recognized and reflects skills at the leading edge of knowledge and technology. By understanding better the nature of this key transition, a clearer picture can emerge of who benefits from the human capital imparted by specialized training. How much of the underwriting of foreign graduate education (through fellowships and research funds) does the U.S. capture through retaining foreign graduates? How much do other countries recoup from support given to students abroad? ([Kuhn and McAusland 2006](#) develop a theoretical model of when movement of knowledge workers is beneficial to the source country.)

Our story begins at the point of earning a PhD from a U.S. university because data are limited on who decides to study abroad and why. The proportion of the population that is both highly skilled and liable to international mobility is small, making it difficult to collect data on international moves *ex ante*. However, U.S.-based post-graduate education collects and concentrates a large fraction of the worldwide population of the highly able. Fortunately the unique role of American post-graduate education is captured by an equally unique survey, the National Science Foundation's Survey of Earned Doctorates (SED). Despite its name, the SED is a census of all PhDs earned in the US since 1957.¹

¹ The NSF also maintains a panel survey on a subsample of the SED. [Mishagina \(2007\)](#)

Some papers such as [Freeman et al. \(2004\)](#) have used the SED to describe the composition of U.S. doctoral graduate students. As far as we know, this is the first paper to use the SED to study an endogenous post-graduation choice. The SED instrument is provided to graduates by their university while completing the final requirement for their doctorate (as some readers of this paper may recall). The coverage and response rate is excellent and comes late in the matriculation process. Thus, most respondents have definite, in many cases executed, plans for their first post-doctorate job.

This wealth of information still suffers from the problem that only a small fraction of American graduates take their first position outside the U.S. And international recipients are coming from widely varying situations that are difficult to measure and compare. We focus attention on the choice of first job location in ways that limit these issues. First, our primary results concern the location of first jobs between the U.S. and Canada conditional on reporting one of the two countries as the destination. Although only a small fraction of all U.S.-educated doctorates report Canada as their destination, the census aspect of the SED makes the sample size large enough that significant effects are still easily obtained. Tightening the focus to U.S. versus Canada choice then makes it straightforward to include the difference between unemployment rates as a measure of prevailing relative labor market conditions. We also consider whether national spending on research and development is important. Comparing the destinations of American and U.S.-educated Canadian PhDs reveals a bias for home that works in opposite directions. Thus several interesting comparisons emerge between Americans, Canadians and other nationalities, because for each group moving to Canada is either an international, neutral or home destination. Second, in a separate analysis we study choices made by citizens of EU-15 countries. For this group we relax the conditions to include choosing not only the U.S. and Canada but also going "home" to the EU. We address this choice using a nested

uses the Survey of Doctorate Recipients to study career transitions for scientists and engineers. The SDR is not useful for the question studied here because it only follows scientists while they remain in the U.S.

logit model.

Besides controlling for many standard demographic factors entering the location decision of graduates, there are two other revealing variations to study inside the SED. First, both economic and non-economic policies have been important over the sample period. The sample for the basic set of variables extends from 1957 to 2005, which means we can detect the influence of the Vietnam War military draft on mobility to Canada. Second, the Canada-U.S. Free Trade Agreement and the North American Free Trade Agreement had direct effects on the cost of hiring workers across the Canada-U.S. border but no direct impact on third-country citizens. Finally, our sample includes several years after the events of September 11, 2001 that likely affected the U.S.-Canada tradeoff for third-country citizens, especially of Muslim Middle Eastern countries.

A second set of determinants come from the SED survey. During long periods the SED asked recipients whether they had debt (except for 2001) and whether their studies received foreign funding. As the next section describes these factors have straightforward implications for the U.S.-Canada choice that depend on whether the person is Canadian or not.

Our analysis complements work on other transitions involved in the international movements related to high skill workers [Huang \(1988\)](#) and [Bratsberg \(1995\)](#) study conversion of student visas to permanent residency using U.S. Immigration and Naturalization Service data. Using information on home countries, they find that variables such as U.S. immigration law changes, GDP, and funding of international students are relative to the return decision. Both studies implicitly assume that student visas that do not convert to permanent residence imply a return to the home country, but temporary work visas are valid for up to six years. In that sense our study of first post-doctoral location fills a gap between student visa and permanent residency. A related literature considers "brain drains," usually from the perspective of developing countries. [Commander, Kangasniemi, and Winter \(2004\)](#) reviews the literature and provides some facts

on brain drain using OECD data. Many studies mention lack of data on the issue or collect their own data with small sample sizes and low response rates. [Freeman \(2005\)](#) suggests that recent changes in the global market for scientists and engineers is changing the role of the U.S.

2. Empirical Framework

Consider a general model for new graduate i planning to move to destination country d having latent utility y_{id}^* . The number of destinations is large and the number of non-native graduates observed moving to most destinations is very small. Further, including destination-specific controls such as the current unemployment rate is difficult to implement at a global level. We start by restricting the sample and the model to the case where d is either Canada or the U.S. We hypothesize that movement from the U.S. to Canada after completing the degree depends on individual preferences, relative demand for specialized training between the two countries, and policies that encourage or discourage the individual to move. Our first set of simple probits therefore takes the form:

$$\begin{aligned}
 v_{io}^{CDN} &= v_{iCDN}^* - v_{iUS}^* \\
 &= f_o^{CDN} \left(DEMO_i, PGM_i, UNIV_i, FIN_i, y_i, ERA_{y(i)}, \right. \\
 &\quad \left. \Delta U_{y(i)}, \Delta R\&D_{y(i)}, ERA_{y(i)} \times DEMO_i, \right).
 \end{aligned} \tag{1}$$

That is, we set plans to remain in the U.S. as the default choice. The choice of Canada depends on v_{io}^{CDN} , a latent value for graduate i , who has origin (citizenship) o . Origin takes on the values American, Canadian, and Other (or 3CN, short for third-country national). The function f is a shorthand for writing out the arguments multiplied by estimated coefficients plus an error term. We index by o because our preferred specification has origin-specific probits. The arguments to f_o are vectors of variables. First come vectors of characteristics specific to graduate i as measured in the SED. These variables are put in four groups: DEMO contains demographic background variables; PGM contains indicators

for the graduate's field of study; UNIV contains indicators for the quality ranking of the graduate's university; and FIN contains variables related to the graduate's financial arrangements.

