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International Mobility of Research Scientists

Paula Stephan*

In the United States, approximately half of all Ph.D.s awarded in science and engineering go to the foreign born.¹ More than two-thirds of temporary residents who receive Ph.D.s in science and engineering work in a research capacity while in graduate school. The proportion is over 80 percent in engineering.² Approximately 60 percent of postdoctoral fellows are in the United States on a temporary visa and approximately 42 percent of those with a doctoral degree working in a science and engineering occupation in the United States were born outside the United States. There is evidence that the foreign born contribute disproportionately to exceptional contributions in science and engineering and that highly productive scientists are even more mobile than the underlying scientific population. Despite the importance of the foreign born, it is difficult to make cross-country comparisons regarding their presence and role because of the absence of consistent data across countries. Most OECD countries, for example, collect data on recipients of tertiary degrees by immigration status, but the data do not distinguish between those with Ph.D.s versus other tertiary degrees, nor do they distinguish field of study. Moreover, most countries have an incomplete picture of the migration patterns of scientists born in their country because it is difficult to track individuals working outside their country of origin.

To provide consistent cross-country data on active researchers, my co-authors and I fielded the GlobSci survey of corresponding authors of articles published in 2009 in four fields of science: biology, chemistry, earth and environmental sciences, and materials. The fields were cho-

sen in part because 95 percent or more of all articles published in these disciplines contain the corresponding author's email. We focused on researchers who were studying or working in one of 16 "core" countries: Australia, Belgium, Brazil, Canada, Denmark, France, Germany, India, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and United States. China was initially included in the survey. However, a low response rate of less than 5 percent for a test sample of Chinese addresses suggested that respondents were either not receiving the invitation or had problems responding to the invitation. The response rate to the web-based survey, which was administered during the spring of 2011, was 40.6 percent. Country of origin was determined by asking the respondents to report country of residence at age 18.

Mobility Patterns of the Foreign Born

We find widely varying patterns of immigration and emigration for the more than 17,000 scientists for whom country of origin and country of residence in 2011 could be determined.³ The country with the largest percentage of Ph.D. scientists who are immigrants was Switzerland (56.7), followed distantly by Canada (46.9), Australia (44.5) and then by the United States (38.4). Virtually no foreign-born scientists reported working in India; only 3 percent of the research-active scientists in Italy and 5 percent in Japan are foreign. Immigrant scientists were asked to evaluate the importance of 14 possible reasons for coming to work or study in their country of residence. Virtually no variation exists across country in response. The "opportunity to improve my future career prospects" and the presence of "outstanding faculty, colleagues or research team" trump all other reasons. Regardless of country, respon-

dents list family reasons or fringe benefits last among reasons for coming to work or study in a foreign country.

Our approach provides information on emigration flows among core countries. We find Indians to be the most likely to emigrate—almost 40 percent of scientists living in India at age 18 were working outside the country at the time of the survey. Approximately one-third of Swiss scientists are outside their home country; the Netherlands and the United Kingdom have the next highest rate of emigration. The country with the lowest percentage of emigrants is Japan (3 percent) but the United States is a close second (5 percent). In all cases, save Belgium, the United States is the most likely destination country. The data also permit us to determine that half or more of the respondents who lived in 13 of the 16 countries at age 18 have an international experience. The three exceptions are the United States, Japan, and Italy. Return rates also vary among emigrants. The country with the highest return rate is Japan (nine out of ten), followed by Spain and Brazil (seven out of eight). Less than one out of two Indian emigrants has returned. The most likely reason that scientists give for return to their country of origin is for "personal or family reasons." Taken together our results suggest that policy levers are extremely important in attracting scientists to work or study abroad, but that they appear to play little role in drawing emigrants to return to their home country.

Graduate School and Postdoctoral training

In companion research we explore factors related to the probability that students who leave their country of origin for Ph.D. or postdoctoral training come to the United States rather than to another country.⁴ We find that those who place

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a higher weight on the prestige/research excellence of the institution as a reason for their choice are significantly more likely to train in the United States than to go elsewhere, as are those who report that opportunities for career advancement played a strong role in their decision to go abroad for study. Individuals who report that the appeal of lifestyle or international experience played an important role in their decision of where to pursue Ph.D. study are significantly less likely to attend graduate school in the United States than go elsewhere.

