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RESEARCH STARS IN NEW ZEALAND

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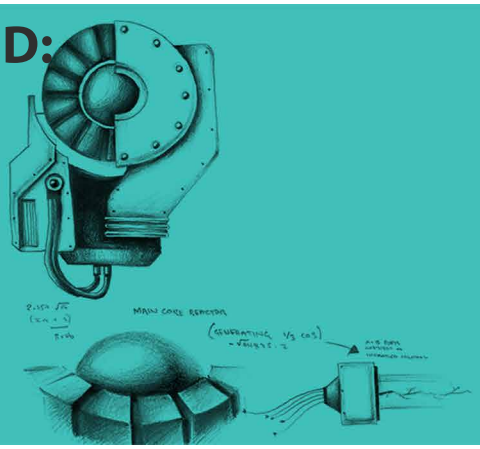
RESEARCH 'STARS' IN NEW ZEALAND: CONCENTRATION, PERSISTENCE AND MOBILITY



Motu Note #34

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SUMMARY HAIKU

Research has its 'stars'.
Stardom waxes and wanes, but
stars don't often leave.

INTRODUCTION

'Star' researchers—those who produce the most influential research outputs—have been shown to play an important role in the overall impact of a country's research and innovation system. This means the behaviour of stars—where they come from, whether they tend to be the same people over an extended period of time, and the likelihood that they will leave New Zealand—has important consequences for innovation policy.

In this report, we identify a set of star researchers in New Zealand, based on the publication of very highly cited papers. We then investigate the concentration of such highly cited papers across authors; the persistence of stardom across time, and the extent to which stars come from abroad or leave New Zealand after their stardom.

IDENTIFICATION OF NEW ZEALAND STAR RESEARCHERS

New Zealand 'star' researchers are those who publish articles, conference papers, and reviews that are highly cited in global scholarly literature. We begin by identifying every publication in the Scopus database between 2002 and 2013 with an author affiliated with a New Zealand institution and which has received (by 2017) a number of citations that places it in the top 1% of the citation distribution for its field, publication type, and publication year.[1] For each of these New Zealand 'home-run' papers, we constructed a measure of the authorship, that accounted for multiple fields and multiple authors.

For each New Zealand author with any fraction of a home-run we summed their fraction of home-runs in three-year periods: 2002-2004, 2005-2007, 2008-2010 and 2011-2013. We chose three-year periods to try to capture something more than transient performance while still allowing us to look at changes over time. Figure One shows the number of authors with fractionalized home-run totals in different ranges. It shows that in the 2002-2004 period, there were 12 authors with 1.0 or greater fractionalized home-runs, 74 between 0.5-0.99, 69 between 0.33-0.49, 79 between 0.25-0.32, and 602 between 0-0.24. Altogether 836 authors had their name on a home-run paper in the initial period, and 1,612 in the more recent period. This dramatic increase is likely driven by the rise in team sizes across the board, which makes it easier to be a co-author on a highly-cited paper. This is part of the reason we think it important to look at contributions on a fractionalized basis to get a meaningful picture of star researchers.

1. Using citation data through 2017 but limiting the analysis to papers published through 2013 allows adequate time for papers to have received a meaningful number of citations.