The other arguments of $f()$ are variables that depend on the year of graduation, including y_i itself as a time trend. ERA includes indicators for whether various policies or events that would affect the choice between Canada and the U.S. are active in year y . Some policy-related variables are targeted to specific countries within the 3CN category. Therefore, $ERA_{y(i)} \times DEMO_i$ includes certain interactions defined below. Our key policy-related variables are ΔU , the relative unemployment rate between the U.S. and Canada in the year of graduation and $\Delta R\&D$, the difference in per-capita expenditures on research and development. We expect the coefficient on ΔU to be positive, but not necessarily large relative to other effects since the flow of new PhDs to Canada may not be greatly affected by current conditions. We would expect $\Delta R\&D$ to have a negative coefficient since PhDs are likely a complementary input to overall R&D activity in the country.²

Obviously there are both demand and supply factors determining the values of v_{io}^* . For example, when looking across fields indicated by the PGM vector, we only observe the net effect of the two sides of the market on the location decision. In other cases some supply and some demand concerns affect individuals differently by their country of origin. Even in cases when demand and supply are not separately identified by cross-comparisons of origins, our results on the net effects are novel and interesting in themselves. They demonstrate the degree to which that international location of high skill workers is related to economic and non-economic factors that are tied to public policy.

² Clearly overall unemployment rates and R&D expenditure are crude measures of local demand for doctorates. We use them rather than more focussed measures because these measures are somewhat sensitive to government policy. Thus we are looking for possibly unintended effects of government actions on the location decision of doctorates.

3. The Data

3.1 SED

Started in 1957, the Survey of Earned Doctorates is a yearly census of individuals receiving their first research doctorate from a US university within 12 months prior to the survey date. The questions cover a range of topics from standard demographics to educational history to postdoctoral plans. In 2005, the survey included over 43,000 individuals from 400 doctorate-granting universities with an extremely high response rate of 92%. In 2005 demographic questions had an average response rate of 95% (given any response). Questions concerning postdoctoral plans had a 93% response rate.

Three questions relate to plans that are used to create the endogenous variable in this paper: 1) postdoctoral plans; 2) status of plans, and 3) planned location. The first question offers the respondent the following choices: postdoctoral fellowship, postdoctoral research associateship, traineeship, residency or internship, employment, military service, other plans (writing a book, homemaking). Blank answers are coded as “plans unknown”. The second question distinguishes plans by definiteness. For persons who provided a response to the first question the choices are: *returning to a pre-doctoral appointment*; *has signed an employment contract*; still negotiating with one or more employers; seeking appointment but no specific employers; other (writing a book, homemaking). We classify the first two italicized options as “having definite plans”. Finally, the same set of individuals who report plans of some sort were asked to provide a location of their future.

[Table 1](#) summarizes citizenship and planned locations of doctorates as well as the aggregate variables, i.e. the difference between the US and Canadian unemployment rates and indicators for various time periods of interest (FTA, NAFTA, Vietnam War, post-Sept 11-period). Overall, the number of observations in the SED since inception is 1,591,834. Of those 84.4% respondents state they have post-degree employment “plans” (provided an answer to question 1 above). This fraction is almost identical for Americans

Table 1. Summary of Planned Post-Doctoral Locations

		By Citizenship			
		Overall	American	Canadian	Other**
Observations	Total	1,591,834	1,083,207	19,346	489,281
	% With Plans*	85.4%	85.4%	89.7%	85.1%
Location					
	USA	88.9%	96.9%	45.5%	62.9%
	Canada	1.5%	0.7%	49.7%	1.3%
	Other	9.6%	2.5%	4.8%	35.7%
For Those With Plans*	Total	100%	100%	100%	100%
	Total Obs. to Canada***	20,390	6,478	8,621	5,415
	Plans are Definite*	75.7%	78.1%	78.8%	61.8%
Location					
For Those With Definite Plans*	USA	90.0%	96.9%	43.8%	63.3%
	Canada	1.6%	0.7%	51.6%	1.5%
	Other	8.4%	2.4%	4.6%	35.2%
	Total	100%	100%	100%	100%

*For definition of "plans" and "definite plans" see section 3 of the text.

**Other is also referred to as 3CN (third country nationals).

*** Total Obs X (%With Plans/100) X (% Canada/100)

Shaded area is the sub-sample used in the main analysis in section 4.1-4.2.

and 3CNs and somewhat higher for Canadians. Our main set of results concern the six shaded cells in Table 1 conditional on plans to stay in North America (as provided in question 3 above). The value of the large sample size is evident here. Americans and 3CNs do not choose Canada at a high rate, but still over 6,000 doctorates in each group have plans to locate there after graduation. Of course, Canadians are much more likely to locate there, but given the sizes of the other groups their share of the total flow of U.S.-trained doctorates into Canada is about the same size as the other sources.

