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**Scientific Mobility and Knowledge Networks
in High Emigration Countries: Evidence from the Pacific**

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Abstract

This paper uses a unique survey to examine the nature and extent of knowledge flows that result from the international mobility of researchers whose initial education was in small island countries. Current migrants produce substantially more research than similar-skilled return migrants and non-migrants. Return migrants have no greater research impact than individuals who never migrate but are the main source of research knowledge transfer between international and local researchers. Our results contrast with previous claims in the literature that too few migrant researchers ever return home to have much impact, and that there is no productivity gain to researchers from migration.

Keywords

diasporas
knowledge networks
scientific mobility

JEL Classification

J6, O3, R1

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1. INTRODUCTION

The highest rates of highly skilled emigration are from small island nations, especially in the Pacific (Gibson and McKenzie, 2011). Possible ‘brain drain’ effects from researchers leaving such countries may impair local capacity for innovation, and thus matter to local research policy. Offsetting this, a highly skilled diaspora may facilitate knowledge transfer from host countries since ethnic scientific and entrepreneurial channels enhance the transfer of codified and tacit knowledge regarding new innovations. As Kerr (2008, p.536) notes: ‘frontier expatriates play an important role in technology transfer’.

Famous cases of a skilled diaspora stimulating growth and innovation focus on migrant entrepreneurs returning from Silicon Valley to set up businesses in China, India and Taiwan (Saxenian, 2006). To the extent these cases generalise, permissive emigration of the highly skilled to build up a diaspora, some of whom then return, is a potentially powerful tool for accelerating technological catch-up. But countries with the highest emigration rates are not like China, India or Taiwan.¹ Hence, the case study evidence may be less relevant to much smaller and peripheral countries, such as those in the Pacific Islands. Indeed, writing about another scientifically peripheral country (Colombia), Meyer (2001, p.101) notes:

‘For those who attempted to return, the unreliability of colleagues and the weakness of infrastructure have often been huge problems. They felt that conditions were such that their skills and knowledge could not be applied properly.’

Whether emigrant researchers from small, peripheral countries provide more benefit to their homeland by being overseas, with better access to research funds and more active scientific networks, remains unknown. It is also not known whether researchers who return to such countries produce any special benefits compared with the researchers who never left. The purpose of this paper is to provide the first systematic empirical evidence on these issues for researchers from high-emigration countries. Our unique survey tracks worldwide the best and brightest academic performers from three Pacific countries (New Zealand, Tonga and Papua New Guinea). Here we focus on scientists and other researchers, who make up about one-quarter of the total sample.² In addition to detailed questions on migration histories, our sample have provided information on the scientific networks that they belong to, their

¹ Comprehensive quantitative evidence shows that the association between knowledge diffusion through ethnic networks and the growth in manufacturing output of countries that share the same ethnicity is especially strong for high technology sectors and for the Chinese ethnic group (Kerr, 2008). Hence, case study evidence on the experience of a skilled Chinese diaspora in Silicon Valley may overstate the general opportunities for positive effects on smaller countries that are losing highly skilled emigrants to the technologically advanced countries.

² In Gibson and McKenzie (2011a) we used the full sample to investigate the determinants of migration and return migration decisions by the highly skilled, but without any special focus on those who are researchers, while Gibson and McKenzie (2012) examine impacts through standard channels like remittances and trade.

publishing activity and research funding, and on-going links to the research environment in their home country. Our sample covers rich (New Zealand) and poor (Tonga and Papua New Guinea) countries, allowing us to draw some general conclusions about the net benefits of scientific mobility for small countries with high rates of skilled emigration.

Unlike prior studies of elite ‘brain drain’ we do not focus on specific scientific disciplines or occupations, such as chemists (Gaulé, 2011), physicists (Hunter *et al.* 2009), health professionals (Clemens and Pettersson, 2008), or economists (Ben-David, 2009). Individuals wishing to migrate may choose portable occupations and disciplines; for example, law has a high degree of country specificity while mathematics is universal, so a talented student wanting to migrate may choose mathematics over law. Furthermore, migration may be needed in order to train for, or pursue, a particular occupation. Consequently, it is not clear that the right counterfactual for a researcher in a particular discipline abroad is necessarily someone in the same occupation or discipline in the home country.

Instead, our focus is individuals of high academic ability – the top performers in their country at the end of secondary school. This can be objectively measured in terms of national examinations, or by being one of the top academic performers (such as a valedictorian or Dux), in elite secondary schools. With this approach we can *ex post* define the sample frame in terms of *ex ante* characteristics, surveying in the present those individuals who were at the top of high school classes in earlier years.³ Conversely, approaches based on revealed career performance (for example, Trippl, 2011; Weinberg, 2011) may be subject to a form of survivorship bias; for example, if the odds of being highly cited are lower for non-migrant researchers than for those who migrated to global centers of scientific activity, a survey frame of highly cited researchers may not give valid counterfactuals. A non-migrant who still manages to be highly cited may be drawn from the more extreme tail of non-migrant productivity than an equally highly cited expatriate researcher. In contrast, our approach allows us to identify individuals before they have self-selected into particular careers or migrated overseas for postgraduate education, and thus provides natural comparison groups of highly skilled emigrants, returnees, and individuals of similar academic talent who never migrated.