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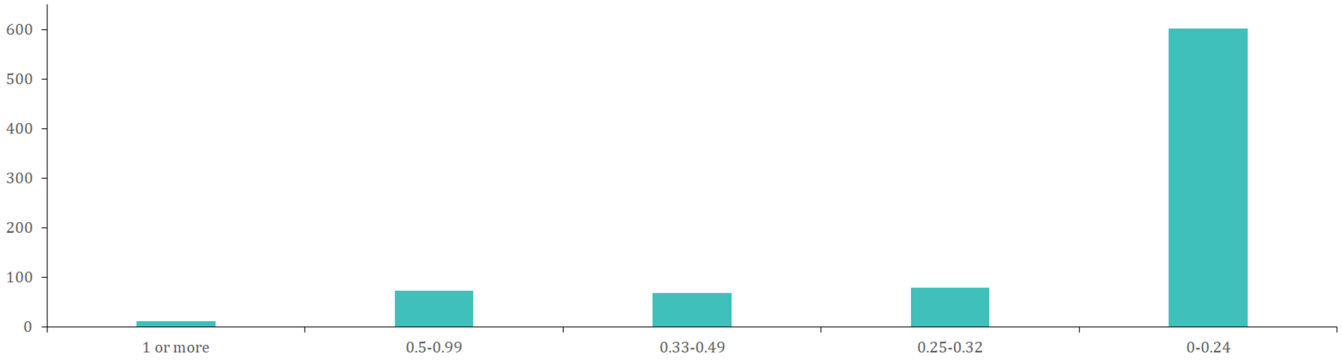
Figure One: The number of authors with fractionalized home-run totals in different ranges 2002-2004