With regard to postdoctoral study, we find that individuals who place a higher weight on the quality of faculty, the excellence/prestige of the country's institutions, and the career prospects associated with where they train are significantly more likely to come to the United States. The U.S. lifestyle discourages individuals from coming to do postdoctoral study, as does the relative unattractiveness of benefits and working conditions provided to postdoctoral researchers. The current discussion on immigration reform focuses on the importance of visa reform for retaining researchers who complete their studies in the United States. Our research suggests that maintaining the level of research funding and the quality of university research infrastructure are likely to be important if the United States hopes to continue to attract foreign-born students and postdoctoral researchers.

Networks

Innovation policies, particularly in Europe, have strongly supported international mobility of the highly skilled workforce as a means for enhancing the overall scientific performance of both source and destination countries. Despite the importance attributed to such ties, little empirical research has systematically investigated mobility, in part because of the lack of international comparable data. We draw on the GlobSci survey to explore the link between mobility and the presence of international research networks.⁵ We classify researchers into

three mobility states: foreign-born (24.3 percent); returned after one or more periods abroad for a Ph.D., postdoc or employment (29.7 percent); and non-mobile (46.0 percent). We create two measures of the individual's propensity to co-author with those from a different country: the first counts the number of distinct international co-authors on the paper that was included in the GlobSci survey and the second draws on the respondents' answer to a question regarding the number of countries in which the scientist reported having one or more collaborations in the past two years. We find the incidence of international collaboration on the survey paper to be lowest for non-mobile researchers. It is generally highest for the foreign born. We also find non-mobile researchers to report the highest incidence of having had no international scientific collaboration in the past two years. The distribution of the number of countries with which the foreign born and returnees report having had a collaborator is almost the same. Approximately one out of three have collaborated with scientists in four or more countries; slightly more than one out of two has collaborated with scientists in one to three countries.

We examine the presence of significant correlation at the individual level between international mobility and the presence of international co-authors, controlling for the researcher's demographic characteristics, field of research, country of residence, number of co-authors, and whether the scientist is independent or works in a support role, such as a staff scientist. We find the marginal effect of being foreign born on the likelihood of having an international collaboration to be 13.8 percentage points. The marginal effect of being a returnee is 7.4 percent. We also examine the correlates of working with co-authors in four or more countries and find that the foreign born and returnees are significantly more likely to collaborate with scientists in a large number of countries than are the non-mobile. This effect is slightly larger for the foreign born than for those who have returned.

Performance

Mobility policies, such as visa reform, are predicated on the assumption that the foreign born perform at the same or a higher level than the non-mobile workforce. Likewise, countries that implement policies to encourage emigrants to return do so on the assumption that the mobility experience enhances the productivity of the emigrant and that the country will benefit from the emigrant's return. Empirical evidence on the correlation of mobility and performance in science, however, is inconclusive and often limited to the foreign born in the United States and focused on those who make exceptional contributions. The GlobSci survey allows us to explore the correlation between mobility and performance within our 16 country sample. We are not able to infer causality given the cross-sectional nature of the data, but the results suggest that mobility is a plus for destination countries and that promoting international experience can have positive returns for a country.

We use two measures of performance: two-year citations to the author's article and the Impact Factor of the journal in which the article was published. We limit the analysis to individuals working in universities, medical schools, and government research agencies, and control for article and individual characteristics.⁶ We find that holding all else equal, the average foreign-born scientist outperforms a homegrown scientist by 0.84 in terms of Impact Factor of the journal in which the article appeared and by 2.29 in terms of two-year citations to the paper. We also find that scientists who have studied or worked abroad and subsequently returned to work and live in their country of origin outperform the non-mobile by 0.63 in terms of Impact Factor and by 1.69 in terms of total citations.

¹ P. Stephan, "The I's Have It: Immigration and Innovation, The Perspective from Academe," pp. 84–127 in *Innovation Policy and the Economy*, Volume 10, J. Lerner and S. Stern, eds.

Chicago: University of Chicago Press, 2010; and P. Stephan, *How Economics Shapes Science*, Cambridge, MA: Harvard University Press, 2012.