One consequence of our sampling approach, and the age range we use to balance the practicality of tracking people with the need to see sufficient career development, is that many of the researchers we study are early in their career and may not yet have had much research success. Thus, our approach can be thought of as yielding a sample of ‘ordinary’ scientists rather than the elite researchers previously studied (for example, Trippl, 2011). While some of the researchers in our sample publish in world class journals within their disciplines, such as *Science*, *Nature*, the *British Medical Journal*, *Lancet*, *Thorax*, the *Journal*

³ The results below focus on students graduating high school between 1976 and 2004, compromising between the better records on more recent students and the longer work histories for earlier students.

of the *American Chemical Society*, *Transactions of the American Mathematical Society*, the *SIAM Journal of Computing*, and the *Quarterly Journal of Economics* others are yet to publish much and are rarely cited. However, *ex ante*, policy makers in emigrant source countries do not know which researchers are going to be successful, so it is likely to be researchers such as the ones we study that policy makers have in mind when they reform research policy so as to either restrain emigration or else attempt to attract emigrant researchers back.

Our findings should be most informative for small, emigrant-sending countries grappling with issues related to the mobility of their scientists.⁴ But policy makers in destination countries also may have an interest in these issues since the appropriate stance of host countries to the return home of foreign research students is currently a topic of debate (Bloomberg, 2011). Similarly, some destination country researchers, especially in the medical field, want to limit the scope for emigration of health professionals from developing countries, under the guise of ‘ethical recruitment’. The view of these researchers is that recruiting by wealthy countries is threatening the viability of health programs in poor countries, especially in sub-Saharan Africa (Scott, *et al.* 2004).

2. PREVIOUS LITERATURE

Several recent papers describe ‘brain drain’ rates for researchers. For example, Gaulé (2011) studies career histories for scientists with undergraduate degrees from outside of the US who were ever faculty of US PhD-granting chemistry departments between 1993 and 2007. Only five percent had returned to the country of undergraduate degree in the observation period, suggesting that the return migration channel is weak. This low return rate implies that claims of a substantial benefit from returnees (for example, Mayr and Peri, 2009) may be overstated. More broadly, Weinberg (2011) examines ISI highly-cited researchers from 21 scientific fields, and finds that 1-in-8 highly cited researchers was born in a developing country but only 1-in-40 now lives in a developing country.⁵ Even richer regions may suffer these ‘brain drain’ effects, with Docquier and Rapoport (2009) finding rates of European emigration to the US for science and technology researchers that are five times higher than the emigration rate of the tertiary educated (the typical measure of ‘brain drain’ adopted in cross-country studies).

⁴ There are over 110 countries with a population below that of New Zealand, so these issues of the appropriate policy response to scientific mobility from small countries are likely to have widespread salience.

⁵ Moreover, an expansive definition of developing countries is used which includes Israel – the home to more highly cited researchers than any other country classified by Weinberg as part of the developing world.

Similarly, Hunter *et al.* (2009) study 158 physicists in the ISI highly-cited database, from 32 different countries of birth, narrowing to 22 countries of PhD study and 16 countries of current residence (with two-thirds currently in the US, though only 30 percent were born there). To test for positive impacts of migration on productivity they calculate the *h*-index (the author has written *k* papers that are each cited at least *k* times) and find that separating the sample by whether they had migrated – since either birth, bachelors, or PhD – shows no statistically significant difference in the *h*-index. The conclusion drawn from this comparison is that migration does not raise the productivity of elite scientists; a point which was argued more forcefully in an earlier working paper (Ali *et al.* 2007, p.28):⁶

‘Our data, however, fail to find a clear productivity difference (some years later) between the elite movers and the elite stayers. This is consistent with, although does not unambiguously prove, the idea that the brain drain creates no significant beneficial externalities for science. Those who advocate the brain drain as good for humanity as a whole need to show that moving makes a migrating scientist do better science. This may be true, and much more research, especially longitudinally, is needed. But we have not found evidence for such a claim.’

One concern with this conclusion is that many stayers in the Hunter *et al.* (2009) study were from countries like the United States, which are migrant destinations rather than sources. Their sampling approach did not yield a sample of stayers in developing countries or scientifically-peripheral countries. Yet it is the stayers in these sorts of emigrant-source countries who are the correct counterfactual for what the productivity of the expatriate scientist would have been if they had not moved. To estimate the correct counterfactual requires an approach that draws a sample from emigrant-source countries before individuals have moved, which is the approach adopted in the current study.

In addition to studies of the locations of highly cited scientists, two other approaches have been used in the literature on the impact of skilled emigration on knowledge flows and innovation. In the first, patent citations are used as a proxy for knowledge flows. For example, Kerr (2008) combines names on individual patent records with an ethnic-name database to examine whether a larger ethnic research community in the United States improves technology diffusion to foreign countries of the same ethnicity.⁷ Evidence of

⁶ Whether migration raises researcher productivity is important for evaluating the welfare consequences of this mobility. As Kuhn and McAusland (2009) note, migration with sufficiently higher productivity of the emigrants may compensate any economic loss to the source country, through the mechanism of source-country consumers benefiting from the knowledge-intensive products derived from the work of these emigrant researchers.

⁷ This approach allows the ethnicity of inventors who may be immigrants to be allocated to one of eight non-English groups (Chinese, European, Hispanic, Indian, Japanese, Korean, Russian, and Vietnamese).

knowledge diffusion through ethnic networks is apparent from the fact that foreign researchers cite U.S. researchers of their own ethnicity 30–50% more frequently than researchers of other ethnicities, all else the same. These knowledge flows are then shown by Kerr to be associated with higher manufacturing output in the foreign countries.