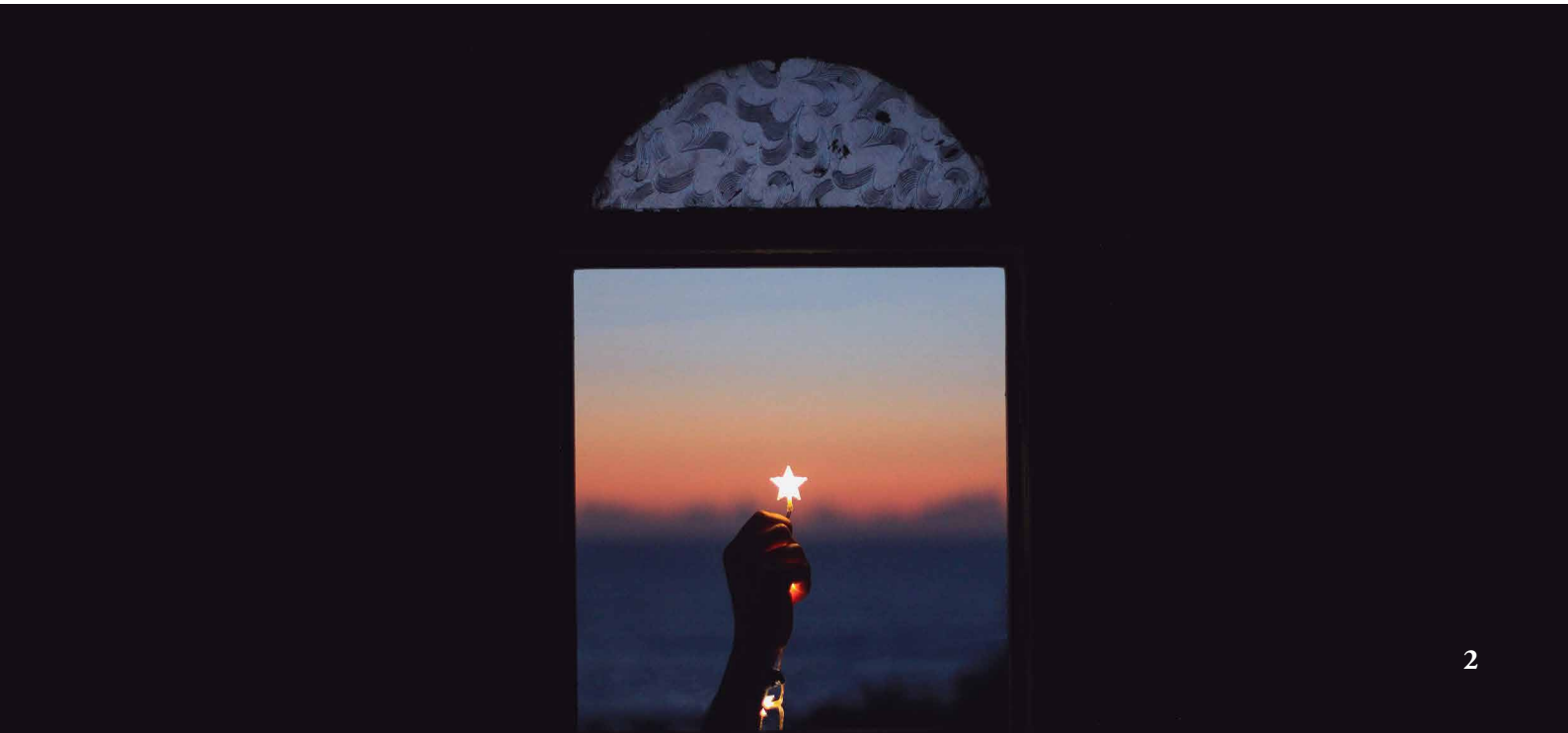


We somewhat arbitrarily chose a threshold of 0.5 fractionalized home-runs over a three-year period to define a New Zealand star. That is, anyone who co-authored a home-run paper with one other person, or two home-runs with four authors, or any combination of fractions totalling to 0.5 (or higher) is considered a star. In this way, we exclude authors whose name appeared on a single home-run paper with more than two authors, or on a handful of home-runs with large numbers of authors. On this basis, 339 New Zealand researchers were identified as stars.[2]

With this threshold, we identified 86 stars in the period 2002-04, 100 in 2005-07, 153 in 2008-10 and 148 in 2011-13. The increase over time in the number of authors that meet the star threshold is likely a combination of increased authors, increased output per author, and a higher share of New Zealand publications reaching the top percentile. Note that these numbers total to more than 339, because some authors were stars in multiple periods: 72 were stars in two periods, 26 in three periods, and 8 in all four periods. We consider the persistence of stardom across time in more detail below.

Once the New Zealand stars had been identified, we collected their full publication histories from Scopus, including publications that are not home-runs and publications when they did not have a New Zealand affiliation. Because of ambiguity as to how Scopus collects publications for a given author, we were concerned that star authors may have additional publications that are linked by Scopus to other author profiles. These would thus fail to be connected to the authors we had identified. Because Scopus disambiguates author names in part based on their institutional affiliations, we were particularly concerned that authors who changed institutions would be most likely to have their publication lists fragmented. This is particularly problematic as one of the issues we hope to study is the extent to which star researchers immigrate and emigrate.

2. There were 341 authors originally identified in Scopus, but manual review of these revealed that two were incorrectly affiliated with New Zealand on the publication(s) that qualified them as a star, so they were dropped.



To investigate this disambiguation, we took a random sample of 85 star authors, and searched for other Scopus authors with the same name. We manually researched those with potential doppelgangers to determine if they were the same researcher or not. Ultimately, for 12 of the 85 authors we found that there was indeed an additional author profile that was most likely the same researcher. For most, there were only a few papers in the doppelganger profile, meaning that failure to merge these profiles would have only a minor impact on the constructed publication histories. One author however, was linked by Scopus to a separate profile with 44 publications. Overall, we concluded that multiple profiles for the same author is problematic enough that we needed to search for potential matches among the remaining star researchers.

To make this task manageable, we considered only name matches that had at least one New Zealand affiliation at some point in time, or had an affiliation that matched one of the affiliations of the original star author profile. This second round of searches for missing publications identified 51 additional authors who appeared to have publications classified by Scopus into one or more doppelganger profiles (a total of 64 other profiles corresponding to these 51 authors). For these 51 authors, we added those papers from the doppelganger profiles that appeared to be by the identified author, and excluded those that did not.

BASIC STATISTICS ON NEW ZEALAND STAR RESEARCHERS

Table One shows the publications and citation metrics for the 339 stars for each of the four three-year periods we examined. The number of publications, the mean normalized citations (MNCS)[3], and the number of home-runs by this group all roughly double from the earliest to the latest period. This reflects both the increase in output per researcher and the growing number of researchers who qualify as stars.