Table 2 summarizes variables in the four individual-specific vectors DEMO, PGM,

UNIV and FIN. The richness of the data and the restricted choice allows us to isolate several forces that would affect individuals differently depending on origin. For example, the SED asked for parental education since 1962. We give this the traditional interpretation as an indicator of ability (controlling for field and university). We posit that mobility is positively correlated with talent. The higher skill for a graduate would interact with demand-side preference for a higher skilled person, extending their market and increasing their chances for mobility. However, mobility must account for a bias for home. Thus, parental education would tend to have a negative effect of returning to Canada for Canadians. A highly talented Canadian would reap greater returns by exploiting their skills and search broadly, making them more likely to overcome a home bias. More parent education should have a positive effect for Americans and 3CNs because in either case moving to Canada represents greater mobility. Meanwhile, graduates with dependents are hypothesized to be less mobile, and the signs for this variable would be the opposite of those for parental education. We can also consider that language is an important determinant of location. Canada's status as a bilingual country gives us some leverage on the issue, even though the SED does not ask about fluency directly. We categorized a person as Francophone if she attended high school in a Francophone country. A person is categorized as non-English speaking if she attended high school in a country where English was not among the official languages. (See [Table A.4](#) for country lists.) Francophone graduates are hypothesized to be more likely to move to Canada, all else constant. While this is a straightforward prediction, the ability to check it and similar predictions against the results increases confidence in the interpretation of other factors within the mobility model.

The demographic composition of graduates of different origin is consistent with historic, political, and cultural differences. For example, mean graduation year for 3CNs is much higher than for both U.S. and Canadian citizens, reflecting increased participation of foreign students in US graduate programs. These graduates are primarily non-English and most come from Asia. Among Canadians, 13% attended school in a non-English and

non-Francophone country, reflecting the larger fraction of naturalized citizens. For the US this number is much smaller, 0.48%. 3CNs are also more likely to be male than Americans or Canadians (76%, 67%, and 74% respectively). The same is true for the proportion of married men, while there are slightly fewer married men with children among American graduates compared to the other two groups. The fraction of graduates with children is similar among the three groups of graduates.

The three most popular fields among 3CNs are Engineering, Life Sciences, and Physical Sciences. For Canadians and Americans the first two most popular fields are Humanities/Law and Life Sciences. The third preferred field for Americans was shared by Physical and Social Sciences, while for Canadians it was Psychology. This difference may be explained by variety of reasons, e.g. differences in language requirements in different fields and others. Canadians were more likely to graduate from top universities than the other two groups, which is consistent with Canadian graduate programs serving as a close substitute for American ones except at the top-end of the quality distribution. (All reported models include field indicators so these differences are not driving any of the results across nationality.)

Graduates of different origin also differed substantially in their financial situation. More than half of American and almost a half of Canadian respondents report having debts, while less than a third of the 3CNs have debts. This may reflect differences in funding of undergraduate education in the countries outside North America or limits on borrowing for foreign education. As for the funding of doctorate education, Canadians are more likely to have non-US funding (of any sort and amount) than the other two groups. Unfortunately, the data does not distinguish the source as private (e.g. savings or loans from parents) or public (government scholarships, grants, etc.).

3.2 The Best Laid Plans

Perhaps intentions are not a good signal of ultimate outcomes, and results based on

Table 2. Summary of Variables For Those With Any Plans

Variable / Span of Years	Obs.	Mean	Mean By Plans		Mean By Citizenship		
			USA	Can.	Amer.	Cdn.	Other
Demographics / 57---05	1,072,007						
Graduation Year		1985	1985	1981	1983	1984	1991
Age at graduation		34.7	34.7	33.7	35.1	34.1	32.8
Temporary visa		0.13	0.12	0.62	0.00	0.76	0.69
Non-English*		0.20	0.20	0.24	0.05	0.13	0.96
Francophone*		0.02	0.02	0.47	0.01	0.90	0.04
Married		0.67	0.67	0.65	0.67	0.62	0.65
Male		0.69	0.68	0.78	0.67	0.74	0.76
Married x Male		0.49	0.49	0.55	0.49	0.50	0.50
Dependents / 57---05	879,757	0.57	0.48	0.46	0.57	0.58	0.58
Male x Married x Dep.		0.44	0.33	0.37	0.44	0.47	0.47
Parents / 62---02							
Father has college degree		0.31	0.31	0.27	0.31	0.23	0.32
post-graduate work		0.23	0.23	0.21	0.24	0.21	0.19
Mother has college degree		0.33	0.34	0.30	0.36	0.29	0.23
post-graduate work		0.11	0.12	0.09	0.12	0.09	0.08
Race / 72 ---- 02	809,922						
Asian		0.17	0.14	0.15	0.03	0.08	0.62
Black		0.05	0.04	0.01	0.04	0.01	0.05
Hispanic		0.03	0.03	0.01	0.02	0.01	0.05
Has school debt / 82---02	307,859	0.50	0.50	0.47	0.56	0.41	0.28
Non-US-funded / 86---02	562,768	0.02	0.01	0.06	0.00	0.11	0.02
University Type** / 57 - 05	1,072,007						
Topschools & Carnegie 1		0.12	0.11	0.20	0.11	0.24	0.13
Carnegie Category 1		0.89	0.86	0.93	0.88	0.91	0.90
Carnegie Category 2		0.08	0.08	0.05	0.08	0.05	0.07
Field of Study*** / 57 - 05	1,072,007						
Computer sciences		0.01	0.01	0.01	0.01	0.01	0.03
Mathematical sciences		0.03	0.03	0.04	0.02	0.03	0.05
Life and Health sciences		0.18	0.18	0.19	0.18	0.20	0.21
Physical sciences		0.12	0.12	0.12	0.11	0.11	0.18
Social sciences		0.09	0.09	0.06	0.10	0.08	0.02
Psychology		0.09	0.08	0.13	0.08	0.11	0.08
Engineering		0.11	0.11	0.07	0.08	0.08	0.28
Humanities and Law		0.32	0.32	0.28	0.36	0.30	0.10

*Person finished high school in a country as categorized in Table A.3.

** See Table A.4 for definitions.

*** Default is Business Administration.

plans are misleading if interpreted as related to actual locations of new doctorates. To check this, [Table 1](#) also reports locations for those with “definite” plans, i.e. a contractual commitment. And [Table 3](#) is the same as [Table 2](#) except it describes patterns for only definite plans. ([Table A1](#) and [Table A2](#) summarize the ERA variables and the key market indicators ΔU and $\Delta R\&D$.)