Similarly, Agrawal *et al.* (2011) examine the impact of co-location and diaspora networks on the patent citations associated with 831 inventions from India (yielding 5527 focal-cited patent pairs) and a matched set of control patents. Inventors are identified as members of the Indian diaspora based on their last names, while co-location is measured at city and country level. There is a large co-location premium for knowledge flows between Indian inventors but a much smaller diaspora effect (less than one-fifth as large, for the average invention). Agrawal *et al.* interpret this pattern as suggesting that having a large domestic innovator stock is more important than having a large diaspora, so emigration of researchers is likely to be harmful to the source economy. But there are two caveats to this conclusion; first, the diaspora effect is relatively more important for high-value inventions, which may be the ones that generate the bulk of the social value from innovation; second, patent citations as a proxy for knowledge flows are most relevant to frontier innovation, which may be atypical of the innovation in small countries that is more in the nature of implementation-innovation.

Instead of using patent citations as an indicator of knowledge flows, another approach to understanding the impact of scientific mobility is to seek direct micro evidence on research connections, by surveying scientists. For example, Tripl (2011) uses a sample of 720 scientists (based on a survey where 2841 scientists from the ISI highly-cited database were sent questionnaires), of whom almost one-half were classified as never migrants, and one-quarter each as current migrants or returnees.⁸ Amongst the current migrants, 82 percent reported maintaining knowledge linkages to the scientific community in the source country, in the form of joint publication, joint patents, or joint attendance at workshops or international scientific conferences. The return migrants were even more active conduits for knowledge transfer, with 90 percent of them engaged in such activities with scientists in their former locations. Nevertheless, this form of international networking was also carried out by the non-migrant scientists, and in logit analyses of the determinants of these forms of academic collaboration (along with parallel analyses of other, more entrepreneurial, activities, such as selling patents to firms), there was no significant effect of being either an expatriate or a return migrant. Based on these results, Tripl (2011, p.12) concludes that:

‘...mobile star scientists do not differ in their regional knowledge transfer activities from non-mobile star scientists.’

⁸ Since the sample frame is defined by outcomes towards the end of their careers (the average age of each group is 61-63 years) rather than before any initial mobility had occurred, it is not possible to determine the ex ante incidence of ever migration or return migration for this sample.

This finding that internationally mobile scientists have no advantage in knowledge transfer over non-mobile scientists serves as a useful antidote to hopes in the literature that return migrants may bring back frontier knowledge and membership of international networks, as a transmission path for technology to flow to the source country (Gaillard and Gaillard, 1997; Davenport, 2004). Despite the claimed ‘death of distance’ due to improved communications (Cairncross, 2001), which might be expected to devolve research to lower cost peripheral areas, centripetal forces from the need for close proximity and face-to-face contact continue to create a demand for research clustering that generates divergence between leading and backward countries (Castellaci and Archibugi, 2008). Thus, systematic empirical evidence on actual patterns of interaction by mobile researchers may provide guidance to policy makers concerned about the spatial distribution of research.

3. METHODS

Our approach is to define a target sample of interest that can be identified before migration has occurred, and then to survey these individuals regardless of their subsequent moves. In our case, we specify the target sample of interest as individuals who were the ‘best and brightest’ in terms of their academic performance at the end of secondary education in their home countries. This can be objectively measured in terms of top performance in national examinations, or in terms of being named as one of the top academic performers in the school such as a valedictorian or Dux, salutatorian or Proxime Accessit. Moreover, it can be measured *ex post*, with the target sample then set as individuals who were top students in earlier years who are surveyed in the present. In our application, we focus on students graduating secondary school between 1976 and 2004, which gives a compromise between the better records on more recent students and the longer work histories for earlier students.

Our New Zealand (NZ) sample frame comprised one older group and three younger groups: members of New Zealand’s Mathematical Olympiad team since 1988 ($n=73$); of New Zealand’s Chemistry Olympiad team since 1992 ($n=48$); and students who were either top overall, top in a subject or top of their sub-population (by gender and ethnicity) in University Bursary examinations from 1991-2004 ($n=484$). For the older group, graduating 1976-91, we sought the top student (the Dux, which is similar to the Valedictorian in the United States) each year back to 1976 from a set of 16 top schools that had supplied many of the individuals in the first three groups ($n=271$). In total the NZ sample frame had 851 highly skilled individuals who graduated secondary school in New Zealand from 1976-2004.

For Tonga our sample frame is the Dux and Proxime Accessit (runner up) from the top three secondary schools on the main island of Tongatapu (containing two-thirds of the population) and two top schools from other islands. For all but one school, which only opened in 1985, we cover 1976-2004. This gave a target sample of 266 individuals and school records provided the names of 245 of them.

For PNG we obtained the names of the 264 students (0.7 percent of all candidates) who had achieved a 4.0 GPA in their Grade 12 national examinations during 1995-98 and 2000-2004. We also included any Duxes or Proxime Accesits from the top two-thirds of schools supplying the 4.0 GPA group, giving a potential sampling frame of 624 if the two groups were mutually exclusive and 376 if all of the 4.0 GPA students were also a Dux or Proxime Accesit. For 1976-1994 our sample frame consists of the Duxes and Proxime Accesits from the four National High Schools that were the only Grade 11 and Grade 12 schools operating during that period, which covers an additional 93 top students.