Figure Two shows the fraction of research output for New Zealand as a whole comes from this small elite group. Indeed these 339 researchers account for about 6 percent of all New Zealand publications, about 15-20 percent of all New Zealand citations, and about 25-30 percent of all New Zealand home-runs.[4] Note that these totals are calculated on a fractionalized basis, i.e. a publication with nine other authors only counts as one-tenth of a publication. This is why this group only accounts for 25 percent of the home-runs—on this fractionalized basis, 75 percent of New Zealand home-runs correspond to authors that never collected a fractionalized total of 0.5 or more in any three-year period. Thus, while our set of identified stars are clearly far more prolific and their papers far more highly cited than average, their role cannot be said to be overwhelmingly dominant in the New Zealand research output landscape.

Table One: Total publications, mean normalized citations (MNCS) and home-run publications by 339 New Zealand star authors within New Zealand by period.

Period	Total Publications	Total MNCS	Home-runs
2002-2004	879	2393	59
2005-2007	1211	4313	80
2008-2010	1469	4594	129
2011-2013	1568	4231	108

3. For more information on MNCS, please see the Data Appendix

4. We know from the profiles we have examined carefully that the Scopus data erroneously connect some authors to New Zealand institutions. For this reason, the above comparison defines New Zealand authors as those that appear with a New Zealand affiliation on 3 or more Scopus papers. If we were to include as New Zealand papers any paper with any New Zealand affiliation, the share of the 339 identified stars would be a few percent lower.