As seen from [Table 1](#), most plans are very concrete. Three quarters of those with plans have actually signed contracts, formally accepted a post-doctoral fellowship or are returning to their previous employment. For third-country nationals (3CNs) the fraction is only three-fifths. We see that the locations for those with “definite” plans (as classified from question 2 above) are nearly identical to the overall group with plans of some kind. Canadians with definite plans are more likely to report returning to Canada, which may indicate that Canadians with indefinite plans are still in the U.S. engaging in job search. If that fails, their definite plans will include more returns to Canada. Even among those that are still seeking jobs, the number that would ultimately end up in a different country than the planned one would likely be quite small. Thus, the signal on planned location asked several months after completing a doctorate is likely to be very close to ultimate outcomes. Thus plans as reported in the SED are not subject to the same concerns about plans stated when, say, entering a program. Including only definite plans would avoid some bias but lose information from those observations whose loose plans are accurate. Given these concerns all our estimates are based on reported plans of any kind, but results using only definite plans are also available.

The limited spans for some of the variables explain our reporting of different specifications. For example, we have already suggested that including parents’ education is a useful (and conventional) control for ability. However, including it in the specification precludes a study of post-9/11 outcomes since the data is not available to us after 2002. Similarly, the short and late coverage of the financing questions preclude inclusion of the Vietnam Draft and NAFTA eras. Thus we report restricted models to take advantage of

Table 3. Summary of Variables For Those With Definite Plans

Variable / Span of Years	Obs.	Mean	Mean By Plans		Mean By Citizenship		
			USA	Can.	Amer.	Cdn.	Other
Demographics / 57---05	810,512						
Graduation Year		1983	1983	1979	1982	1981	1988
Age at graduation		34.5	34.6	33.5	34.9	34.0	32.3
Temporary visa		0.10	0.09	0.60	0.00	0.76	0.68
Non-English*		0.16	0.16	0.20	0.04	0.12	0.94
Francophone*		0.02	0.02	0.47	0.00	0.90	0.04
Married		0.68	0.68	0.67	0.69	0.64	0.65
Male		0.70	0.70	0.80	0.69	0.77	0.79
Married x Male		0.52	0.52	0.59	0.52	0.54	0.53
Dependents / 57---05	661,174	0.52	0.52	0.60	0.51	0.43	0.55
Male x Married x Dep.		0.37	0.37	0.42	0.36	0.34	0.45
Parents / 62---02	754,877						
Father has college degree		0.33	0.33	0.28	0.32	0.24	0.38
post-graduate work		0.24	0.24	0.21	0.24	0.21	0.24
Mother has college degree		0.36	0.36	0.32	0.37	0.30	0.29
post-graduate work		0.12	0.12	0.09	0.12	0.09	0.11
Race / 72 ---- 02	592,090						
Asian		0.12	0.12	0.12	0.03	0.07	0.66
Black		0.04	0.04	0.01	0.04	0.01	0.03
Hispanic		0.02	0.02	0.01	0.02	0.00	0.04
Has school debt / 82---02	289,190	0.01	0.01	0.05	0.03	0.10	0.07
Non-US-funded / 86---02	442,581	0.50	0.50	0.47	0.55	0.49	0.27
University Type** / 57 - 05	810,512						
Topschools & Carnegie 1		0.12	0.12	0.20	0.11	0.24	0.15
Carnegie Category 1		0.89	0.89	0.93	0.89	0.92	0.92
Carnegie Category 2		0.08	0.08	0.05	0.08	0.05	0.06
Field of Study*** / 57 - 05	810,512						
Computer sciences		0.01	0.01	0.01	0.01	0.01	0.03
Mathematical sciences		0.03	0.03	0.04	0.02	0.04	0.05
Life and Health sciences		0.18	0.18	0.19	0.18	0.20	0.21
Physical sciences		0.13	0.13	0.12	0.12	0.11	0.19
Social sciences		0.09	0.09	0.06	0.10	0.07	0.02
Psychology		0.08	0.08	0.14	0.08	0.12	0.08
Engineering		0.10	0.10	0.06	0.08	0.08	0.27
Humanities and Law		0.32	0.32	0.29	0.36	0.30	0.09

*Person finished high school in a country as categorized in Table A.3.

** See Table A.4 for definitions.

*** Default is Business Administration.

the complete 49 year span of data along with other specifications that exploit the richer information from shorter spans.

To relax the restriction to locating in the U.S. or Canada, section 5 considers a subset of the 3CN group, citizens of fifteen EU countries (listed in [Table A](#)). These countries provide a large sample and data on ΔU and $\Delta R\&D$ are available. (The disadvantage is that consistent definitions and data are available for a shorter time period.) For the EU-15 we expand the choices to include locating in the EU-15. We consider some specifications that are directly comparable to the previous specification, but we focus on a nested logit model in which EU-15 citizens choose the continent (North America or Europe) and within North American either Canada or the U.S.

4. North American Options

4.1 Preliminary Estimates: Shared Coefficients

Before discussing our preferred specification of the baseline model (whether planning to locate in Canada conditional on plans for Canada or the U.S.) we report five versions of a restricted model in [Table 4](#). These models are based on the pooled sample so $f_i^{CDN_o}$ is the same function (coefficients) across origin o up to a additive term. It includes only variables available for the full span of 1957-2005 and (unreported) PGM and UNIV vectors. Standard errors are reported and coefficients that are significantly different from zero at the 10% level are indicated. These versions are restrictive in that the student's citizenship (origin) only shifts the probability of locating in Canada. Coefficients on other variables are shared among all origins.