Almost all these individuals who were academic high achievers in secondary school went on to receive a bachelors degree and many went on to get postgraduate education: 99 percent of the New Zealand sample aged 22 and above had a bachelors degree and two-thirds had a Masters or above; three-quarters of the Tongan sample aged 22 and above had a bachelors degree, and 38 percent had a Masters or above; and 87 percent of the PNG sample had a bachelors degree and 34 percent had at least a Masters. The educational attainment of the sub-sample of ever-researchers is even higher. For PNG, most of the researchers had degrees from Australia, New Zealand and Papua New Guinea, while the PhD degrees were obtained from a wider variety of international institutions including the Claremont Graduate University and the University of London. For the Tongan sample, most terminal degrees (whether Masters or PhD) were obtained from institutions in Australia, New Zealand and the two main universities in the Pacific (University of South Pacific and University of Papua New Guinea) but also from Reading, Hawaii, Waseda (Japan), and Lancaster. Most of the researchers in the New Zealand sample had undergraduate degrees from New Zealand, while the PhDs were predominantly from overseas, including from prestigious institutions such as Harvard, Yale, Princeton, MIT, Stanford and Cambridge.

4. RESULTS

In Table 1 we describe our samples, the survey rate, and the migration rate, which is based on ever having worked or studied abroad after finishing secondary school. We do not specify a minimum amount of time this must have occurred for, but it is very rare for the time abroad to be less than one year for these populations. Migration for study and for work are strongly interrelated (one is often needed for the other) so we do not attempt to separate them. In Gibson and McKenzie (2011a) we show that for these samples, the determinants of ever working abroad (a narrower definition) are similar to the determinants of ever migrating.

Table 1: Sample Sizes, Response Rates, and Migration Rates, for the Full Samples and Researcher Sub-Samples

Country	# in sample frame	# of survey respondents	Survey Rate	% who ever migrated	% who are current migrants	# ever been researchers	% of researchers who ever migrated	% of researchers current migrants
New Zealand	851	371	43.6	67.2	44.1	161	75.8	55.3
Papua New Guinea	691	236	34.2	37.2	10.3	25	80.0	36.0
Tonga	266	193	72.6	85.7	48.2	16	100.0	62.5
Total	1808	800	44.2	64.6	35.8	202	78.2	53.5

Notes:

% who ever migrated or are current migrants, for both the full sample and for the researcher sub-sample, is for those who are aged 22+.

A total of 1808 elite academic students are in the sample frames for the three countries; of these, we tracked and surveyed just over 44 percent ($n=800$). Often the starting point was just a name (which may have changed upon marriage) from up to 30 years earlier, which then had to be traced to get current contact information for administering the survey. Our response rate compares very favorably with similar surveys that had much more current information.⁹ For example, Constant and D'Agosto (2010) had just 28 percent respond to their survey of Italian researchers and scientists living abroad, despite assistance from the Italian Ministry of Foreign Affairs and the use of a pre-existing database. Anas and Wickremasinghe (2010) had a 50 percent response (but just $n=110$) for their survey of migrant researchers from Sri Lanka, which relied on an online database of expatriate scientists maintained by the National Science Foundation of Sri Lanka. Tripp (2011) had a response rate of just 25 percent in a survey of ISI highly-cited scientists, despite the sample frame being defined by the scientist having an e-mail contact address available in the ISI database.

In the overall sample of top students the incidence of ever migrating is very high. Restricting attention to those who are 22 years or older (a typical age for completing a bachelors degree), we find that almost two-thirds of the sample had ever worked or studied abroad. The incidence of current migration is highest for the Tongan and NZ samples, at between 44-48 percent, and much lower for PNG, at just 10 percent (due in part to the bonding requirements for scholarship holders to return home for several years after postgraduate studies). The incidence of return migration is also very high, with between one-quarter and one-third of the sample from each country being return migrants.

The proportion of top students who have ever been researchers varies from 43 percent for New Zealand to under ten percent for Tonga.¹⁰ The researchers are even more internationally mobile than the other top students, with at least three quarters of the researchers from each country having ever been migrants and 54 percent being current migrants. Thus, even though return migration is fairly common, with at least one fifth of researchers returning to the country of their secondary schooling,¹¹ the rate of researcher return migration is lower than it is for the overall sample of top students.

⁹ Moreover, Gibson and McKenzie (2011a, 2012) use differences in the effort required to find different migrants to show that harder to find individuals do not seem to differ in income, migrant status, or impacts on the home country from those found more easily, suggesting that selective attrition is not a large problem in this sample.

¹⁰ Our broad, self-reported, definition of researchers includes those who were ever Doctoral or post-doctoral students. Subsequently, however, we narrow our focus to active publishers in peer-reviewed academic journals.

¹¹ Some of the top secondary school students had been born elsewhere, especially in New Zealand where immigrants now make up almost one-quarter of the population. It is therefore not clear what country would be described as the 'home country' and we steer clear of using this term when describing the results.