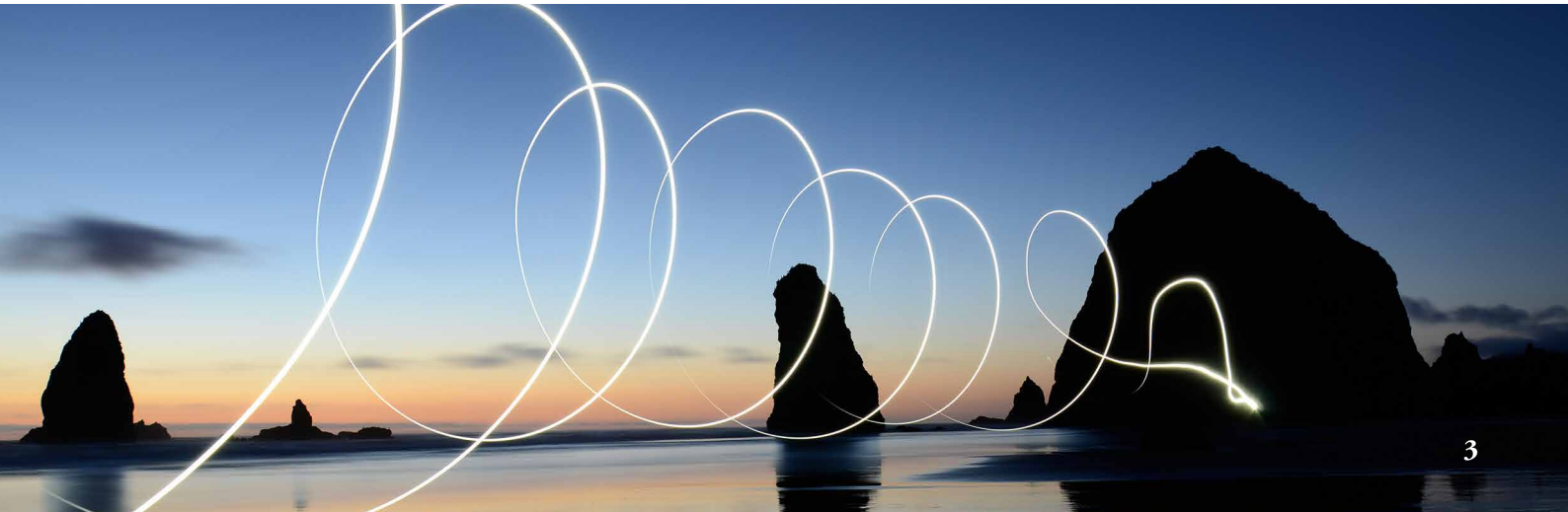


Figure Two: Star researchers output as a share of all New Zealand researchers

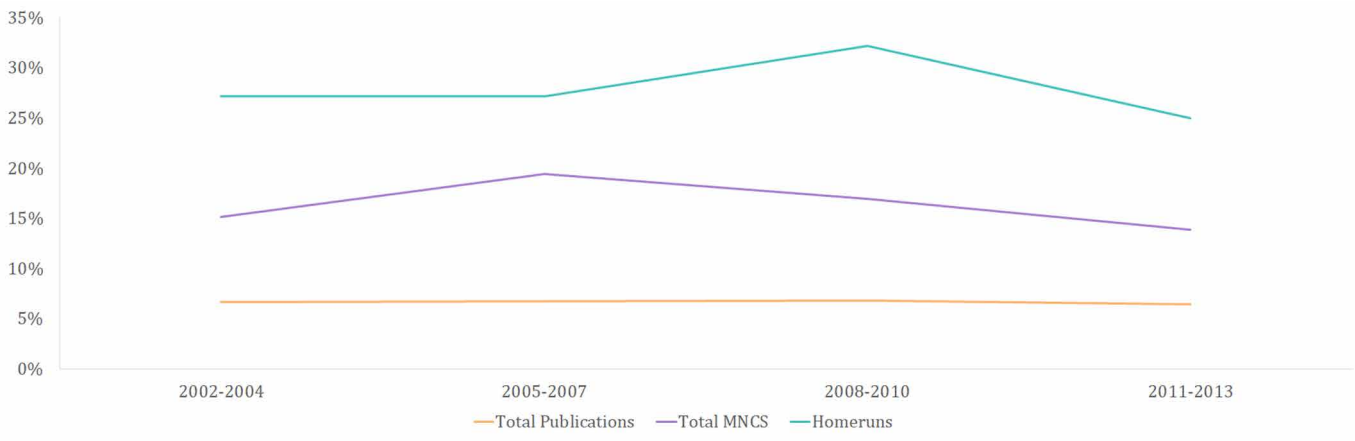


Table Two and Figure Three illustrate the concentration of these home-runs within this elite group of 339 authors. As expected, the very top authors have more home-runs than those who just made the star threshold. However, the difference is not as large as one might expect. For example, the top 10 percent of these authors account for 20-30 percent of the home-runs of the group. You need approximately half of the authors to aggregate to 80 percent of the total. Thus, again, we find that output is somewhat concentrated among the best of the best, but not overwhelmingly so.

Table Two: Share of New Zealand star authors responsible for different shares of home-runs over time.

Percent of home-runs	Number of authors	Share of authors	Number of authors	Share of authors	Number of authors	Share of authors	Number of authors	Share of authors
	2002-2004		2005-2007		2008-2010		2011-2013	
10%	5	4%	5	3%	7	4%	6	3%
20%	11	8%	12	8%	14	7%	12	6%
30%	17	14%	19	13%	22	11%	22	11%
40%	25	21%	26	17%	33	17%	32	17%
50%	33	28%	34	23%	44	23%	46	24%
60%	42	35%	44	29%	58	30%	62	32%
70%	53	44%	58	38%	77	40%	80	42%
80%	64	53%	72	48%	100	52%	100	52%
90%	77	64%	91	60%	124	64%	120	63%

Figure Three: Share of New Zealand star authors responsible for different shares of home-runs over time