It can be seen from the table that many of the predictions from a simple mobility model are consistent with the data. For example, temporary visa students are more likely to move to Canada as are American and international students who went to high school in Francophone countries. Married graduates and female graduates have a home bias. Conditional on staying in the North America, both male and married 3CNs are more

likely to move to Canada, as are older graduates. The graduates were found in general to be sensitive to the labor market conditions: whenever the unemployment rate difference increases, graduates were more likely to go to Canada. During the pre-NAFTA period, individuals were less likely to go to Canada. After NAFTA was introduced only the graduates on temporary visas were less likely to choose Canada. During the Vietnam War graduates were more likely to locate in Canada, especially if they were in a temporary visa in the U.S. During the post-9/11 years, the citizens of Muslim Mid-Eastern countries were more likely to locate in Canada.

Later estimates build on Specification 4 in [Table 4](#). Specification 5 adds $\Delta R\&D$ which reduces the span of years and requires eliminating several of the ERA variables. The coefficient is positive, the opposite of the expected sign. And the coefficient on ΔU changes sign and becomes much smaller in magnitude. However, both coefficients are insignificant. Since the macro variables are correlated it appears that the range available with both is not sufficient to distinguish their effects. We return to R&D later with the EU-15 and a different type of model.

4.2 Origin-Specific Coefficients

Next, the baseline model was re-estimated separately for Americans, Canadians, and 3CNs. In [Table 5a](#) and [Table 5b](#) we report two specifications of origin-specific probits. The first specification is the same as specification 4 in [Table 4](#) (including unreported program and university controls). Comparison of estimates across the three origin columns provides variation in home bias and conditions in Canada relative to the U.S. From specification 1 we learn that older graduates, females, and married graduates have stronger home bias. That is, the respective coefficients are negative for Americans and positive for Canadians. Interestingly married Canadian men have a net positive coefficient meaning they have a home bias compared to single female. For 3CNs the coefficients follow the Canadian values in sign but are smaller and in some cases insignificant.

Table 4. Shared Coefficients Across Origin

Variable	Specification				
	1	2	3	4	5
Other (3CN)	-1.389 *	-1.340 *	-1.336 *	-1.331 *	-1.281 *
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
American	-1.314 *	-1.294 *	-1.294 *	-1.274 *	-1.134 *
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
age	-0.009 *	-0.005 *	-0.005 *	-0.005 *	0.002 *
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
non-English hs	-0.261 *	-0.221 *	-0.223 *	-0.210 *	-0.033
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
francophone hs	0.537 *	0.550 *	0.553 *	0.547 *	0.682 *
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
temporary visa	0.920 *	0.968 *	0.966 *	1.015 *	0.889 *
	(0.02)	(0.02)	(0.02)	(0.02)	(0.04)
married	-0.035 *	-0.013	-0.017	-0.025	-0.057 *
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
male	0.089 *	0.039 *	0.038 *	0.039 *	-0.018
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
x married	0.120 *	0.043 *	0.043 *	0.052 *	0.098 *
	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)
yr graduation		-0.013 *	-0.011 *	-0.003 *	-0.018 *
		(0.0003)	(0.0004)	(0.0008)	(0.0046)
UE			0.030 *	0.027 *	-0.001
			(0.0032)	(0.0034)	0.011
R&D					0.026
					0.09
US/CDN FTA				-0.041 *	0.090 *
				(0.02)	(0.03)
NAFTA				-0.028	0.110 *
				(0.02)	(0.05)
x Mexican				0.065	0.262
				(0.11)	(0.19)
x visa				-0.269 *	-0.060 *
				(0.02)	(0.03)
Vietnam War				0.196 *	
				(0.02)	
x male				-0.026	
				(0.02)	
x visa				0.215 *	
				(0.02)	
Post 9-11				0.015	
				(0.02)	
x Mid. Eastern				0.210 *	
				(0.10)	
N obs	1072007	1072007	1071577	1071577	393692
log like	-60428	-59552	-59485	-59048	-17331

Estimates of a probit in equation (1) for the whole sample. Standard errors in parentheses.

* indicates significance at the 10% level.

Specification 2 adds parental education variables which are available in the years 1962 to 2002. The coefficients are only significant for the much larger American sample. The signs and relative values are such that more educated parents result in doctorates that are more likely to leave the U.S. This is consistent with higher ability graduates being more mobile. It also may reflect preferences for mobility since more educated parents may themselves traveled. For our purposes it is also important that including parental education controls does not alter the sign or significance of other included variables in [Table 5a](#). That is because the limited span for parental education reduces the secular variation available to estimate variables in [Table 5b](#). Relative unemployment rate ΔU has a positive coefficient for Americans and 3CNs. A relatively worse U.S. labor market is associated with Americans and 3CNs being more likely to move to Canada. This is consistent with a simple story that local demand for doctorates is correlated (negatively) with the overall unemployment rate. However, for Canadians the sign is reversed. The positive coefficients in [Table 4](#) are not robust to allowing all effects to depend on origin. Along with these cyclical patterns is a secular trend for more international mobility. Over time American graduates are more likely to locate in Canada (a small but significant effect) which goes against the pooled effect in Table 1. The trend for Canadians is to stay south of the border. As with the demographic controls in the previous table we see that 3CNs fall in between but the same sign as Canadians.

During the NAFTA period Americans are less likely to move to Canada. The loosening of visa requirements across the border did not result in a greater likelihood to locate in Canada after accounting for other factor. The result for Canadian visa students is negative, in this case the same sign as Americans. Thus NAFTA appears to be associated with Canadians being more likely to remain in the U.S. to start their post-doctoral careers but not for Americans to move north to pursue a greater variety in opportunities. For Canadians, NAFTA lowered barriers to employment in an economy roughly ten times the size of their domestic market. For Americans, NAFTA lowered barriers to a market

of about the size of California and typically with no prior connection. Thus, the mobility effect of NAFTA should be much larger on Canadians than Americans. Indeed the estimated propensity is larger for them in absolute value. For 3CNs visa students the effect is the opposite sign but relatively small.