In Table 2 we describe the (self-reported) research activity of those who have ever been researchers. Since there are few researchers from Tonga and Papua New Guinea we combine those two samples into one group to contrast with the results for New Zealand. This contrast may show the impact that higher national income and a more developed research infrastructure have for similarly sized island countries.¹² In this table and all following tables, the samples are further split into current migrants, returnees and never-migrants. To the extent that all three groups are from the upper tail of the skill distribution, the never-migrants may be considered a counterfactual for what might have been the outcomes for the expatriate researchers had they never left. Comparing outcomes for returnees with the current- and never-migrants may help sift between two competing theories of migration (Clemens, 2010); the first is that local attributes of the country of work make individuals more productive when they are abroad, while the second is that workers learn how to be more productive when working abroad and can bring that knowledge back with them when they return.

Table 2: Research Activity by Migration Status

	Researchers who are current migrants	Researchers who are returned migrants	Researchers who never migrated
<i>New Zealand</i>			
% holding any patents	7.9	0.0	2.6
% publishing refereed journal article in last 5 years	71.9***	48.5	46.2
Number of articles published (last 5 years)	7.6*	3.9	4.4
Unconditional number of articles (last 5 years)	5.2***	2.0	2.2
<i>Papua New Guinea and Tonga</i>			
% holding any patents	0.0	11.8	0.0
% publishing journal article in last 5 years	47.4	35.3	40.0
Number of articles published (last 5 years)	3.2**	4.7**	0.5
Unconditional number of articles (last 5 yrs)	1.5*	1.6	0.4

Notes:

Samples are restricted to those who reported ever being researchers (including doctoral and post-doctoral students), aged 22+.

*, **, and *** indicate significant difference from the never migrants, at the 10, 5 and 1 percent levels respectively.

The expatriate researchers from New Zealand are much more active than either the never-migrants or the returnees (Table 2). The odds of expatriates publishing in the five years prior to the survey were 50 percent higher than for the two sub-samples in New Zealand, and the (conditional) number of articles published was almost twice as high. Combining the publishing odds and the number of articles, an unconditional average of five articles were published in the previous five years by current migrants, versus only two articles published by either returnees or never-migrants.

¹² The combined population of Papua New Guinea and Tonga is about 40 percent greater than that of New Zealand, and the combined number of universities (eight) is the same as in New Zealand. But universities in Papua New Guinea and Tonga are much more teaching oriented than are the New Zealand universities.

For the smaller sample of researchers from Papua New Guinea and Tonga, the odds of publishing are lower for all groups and show no significant difference by migration status. Amongst those who had published, both current- and return-migrants were significantly more active publishers than the never migrants. While the mean number of articles published by returnees exceeded that of current migrants, this reflected two prolific medical researchers in Papua New Guinea. The median number of articles published was identical ($n=3$) for current migrants and returnees.

To examine scientific impact of the active researchers (those publishing in the previous five years) we use the *Publish or Perish* software of Harzing (2007) to calculate their lifetime publications, citations and h -index. Publication lags and access to pre-print articles differ by discipline so we set the time frame that we searched over to end in 2010, to allow for lags, and started it in the second undergraduate year for each researcher (in case they published from an undergraduate thesis). Measuring the impacts of researchers with common names can be difficult, but our survey asked each researcher to name the journal that published their most significant paper and this made it easier to identify specific authors. Finally we note that *Publish or Perish* relies on *GoogleScholar* and so tends to capture more citations than the *ISI Web of Science* since it searches more broadly, especially over working papers.¹³

The New Zealand-schooled researchers who are current-migrants have a substantially larger scientific impact than either the returnees or the never migrants (Table 3). Their lifetime citations average almost 600; roughly double that of the returnees and ten-times greater than the never-migrants. Returnees seem to have greater impact than never-migrants, so to the extent that the never-migrant researchers are a counter-factual, this finding might be taken as partial evidence for the view that workers learn a portable skill of how to be more productive while working abroad that returns to the source country with them.

A complication in interpreting the Table 3 evidence as supporting a portability theory of learning abroad is that returnees are older than current migrants (by three years, on average) and never-migrants (by four years).¹⁴ Since scientific impacts accumulate with age, the apparently greater impact of returnees may just be from being older. Therefore in Table 4 we report the results of OLS and median regressions that compare each indicator of scientific impact after controlling for age. This regression is just carried out for the New Zealand sample since the other sample is too small. It is apparent that adjusting for age removes all of the apparent extra impact of returnees compared with never-migrants, at both the mean and the median. For each of the three indicators, the coefficient on return migrants indicates

¹³ The average age of the active publishers was 33 years. For early career researchers a large fraction of citations may be to working papers so we wanted to capture these impacts which would be missed by *Web of Science*.

¹⁴ The same pattern is true for Papua New Guinea and Tonga, but with a wider spread; the averages are 40 years for returnees, 37 years for current migrants and 26 years for never migrants.

statistically insignificantly differences from the never-migrant group (and with negative point estimates for the number of papers and citations). This evidence in Table 4 is consistent with the idea that local attributes of the host country make migrants more productive when they are abroad and they lose this advantage when they return to the source country.