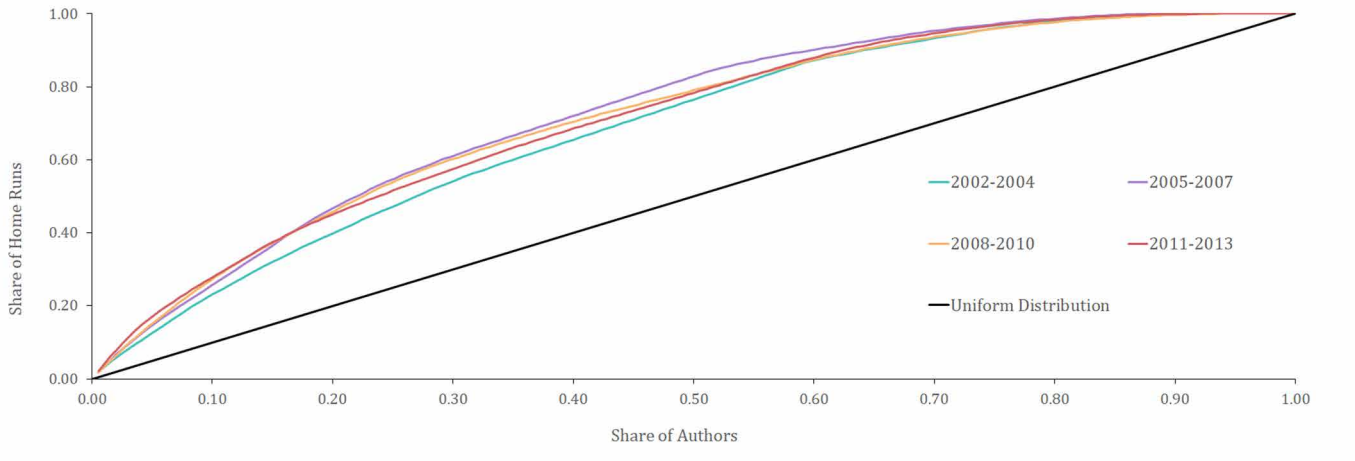


Table Three: Share of New Zealand Star Authors who make up different shares of home-runs from 2002-2013, by field.

	Percent of home runs								
	10%	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Agricultural & Biological Sciences	2%	5%	7%	12%	17%	23%	32%	44%	59%
Arts and Humanities	2%	5%	10%	12%	17%	22%	29%	39%	56%
Biochemistry, Genetics & Molecular Biology	1%	2%	4%	5%	7%	12%	20%	29%	45%
Business, Management & Accounting	4%	4%	8%	12%	15%	23%	31%	50%	69%
Chemical Engineering	6%	6%	12%	12%	18%	24%	29%	35%	47%
Chemistry	4%	7%	14%	18%	21%	29%	36%	46%	57%
Computer Science	2%	3%	7%	10%	15%	21%	31%	43%	61%
Decision Sciences	11%	11%	11%	22%	22%	33%	44%	56%	67%
Dentistry	33%	33%	33%	67%	67%	67%	67%	100%	100%
Earth & Planetary Sciences	3%	7%	10%	13%	17%	23%	33%	43%	60%
Economics, Econometrics & Finance	9%	9%	9%	9%	9%	18%	27%	45%	64%
Energy	6%	11%	11%	17%	22%	28%	33%	44%	56%
Engineering	3%	5%	8%	11%	17%	22%	30%	40%	54%
Environmental Science	2%	5%	8%	13%	17%	23%	30%	39%	56%
Health Professions	17%	17%	17%	17%	17%	17%	33%	50%	50%
Immunology & Microbiology	3%	7%	7%	14%	17%	24%	31%	41%	52%
Materials Science	4%	8%	8%	12%	16%	24%	32%	44%	64%
Mathematics	5%	7%	12%	16%	21%	26%	35%	47%	60%
Medicine	2%	5%	7%	10%	14%	19%	24%	35%	50%
Multidisciplinary	3%	3%	7%	10%	13%	20%	27%	33%	47%
Neuroscience	5%	5%	11%	11%	16%	21%	26%	32%	42%
Nursing	8%	15%	23%	31%	31%	46%	54%	62%	77%
Pharmacology, Toxicology & Pharmaceutics	6%	13%	13%	19%	25%	38%	44%	56%	69%
Physics and Astronomy	3%	6%	9%	12%	18%	24%	29%	41%	56%
Psychology	4%	8%	8%	13%	17%	25%	33%	46%	58%
Social Sciences	1%	5%	9%	14%	21%	26%	35%	46%	59%
Veterinary	11%	11%	11%	11%	11%	22%	33%	33%	56%