During the Vietnam War era, Americans were much more likely to locate in Canada regardless of gender. Canadian visa students were also more likely to move home although the net coefficient is relatively small. For 3CNs the effect is very large, particularly compared to, say, the NAFTA era. Thus, the Vietnam War effect survives even when controlling for many other background variables.

Returning to the post-9/11 world we see that, as a control, the international flow of Americans is not significantly different in those four years of data (after controlling for the time trend and unemployment). However, Canadians are now much more likely to return home. For 3CNs it is striking that the effect is concentrated among Muslim Mid-Eastern countries who are much more likely to move to Canada conditional on staying in North America. The 9/11 coefficient is only a fraction of the size of the temporary visa and non-English coefficients, but it is over 10 times the size of the one-year time trend by origin. The Canadian and Mid-East effects may simply capture rationing of visas rather than a supply-side preference. However note that the net effect for all other countries is essentially zero. This suggest that visa rationing is not the only effect here. Highly trained workers appear to respond to macro conditions that are not necessarily economic.

If we look at specification 2 in [Table 5b](#) we see that many of these effects remain in terms of sign but not significance. As mentioned earlier the difference is the addition of parental controls which reduces the number of observations substantially. The post-9/11 effects are now essentially identified off one year (2002) so it is not surprisingly that the effects are less precisely estimated.

Table 5a. Origin-Specific Coefficients, Part 1

Variable	Specification 1			Specification 2		
	Am	Cdn	Other	Am	Cdn	Other
age	-0.019 *	0.043 *	0.009 *	-0.014 *	0.041 *	0.012 *
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
non-English hs	-0.085 *	-0.138 *	-0.475 *	-0.114 *	-0.023	-0.237 *
	(0.02)	(0.04)	(0.03)	(0.03)	(0.05)	(0.04)
francophone hs	1.056 *	0.105 *	0.427 *	1.168 *	0.161 *	0.370 *
	(0.03)	(0.04)	(0.03)	(0.04)	(0.05)	(0.04)
temporary visa		1.686 *	0.800 *		1.649 *	0.770 *
		(0.04)	(0.04)		(0.05)	(0.04)
married	-0.037 *	0.134 *	0.070 *	-0.050 *	0.157 *	0.023
	(0.02)	(0.04)	(0.03)	(0.02)	(0.05)	(0.04)
male	0.089 *	-0.140 *	-0.007	0.066 *	-0.160 *	0.071 *
	(0.02)	(0.04)	(0.02)	(0.02)	(0.04)	(0.03)
x married	-0.009	0.190 *	0.010	0.001	0.211 *	-0.015
	(0.02)	(0.05)	(0.04)	(0.03)	(0.06)	(0.04)
father college				0.049 *	0.045	-0.024
				(0.02)	(0.04)	(0.02)
father grad sch				0.058 *	-0.015	-0.015
				(0.02)	(0.04)	(0.03)
mother college				0.023	-0.041	0.023
				(0.02)	(0.03)	(0.02)
mother grad sch				0.039 *	-0.049	0.007
				(0.02)	(0.05)	(0.04)

Estimates of equation of two specifications of (1). Additional variables listed in the following table. Also included are variables in Table 5b and indicators for race, field of study, and university program. Standard errors are in parentheses. * indicates significance at the 10% level.

4.3 Additional Factors

Americans from top schools tend to choose Canada (all else constant) relative to other research university, while Canadians from the top tier schools are more likely to stay in the US. For 3CNs from top schools they are like their American counterparts, more likely to locate in Canada than 3CNs in lower-tiered schools. This indicates greater mobility relative to home country for top programs.

Questions on dependents were dropped in 2003 and as seen from Table 2 were subject to a lower response rate than other demographic questions. Thus we ran separate

Table 5b. Origin-Specific Coefficients, Part 2

Variable	Specification 1 (cont.)			Specification 2 (cont.)		
	Am	Cdn	Other	Am	Cdn	Other
yr of graduation	0.003 *	-0.023 *	-0.013 *	-0.018 *	-0.046 *	-0.029 *
	(0.001)	(0.002)	(0.002)	(0.003)	(0.01)	(0.004)
D UE	0.020 *	-0.021 *	0.062 *	0.014 *	-0.036 *	0.056 *
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
US/CDN FTA	-0.001	-0.062	0.050	0.173 *	0.134 *	0.210 *
	(0.02)	(0.05)	(0.04)	(0.03)	(0.07)	(0.05)
NAFTA	-0.131 *	0.179 *	0.294 *	0.173 *	0.513 *	0.516 *
	(0.03)	(0.08)	(0.06)	(0.04)	(0.11)	(0.08)
xMexican			-0.012			0.101
			(0.11)			(0.13)
x visa		-0.598 *	-0.251 *		-0.552 *	-0.220 *
		(0.07)	(0.05)		(0.07)	(0.06)
Vietnam war	0.291 *	-0.171 *	0.137 *	-0.022	-0.404 *	0.072
	(0.03)	(0.10)	(0.08)	(0.05)	(0.18)	(0.14)
x male	-0.042	0.067	-0.019	0.106 *	0.200	0.002
	(0.03)	(0.08)	(0.06)	(0.05)	(0.15)	(0.13)
x visa		0.194 *	0.177 *		0.125	0.156
		(0.07)	(0.06)		(0.14)	(0.10)
Post 9-11	0.025	0.138 *	0.009	0.205	0.297	0.104
	(0.03)	(0.05)	(0.03)	(0.21)	(0.30)	(0.10)
x Mid East.			0.175 *			0.062
			(0.10)			(0.06)
Nobs	886651	16078	167701	656902	11097	141696
log-likelihood	-33629	-8266	-14918	-20744	-5869	-11103

Continuation of Table 5a. Estimates of two specifications of (1) by origin. Also included are indicators for field of study and university program. Standard errors in parentheses. * indicates significance at the 10% level.