Table 3: Scientific Impacts by Migration Status for Active Publishers

	Researchers who are current migrants	Researchers who are returned migrants	Researchers who never migrated
<i>New Zealand</i>			
Number of publications (through 2010)	22.6***	14.6**	5.3
Total citations (through 2010)	594.4***	366.7*	64.8
<i>h</i> -index (<i>k</i> -articles each cited at least <i>k</i> -times)	7.8***	6.1**	2.7
<i>Papua New Guinea and Tonga</i>			
Number of publications (through 2010)	3.6*	4.0**	0.5
Total citations (through 2010)	20.1*	24.5**	0.0
<i>h</i> -index (<i>k</i> -articles each cited at least <i>k</i> -times)	1.2***	2.3**	0.0

Notes:

Samples are restricted to those who reported ever being researchers (including doctoral and post-doctoral students), aged 22+, who had published in a refereed academic journal in the previous five years ($n=98$ for NZ and $n=17$ for PNG+Tonga).

*, **, and *** indicate significant difference from the never migrants, at the 10, 5 and 1 percent levels respectively.

Table 4: Scientific Impacts by Migration Status, New Zealand Sample with Age-Adjustment

	OLS			Median Regression		
	Papers	Citations	<i>h</i> -index	Papers	Citations	<i>h</i> -index
Currently a migrant	13.88 (3.58)**	418.76 (2.76)**	4.24 (4.33)**	5.00 (2.32)*	78.57 (1.41)	2.25 (2.31)*
Return migrant	-1.12 (0.17)	-33.80 (0.13)	0.86 (0.61)	-1.00 (0.35)	-48.86 (0.66)	0.75 (0.57)
Age	1.85 (2.06)*	59.46 (1.68)+	0.44 (3.01)**	0.57 (4.02)**	13.57 (3.57)**	0.25 (3.74)**
Constant	-50.65 (1.87)+	-1,729.00 (1.63)	-10.53 (2.41)*	-12.14 (2.57)*	-323.29 (2.61)*	-4.75 (2.22)*
R-squared	0.17	0.13	0.22			

Notes:

Regressions based on $N=98$ active researchers (those who published in refereed journals within the last five years).

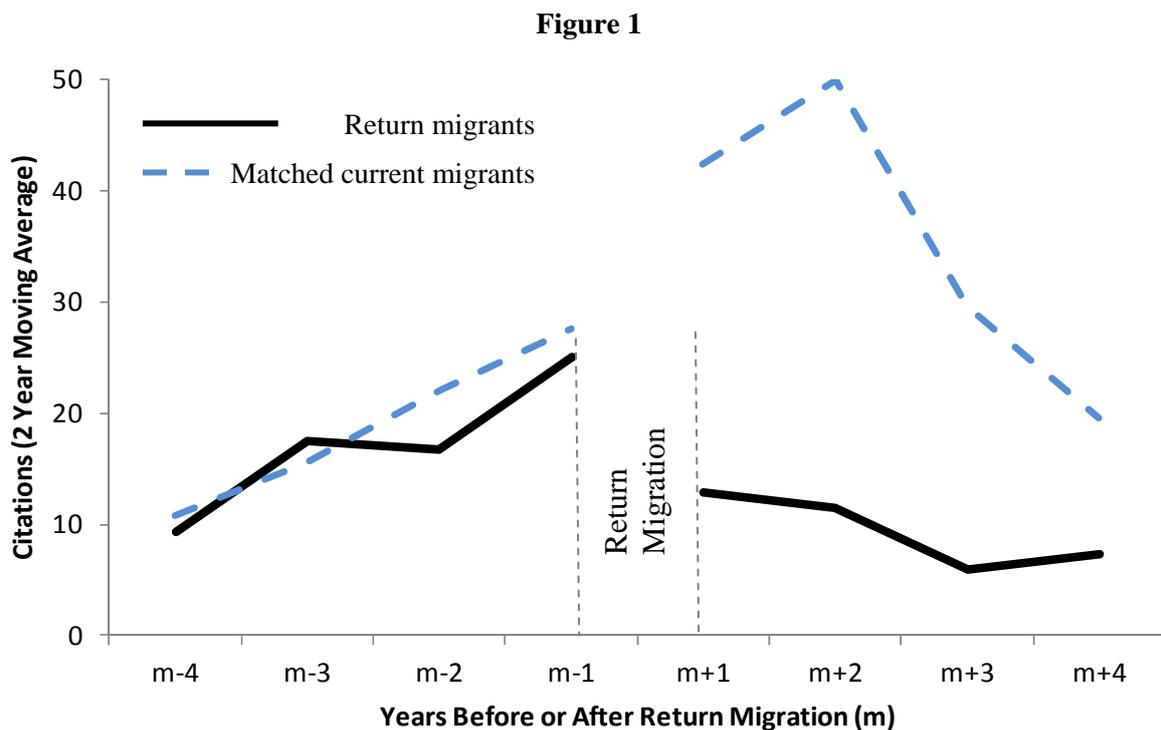
Those who never migrated are the control group.

Robust t-statistics in (); + significant at 10%; * significant at 5%; ** significant at 1%.