Table Three examines the concentration of output among stars in different fields. This takes us down to small numbers in some fields, so the numbers should be viewed as illustrative only. They do confirm limited concentration, however. The most concentrated field is Biochemistry, Genetics and Molecular Biology, for which 29 percent of the stars hold 80 percent of the star home-runs. Most fields have distributions similar to the overall pattern in Table Two, such that 40-50 percent of the stars are needed to account for 80 percent of the home-runs.

PERSISTENCE OF STARDOM OVER TIME

We have already seen that approximately 90 percent of the stars we identify met the threshold for stardom in only one or two of the three-year periods. In this section we explore in slightly more detail the extent to which home-runs are produced by the same people over time.

Table Four looks at the home-runs in each field in each period and examines what fraction of them are associated with authors who were stars in the previous period. Given that overall our identified stars account for only 25-30 percent of (fractionalized) New Zealand home-runs, it should not be surprising that in almost all fields the preponderance of home-runs are not associated with previous stars. There are only a handful of fields in which there is a time period in which the share of home-runs by previous stars is as high as 60-70 percent (e.g. Business, Management and Accounting in the last period), and for these fields this persistence percentage is lower across other time periods. Thus, looking at the home-runs over time in this way reinforces the picture that stars are important but not dominant.

MOBILITY OF STAR RESEARCHERS

Table Five explores what happened to star researchers from the initial period (2002-04) over time. Specifically, we look in Scopus to find publications by these authors in which the author is listed with a non-New Zealand affiliation. We take such a listing as evidence that the star author is at least partially active overseas. We say 'at least partially' because many of these authors have New Zealand-affiliated and non-New Zealand-affiliated publications interspersed in their records. In the initial period, these authors had non-New Zealand affiliations on about 7 percent of their home-runs and about 9 percent of their papers. The non-New Zealand share increases modestly over the subsequent periods, so that by the 2011-13 period about 19 percent of their publications and 14 percent of their home-runs have non-New Zealand affiliations. In addition, of the 86 stars identified in the initial period, 7 could not be found in Scopus in the later period. We do not know if these 7 retired, ceased publishing, or changed affiliations in such a way that Scopus was not able to link their later publications to the initial author profile (and our attempts at manual splicing also failed to find them). However, even if all 7 in fact moved overseas—which we think is unlikely given our efforts to manually check the data—this still shows only a fairly modest attrition of star researchers: something on the order of 10-25 percent of the initial publication-weighted capability from the initial period not being available to New Zealand in the later period. This is certainly a loss from New Zealand's perspective, but it is not a particularly surprising or worrisome rate of departure, given the overall mobility of researchers in and out of New Zealand.

Table Four: **Number of New Zealand home-runs in each period and the share of those home-runs that were by authors who were a New Zealand star in the previous three-year period, by field.**