(unreported) specifications with dependents and some interactions. Our key results are not altered. Having dependents increases the home bias for Americans and Canadians and is not related to plans of 3CNs conditional on their staying in North America. Married Canadian men with children had higher chances of staying in the US during the Vietnam war, while married 3CNs with children were more likely to go to Canada during the same period. No such differential effect is found for Americans.

We also ran (unreported) models that included controls for debt and foreign funding of the doctorate. The effect of leaving school with debts was insignificant for all origins for the location decision. Foreign funding of the PhD was positive for all origins but significant only for Americans and 3CNs. Somewhat surprisingly, Canadians with foreign funding were not more likely to return to Canada than those without such funding.

5. Safe European Home

5.1 The EU-15 Sample

The EU-15 sample is summarized in [Table 6](#). Recall this is a subset of 3CNs included in the previous section. We checked whether the EU-15 differs in some qualitative way from the overall Other/3CN sample. We estimated a basic specification of a probit (U.S./Canada) on all 3CNs including the EU-15. Next to it we report the corresponding coefficients from a multinomial logit for the EU-15 for the "Canada" equation. Since the U.S. is the default choice in both the coefficients in both equations have the same interpretation as the effect on the difference in value between Canada and U.S. As reported in [Table A.5](#) only four of the coefficients differ in sign. In three of these four cases the coefficients are not estimated precisely in the sense that neither coefficient is significantly different from zero. The one case in which the sign changed and the estimate is precise is for the male-married interaction term.

5.2 Nested Estimates

The comparison across columns in [Table A.5](#) suggests that conditioning on staying in North America and not attempting to model the home choice for 3CN may not have a major effect on the coefficients. In this case of the EU-15 adding their home choice and eliminating the conditioning on North America does not have a qualitative effect on the estimates. However, a multinomial logit framework is problematic when some options are strongly correlated. For Europeans putting the U.S. and Canada choice on the same

Table 6. Selected Variables for the EU-15 Sample

Variable	Mean	Mean By Plans		
		EU-15	USA	Can.
Age at graduation	32.5	32.0	32.7	32.3
Temporary visa	0.70	0.93	0.60	0.86
Non-English*	0.83	0.90	0.80	0.79
Francophone*	0.13	0.13	0.13	0.22
Has school debt	0.12	0.16	0.10	0.06
Non-US-funded	0.32	0.27	0.33	0.31
Computer sciences	0.03	0.02	0.04	0.07
Mathematical sciences	0.06	0.07	0.05	0.09
Life and Health sciences	0.16	0.15	0.16	0.16
Physical sciences	0.16	0.18	0.14	0.17
Social sciences	0.03	0.03	0.04	0.03
Psychology	0.12	0.14	0.11	0.18
Engineering	0.15	0.17	0.15	0.07
Humanities and Law	0.24	0.18	0.26	0.14
Topschools & Carnegie 1	0.21	0.22	0.20	0.20
Carnegie Category 1	0.93	0.94	0.93	0.93

level as returning to Europe may be akin to the distinguishing between red buses and blue buses in a transportation mode model. So we consider a nested logit framework in which North America (NA) versus Europe is consider the top level. This level then captures the bias for returning to Europe (home). Then within North America there is a choice between U.S. and Canada. Formally, the estimated model can be written:

$$z_i^{NA} = g(DEMO_i, PGM_i, UNIV_i, FIN_i, y_i) \quad (2)$$

$$v_{io}^{USA} = \lambda^{NA} z^{NA} + h(U_{y(i)}^{US}, R\&D_{y(i)}^{US})$$

$$v_{io}^{CDN} = \lambda^{NA} z^{NA} + h(U_{y(i)}^{CDN}, R\&D_{y(i)}^{CDN})$$

$$v_{io}^{EU} = \lambda^{EU} z^{EU} + h(U_{y(i)}^{EU}, R\&D_{y(i)}^{EU}).$$

The term z^{EU} is normalized to 1 whereas the included value z^{NA} captures the value of locating in that continent inherited by both choices. Home bias for the EU-15 citizens is determined by $z^{EU} - z^{NA}$. Then the choice between countries is restricted to country-

Table 7. EU-15 Nested Logit

Level	Variable	Estimate	Standard Error
EU/US/Can	R&D	2.1030 *	0.2801
	UE	-72.8884 *	10.2492
North America	age	-0.0220 *	0.0060
	non-English hs	-0.6081 *	0.0792
	francophone hs	0.1448 *	0.0770
	temporary visa	-2.0954 *	0.0811
	married	-0.0274	0.0931
	male	-0.1145	0.0738
	x married	-0.1375	0.1097
	debts	0.1787 *	0.0543
	foreign_fund	-0.3654 *	0.0663
	yr of graduation	0.0016 *	0.0002
z	EU	0.0066	0.0420
	North America	0.2304 *	0.0547
Nobs		27,597	
log-likelihood		-5534.3	

Estimates of nested logit in equation (2). Continent equation also includes race, program and university type. * indicates significance at the 10% level.

specific values, where we do not distinguish between countries within Europe. The two specific series we have is share of GDP devoted to research and development (R&D) and the unemployment rate (U). Because of the nested framework, these variables enter in levels not differences.

The results of estimating (2) are reported in Table 7. First, a test that the nesting by continent is irrelevant amounts to a test of the coefficients on z equaling 1, which is strong rejected (a chi-squared likelihood ratio test statistics of 56.61 with two degrees of freedom). This indicates a home bias. The coefficients have reasonable values when interpreting them as affecting home bias. Older EU-15 citizens on temporary visas with

foreign funding from non-English and non-French countries strongly favor a return to Europe. On net students from francophone countries still favor Europe but much less than those from non-English countries, perhaps reflecting the value of Quebec in North America to them. Demographic variables are not significant, however.