² Black and Stephan find that graduate students constitute 29.3 percent of the first authors of papers published in Science; 40.7 percent of first authors are postdocs. Using data supplied by Bill Kerr they infer ethnicity of the first and last name of the authors, finding that 58.5 percent of the graduate students and 54.4 percent of the postdocs have names that are neither “English” nor “European.” G. Black and P. Stephan, “The Role of Foreign Graduate

Students and Postdoctoral Scholars,” pages 129–61 in *American Universities in a Global Market*, C. Clotfelter, ed. Chicago: University of Chicago Press, 2010.

³ C. Franzoni, G. Scellato, and P. Stephan, “Foreign Born Scientists: Mobility Patterns for Sixteen Countries,” *Nature Biotechnology*, 30 (2012), pp. 1250–3 (also NBER Working Paper No. 18067, May 2012.) For interactive charts and map see R. Van Noorden, “Global Mobility: Science on the Move,” *Nature*, 490 (2012), pp. 326–9.

⁴ P. Stephan, C. Franzoni, and G. Scellato, “Choice of Country by the Foreign

Born for Ph.D. and Postdoctoral Study: A Sixteen-Country Perspective,” NBER Working Paper No. 18809, February 2013.

⁵ G. Scellato, C. Franzoni, P. Stephan, “Mobile Scientists and International Networks,” NBER Working Paper No. 18613, December 2012.

⁶ C. Franzoni, G. Scellato, and P. Stephan, “The Mover’s Advantage: Scientific Performance of Mobile Academics,” NBER Working Paper No. 18577, November 2012.

Inflation-Indexed Bonds

Luis M. Viceira*

Introduction

Inflation-linked bonds, which in the United States are known as Treasury Inflation Protected Securities (or TIPS), are bonds that pay investors a fixed inflation-adjusted coupon and principal. Their nominal payments adjust automatically with the evolution of a price index describing the cost of a basket of consumer goods such as the Consumer Price Index in the United States. Although the popular press often labels inflation-indexed bonds as “exotic securities,” nothing could be farther from reality.

Inflation-indexed bonds constitute today a significant fraction of outstanding bonds issued by the U.S. Treasury—around 10 percent of total marketable debt, and more than 3.5 percent of GDP. Both institutional investors such as endowments and pension funds and retail investors hold them in their

portfolios, either directly or indirectly through TIPS mutual funds, exchange-traded funds, and asset allocation funds such as target retirement funds. TIPS have become a building block of investors’ portfolios. TIPS also play an important role in policy. Central bankers, professional economists, and market observers routinely follow the evolution of “breakeven inflation,” or the spread between the yields on nominal government bonds and the yields on inflation-indexed bonds of equivalent maturity, as an indicator of real-time inflation expectations from bond market participants.

The relevance of inflation-indexed bonds to investors and policymakers is not unique to the United States. The United Kingdom has a longer and even more established tradition of issuing and investing in inflation-linked bonds (or “gilts” as government bonds are known in the United Kingdom). Inflation-indexed linkers represent more than 30 percent of British public debt, equivalent to almost 10 percent of U.K. GDP. The U.K. government is now considering issuing inflation linkers with super-long maturities (in excess of 50 years) and

even perpetual inflation-indexed gilts. In the Euro area, France, Germany, and Italy regularly issue inflation linkers, linked to either Euro-area inflation or to domestic inflation. Demand for linkers in both the United Kingdom and the Euro area is strong, particularly from pension funds, as pensions in those countries are typically indexed to inflation. After a brief interruption, Japan is re-starting regular issuance of inflation-linked bonds and, among emerging economies, Brazil has become a large issuer of such bonds. Australia, Canada, Chile, Israel, Mexico, Turkey, and South Africa are also economies with non-trivial issuance of inflation linkers. The hedge fund Bridgewater has recently calculated the size of the global inflation-linked market at \$2.5 trillion, larger than the high-yield corporate bond market and twice as large as the dollar-denominated emerging market bond market.

My research on inflation-indexed bonds has been focused on understanding the role of these securities in investors’ portfolios, their pricing and risk, and the impact of institutional factors on the market for inflation-indexed bonds.

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