The patterns in Table 4 also are consistent with positive selection of ever-migrants and negative selection of returnees (Borjas and Bratsberg, 1996). More productive researchers leave, and amongst those who migrate, the least successful return. But neither qualitative nor quantitative evidence lends support to the negative selection story, and so we interpret the lower scientific impact of return-migrants compared with current-migrants as a causal impact of relocation to a scientifically peripheral country. In terms of qualitative evidence, the reasons given by the returnees for their return emphasize constraints that are unrelated to

individual productivity; for almost one-half of the New Zealand sample the stated reasons were concerns about aging parents, child-raising and location of extended family.¹⁵

To obtain quantitative evidence on negative selection we examined the citations to papers that the New Zealand returnees had published in each of the five years prior to return. This citation profile is presented in Figure 1, in the form of a two-year moving average, to smooth out annual volatility from a few highly cited papers. The figure also has the citation profile to papers published in each of the five years after return (also as a two-year moving average).¹⁶ There is an upward trend in the citations to papers published prior to return migration; rising from nine citations for those published 4-5 years prior to return to 25 citations for the papers published 1-2 years before return. There is then a sharp drop, with an average of just 13 citations to papers published 1-2 years after return and seven citations to papers published 4-5 years after return. Some of this decline in citations is a mechanical effect, since the papers published 4-5 years after return are more recent, so less time has elapsed for them to be cited (on average, return migration occurred in 2003 so these papers are from 2007 onwards).



¹⁵ Similarly, PNG and Tonga returnees listed family commitments, along with scholarship bonding provisions and a desire to contribute to national development and utilize their skills where they are most needed.

¹⁶ Papers published in the year of return are excluded from the calculations since we do not know when return occurred within the year. Moreover, papers published that year are likely to have been accepted prior to return.

To obtain a sub-sample of current migrants to compare with the returnees, we estimated a nearest-neighbor propensity score match, controlling for age, gender, birth place, overseas trips during high school, subjects studied, and highest degree.¹⁷ To ensure that citations for the matched current migrants were for papers published at the same career stage as for the returnees, a simulated date of return was set as the number of years between their matched returnee's highest degree and return date. We then gathered citations to papers published by the current migrants in the five years before and after this date, to compare with the impact of the pre-return research of the returnees and also to serve as a counterfactual for research impacts had they not returned. There is no evidence of negative selection of returnees; the citations to papers published pre-return have an almost identical trend and are just 10 percent higher (an average of 2.6 extra citations) for the current migrants at the same stage in their career as the return-migrants were in the year prior to return. But there is a clear divergence after return, with an average of 50 citations to the output of the current migrants two years after the simulated date of return versus only 12 citations for papers produced at the same stage by the returnees. Thereafter, citations for the matched current migrants begin to decline, for the same mechanical reason as noted above – these are for quite recent papers which have not yet had time to accumulate many citations.

Irrespective of whether the larger impact of current migrants reflects causal effects of migration rather than selection effects, evidence for their ongoing interaction with the source country is needed to evaluate claimed benefits of a skilled diaspora facilitating knowledge transfer. In Table 5 we describe the scientific collaboration networks of our samples, focusing on the location of co-authors and the number of papers written with co-authors in different countries. Only researchers who had published in the prior five years are considered here.

Table 5: Scientific Collaboration Networks by Migration Status, for Active Publishers

	Researchers who are current migrants	Researchers who are returned migrants	Researchers who never migrated
<i>New Zealand</i>			
Number of co-authors in country of secondary schooling ^a	0.8***	3.8	4.5
Number of co-authors in other countries ^a	10.3***	4.4**	0.6
Total number of co-authors ^a	11.1**	8.2	5.1
Number of papers with co-author in different country ^a	2.6***	2.3**	0.3
<i>Papua New Guinea and Tonga</i>			
Number of co-authors in country of secondary schooling ^a	1.0	4.3	2.5
Number of co-authors in other countries ^a	3.4***	7.2***	0.0
Total number of co-authors ^a	4.4	11.5	2.5
Number of papers with co-author in different country ^a	2.0***	4.5**	0.3

Notes:

^aIn the last five years. See Table 3 for other notes.

¹⁷ The probit equation used to estimate the propensity score has a pseudo- R^2 of 0.36 and the estimated propensity score satisfies the balancing property.

There is little evidence of active and broad links between current migrants and researchers in the source country. The current migrants have an average of just 0.8 (New Zealand) and 1.0 (PNG and Tonga) co-authors in the source country, which is just 7 percent and 23 percent of their total number of recent co-authors (Table 5). Instead it is return migrants who are the link between researchers in the source country and those located abroad; the returnees have significantly more international co-authors than do never-migrants but are at least as active in publishing with co-authors from different countries as are the current migrants.¹⁸ Evidently, even if the skills learnt abroad of how to be more productive are not easily transferred to the source country, the contacts made overseas can be utilized by returnee researchers to ensure that the source country has at least some participation in international research networks.

Even if expatriate researchers do not co-author with researchers in the source country, the diaspora could help in the dissemination of research. Our surveys asked for evidence of this in the form of academic conferences attended and seminar presentations to universities or government agencies in the source country. This type of engagement by the diaspora with the source country also appears to be rare; only ten percent of the conferences attended in the previous year by current-migrant researchers were in the source country (Table 6). On average, each migrant researcher would attend a source country conference only once every five years, so this face-to-face communication with researchers in the source country is unlikely to be an effective method of knowledge transfer. The same holds for seminar presentations to source country audiences, where the average number per year (0.2) is too low to expect any sustained knowledge transfer from the diaspora.