Having controlled for preferences for Europe versus North America we consider the country-specific variables in (2), where ‘country’ means the EU-15 collectively. Here we see that unemployment rates and per capital R&D expenditures help explain locations and the signs are as expected. A lower unemployment rate and greater R&D are both associated with flows of Europeans to that region.

6. Conclusion

Research and graduate education take place at the international level. In developing high skilled human capital, the large U.S. system of higher education tends to concentrate ‘raw’ product which is refined into PhDs that are then allocated back throughout the world. The products of the system (the new doctorates) have complex motives, including the pursuit of comparative advantage and a bias for returning home independent of career concerns. In pursuing goals based on these motives new graduates face demand for their skills that is sensitive to local public policies related to education, research and immigration. The joint effect of these factors has not been considered in previous research, mainly due to the limited access to data rich enough to disentangle the effects. This paper has taken a first step in weighing supply and demand factors in determining international mobility of highly trained workers in order to confirm or call into question some common perceptions.

By and large we find location decisions that involve more movement across international borders are more likely over time, even after controlling for many factors not usually available with other data sources. But this trend exists within a complex context. We confirm that at least two major periods related to U.S. immigration, the Vietnam War

and post-9/11 eras, had expected effects on international location of new U.S.-trained doctorates. In particular, the notion of Canada as a haven during the Vietnam War is consistent with conditional choices during that period. And Canada also appears to have taken on a similar role for doctorates from Mid-Eastern countries after 9/11. The effects of the North American Free Trade Agreement are less clear.

Also less clear is the extent to which current labor market conditions and overall expenditure on R&D play a role in attracting new doctorates. Higher relative unemployment in the U.S. appears to push American and third-country nationals towards Canada, but does not increase the pull for Canadians to return home. In fact, the effect is the opposite for them. However, both unemployment and R&D have significant effects of the expected sign for Europeans within a nested logit framework. On the other hand, to a large extent factors that should increase a graduate's ties to their home country have the expected effect. Foreign funding of the graduate's education has the expected effect of making the U.S. a less likely location. Age, language, sex, and marital status all have the expected effects on international mobility.

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Table A.1. Eras

Variable	Era	= 1 in Years
US/CDN FTA	US/Canada Free Trade Agreement	1988 — 1993
NAFTA	North American Free Trade Agreement	1994 — 2005
Vietnam War	Vietnam War Draft	1964 — 1974
Post 9-11	Post attacks of September 11, 2001	2002 — 2005

Table A.2. Policy Variables

Variable	Var.	Definition	Span	Mean	St. Dev.
UE	U	Unemployment Rate	81 — 05		
			Canada	0.096	0.016
			US	0.074	0.014
			EU-15	0.060	0.014
R&D	R&D	R&D Expenditure / GDP	81 — 05		
			Canada	1.346	0.254
			US	2.564	0.101
			EU-15	1.694	0.076
ΔU	ΔU	(US - Canada) UE	58 — 05	-0.015	0.0151
$\Delta R\&D$	$\Delta R\&D$	(US - Canada) R&D	81 — 05	0.0097	0.0025

Table A.3. School Categories

University Category	Description
Category 2	School awarded at least 10 doctoral degrees per year across 3 or more disciplines or at least 20 doctoral degrees per year overall.
Category 1	School awarded 50 or more doctoral degrees per year across at least 15 disciplines.
Top School	Category 1 AND Cal Tech, UC Berkeley, Yale, Harvard, MIT, Columbia, Cornell, Stanford, or Princeton

Table A.4. Country Categories

Variable	Source	Details
Middle Eastern	geography.about.com /library/maps/ blrmideast.htm	Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen. <i>Excluding: Israel, Georgia, Armenia, Azerbaijan, and Turkmenistan</i>
English	en.wikipedia.org /wiki/English_language	UK, Canada, Australia, Ireland, South Africa, New Zealand. Non-English is all other countries.
Francophone	en.wikipedia.org /wiki/Francophonie	Members of "La Organisation Internationale de la Francophonie" including only those where French is: a) one of the official language b) an administrative language or c) a former French colony..
EU-15	European Union as of 1995	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, UK

Table A.5. Multinomial Logit EU-15 versus Other Origin Probit

Variable	Probit on Sample of Other Citizenship (3CNs)	Multinomial Logit on Sample of EU15: Canada	Opposite Sign
age	0.0080 (0.0042)	0.0514 (0.0169)	
non-English hs	-0.1614 (0.0759)	-0.0932 (0.2397)	
francophone hs	0.4383 (0.0715)	0.6957 (0.2240)	
temporary visa	0.5686 (0.0560)	1.5211 (0.2436)	
married	0.0341 (0.0759)	0.1027 (0.3019)	
male	0.0677 (0.0661)	-0.2353 (0.2653)	Y
x married	-0.0321 (0.0042)	0.4039 (0.0169)	Y
father college	-0.0608 (0.0476)	0.0579 (0.2331)	Y
father grad sch	-0.0601 (0.0568)	-0.2708 (0.2569)	
mother college	0.0620 (0.0465)	0.2301 (0.2262)	
mother grad sch	0.0483 (0.0657)	0.2518 (0.3026)	
yr of graduation	-0.0208 (0.0045)	-0.0439 (0.0234)	
debts	0.0255 (0.0387)	0.0962 (0.1832)	
foreign_fund	0.0930 (0.0593)	-0.0523 (0.2626)	Y
Nobs	37,523	9,317	

EU-15 citizens). The second column reports multinomial logit estimates for the Canada option based on EU-15 citizens only and when the choice set includes EU-15, US, or Canada. Since the default choice is US these coefficients are comparable to the probit coefficients in the first column. Race and PGM controls are also included. Standard errors in parentheses.