Table 6: Participation in Dissemination of Research - Conferences and University and Government Presentations

	Researchers who are current migrants	Researchers who are returned migrants	Researchers who never migrated
<i>New Zealand</i>			
# of academic conferences in country of secondary schooling ^a	0.2***	0.7	0.9
# of seminar presentations to source country universities & gov't ^a	0.2*	0.7	1.0
# of academic conferences attended in other countries ^a	1.9***	0.7**	0.3
<i>Papua New Guinea and Tonga</i>			
# of academic conferences in country of secondary schooling ^a	0.2	2.4**	0.6
# of seminar presentations to source country universities & gov't ^a	0.2**	1.4	1.0
# of academic conferences attended in other countries ^a	1.8***	1.8***	0.0

Notes:

^aIn the last year. See Table 2 for other notes.

In contrast, return migrants may be a potential conduit for knowledge transfer, since they attend source country and international conferences in approximately equal proportions (Table 6). Moreover, the returnees are much more frequent conference participants than the

¹⁸ The higher number of total co-authors and international co-authors for returnees compared with current migrants from PNG and Tonga reflects two medical professionals in PNG who are active publishers with large co-author networks.

never-migrants, and attend almost as many (New Zealand sample) or twice as many (PNG and Tonga) conferences as the current migrants. The returnees are also the most active group in presenting seminars to source country university and government audiences.

The last form of interaction that our survey considered is research funding, where respondents were asked if they had ever received research funds from the source country, whether they had current research funding from other countries, and the total value of research grants won in the last three years. There is no difference across the three migration groups in the (low) odds of ever receiving source-country research funding (Table 7), although this may not be very informative since we do not know the timing of these grants. However, there are significant differences in the likelihood of having current funding from other countries, with almost one-third of the expatriate New Zealand researchers currently receiving research funds from agencies outside of New Zealand. This funding advantage for the expatriates is also revealed in their level of funding, with an unconditional average of US\$113,000 grants won over the previous three years.

Table 7: Research Funding, by Migration Status

	Researchers who are current migrants	Researchers who are returned migrants	Researchers who never migrated
<i>New Zealand</i>			
% ever receiving research funding from home country sources	13.5	18.2	15.4
% with current research funding from agencies in other countries	30.3***	3.0	5.1
Total value of all research grants in last 3 years (US\$) ^a	113070***	15640	2010
<i>Papua New Guinea and Tonga</i>			
% ever receiving research funding from home country sources	15.8	41.2	40.0
% with current research funding from agencies in other countries	36.8	35.3	20.0
Total value of all research grants in last 3 years (US\$) ^a	9020	52130	3840

Notes:

^aUnconditional average over all researchers, regardless of whether ever received funding, converted to US\$ using PPP exchange rates. See Table 2 for other notes.

In contrast to some of the other indicators considered in the previous tables, there appear to be no statistically significant productivity advantages for returnees obtaining research funding. The odds of a return migrant to New Zealand having current funding from outside of New Zealand are only one-tenth of the odds for the expatriates, and their current funding from all sources is only one-seventh the level of the expatriates, and not significantly different from the funding won by those who never migrated. While the returnees look better in the results for Papua New Guinea and Tonga, this reflects just two researchers; without these two the mean value of current funding for the return migrants would be just US\$4500.

Finally top students were asked an open-ended question, about policies they would personally recommend to Government officials and universities attempting to recruit top researchers back to their country. The majority of New Zealand emigrants answering this question gave recommendations about improving the academic system, commenting on the

relatively poor environment for academic research in New Zealand compared to abroad. In addition to complaints about low salaries and high teaching loads, poorly funded scientific laboratories and the low success rate of grant funding requests were frequently mentioned. There were also some more specific complaints about current regulations that restrict work in genetic engineering and related biological fields. For the PNG and Tongan respondents, higher salaries and improved research infrastructure and basic utilities such as telecommunications were frequently mentioned, along with allowing dual citizenship.

5. CONCLUSIONS

Using an innovative survey we have examined the migration outcomes and scientific productivity of researchers from three small island countries. The key advantage of our method is that we are able to identify a study population that is less subject to selection issues than previous studies. Perhaps as a result, our findings challenge some of the conclusions of existing literature. For example, Gaulé (2011) suggests that the return migration channel is very limited, but bases this on a sample of individuals who have chosen to start their research careers in the U.S. We find return migration rates among researchers which are 5 to 8 times those in this previous work, suggesting that returning to small, island countries with education and skills learned abroad is an important source of knowledge gain for these types of high-emigration countries. We also find these return migrants to be actively engaged in maintaining international knowledge networks, having more international co-authors and more participation in international conferences than researchers who never migrate.

Second, our findings are not consistent with the claim by Ali et al., (2007) of no clear productivity difference between elite movers and elite stayers, which was based on an analysis of stayers from developed countries. We find current migrants to be substantially more productive in terms of research output and research impact than either return migrants or individuals who never migrate from small island countries. Using a difference-in-difference analysis, we show that this pattern is unlikely to reflect negative selection of the return-migrants, and instead appears to be a causal impact of relocation to a scientifically peripheral country. Thus, to answer the question posed by Hunter et al., (2009), the evidence here suggests that moving does indeed make a scientist do better science.

Taken together our results do show migration to be an important channel for both knowledge acquisition and knowledge transfer for researchers from small countries. Nevertheless, current migrants and returnee researchers still point to a number of obstacles that prevent these gains from being as large as they could be – with issues such as research funding, the availability of flexible positions that allow time working in multiple countries, and reward systems that reward on ability and not seniority coming up as areas for possible action if high-emigration countries wish to modify research policy to take account of the constraints and opportunities afforded by the international mobility of their researchers.

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