Field	Home-runs	Authors with home-runs in the previous period	Home-runs	Authors with home-runs in the previous period	Home-runs	Authors with home-runs in the previous period
	2005-2007		2008-2010		2011-2013	
Agricultural and Biological Sciences	9.65	26%	16.81	29%	13.83	35%
Arts & Humanities	1.36	16%	4.51	22%	2.16	22%
Biochemistry, Genetics & Molecular Biology	5.18	16%	7.50	46%	6.06	52%
Business, Management & Accounting	4.63	37%	2.51	21%	3.17	60%
Chemical Engineering	1.22	0%	1.74	42%	1.32	31%
Chemistry	3.70	2%	2.69	26%	1.30	16%
Computer Science	3.14	39%	9.42	34%	9.30	46%
Decision Sciences	0.14	N/A	1.10	52%	0.04	N/A
Dentistry	0	N/A	0	N/A	0.04	N/A
Earth & Planetary Sciences	1.69	6%	2.46	7%	2.91	59%
Economics, Econometrics & Finance	0.55	N/A	1.03	31%	1.75	2%
Energy	0.30	N/A	2.41	35%	2.22	77%
Engineering	4.10	31%	12.61	40%	11.77	56%
Environmental Science	2.29	48%	6	27%	1.88	39%
Health Professions	0.50	N/A	0.06	N/A	0.35	N/A
Immunology & Microbiology	1.08	73%	0.71	N/A	1.03	38%
Materials Science	0.38	N/A	0.79	N/A	1.56	22%
Mathematics	3.23	17%	4.45	24%	1.67	13%
Medicine	11.65	25%	14.69	50%	10.57	45%
Multidisciplinary	1	51%	1.19	34%	1.92	61%
Neuroscience	0.44	N/A	0.73	N/A	0.18	N/A
Nursing	0.11	N/A	0.02	N/A	0.63	N/A
Pharmacology, Toxicology & Pharmaceutics	1.02	25%	0.74	N/A	1.57	0.4%
Physics and Astronomy	4.09	29%	5.31	40%	5.19	35%
Psychology	2.03	27%	4.33	18%	1.61	37%
Social Sciences	6.11	4%	11.08	9%	11.29	30%
Veterinary	0.002	N/A	1.01	16%	2.75	0%

Table Five: Total publications and home-runs by period in New Zealand and overseas for New Zealand star authors with a home-run in 2002-2004.

		New Zealand		Overseas		New Zealand Share	
Period	Number of Authors	Total Publications	Home-runs	Total Publications	Home-runs	Total Publications	Home-runs
2002-2004	86	395.33	51.25	39.77	3.95	0.91	0.93
2005-2007	82	394.76	16.8	47.87	1.64	0.89	0.91
2008-2010	81	387.35	22.82	69.23	3	0.85	0.88
2011-2013	79	382.5	14.94	87.74	2.51	0.81	0.86

Table Six is a conceptual mirror image of Table Five: it looks at those researchers who were stars in the final period and examines where they were publishing in the earlier periods. Interestingly, it shows a slightly larger difference in the New Zealand share between the two periods, with the fraction of non-New Zealand-affiliated papers falling by about 12 percentage points and the fraction of non-New Zealand home-runs falling by 25 percentage points. As before, there are also 34 end-period stars that cannot be found in the initial period. We cannot say whether they were just starting their careers, or whether they moved to New Zealand in such a way that we are unable to connect to their earlier publication records. Given this ambiguity we cannot precisely pin down the significance of flows of stars and stars-to-be in and out of New Zealand. However, the evidence suggests the net flow is inward—we see more stars and potential stars coming to New Zealand than we see established stars leaving New Zealand.

Table Six: Total publications and home-runs by period in New Zealand and overseas for New Zealand star authors with a home-run in 2011-2013.

		New Zealand		Overseas		New Zealand Share	
Period	Number of Authors	Total Publications	Home-runs	Total Publications	Home-runs	Total Publications	Home-runs
2002-2004	114	355.47	16.55	107.68	0.77	0.77	0.79
2005-2007	124	468.9	20.54	80.83	0.85	0.85	0.89
2008-2010	133	673.09	50.98	87.35	0.89	0.89	0.95
2011-2013	148	837.55	94.87	101.47	0.89	0.89	0.94

Finally, Table Seven breaks down the change in publication affiliations between New Zealand and non-New Zealand for early and late stars by field. There are no big differences or obvious patterns. In general, the New Zealand-share within a given field across the early and late periods are similar both for the first-period stars and the last-period stars.

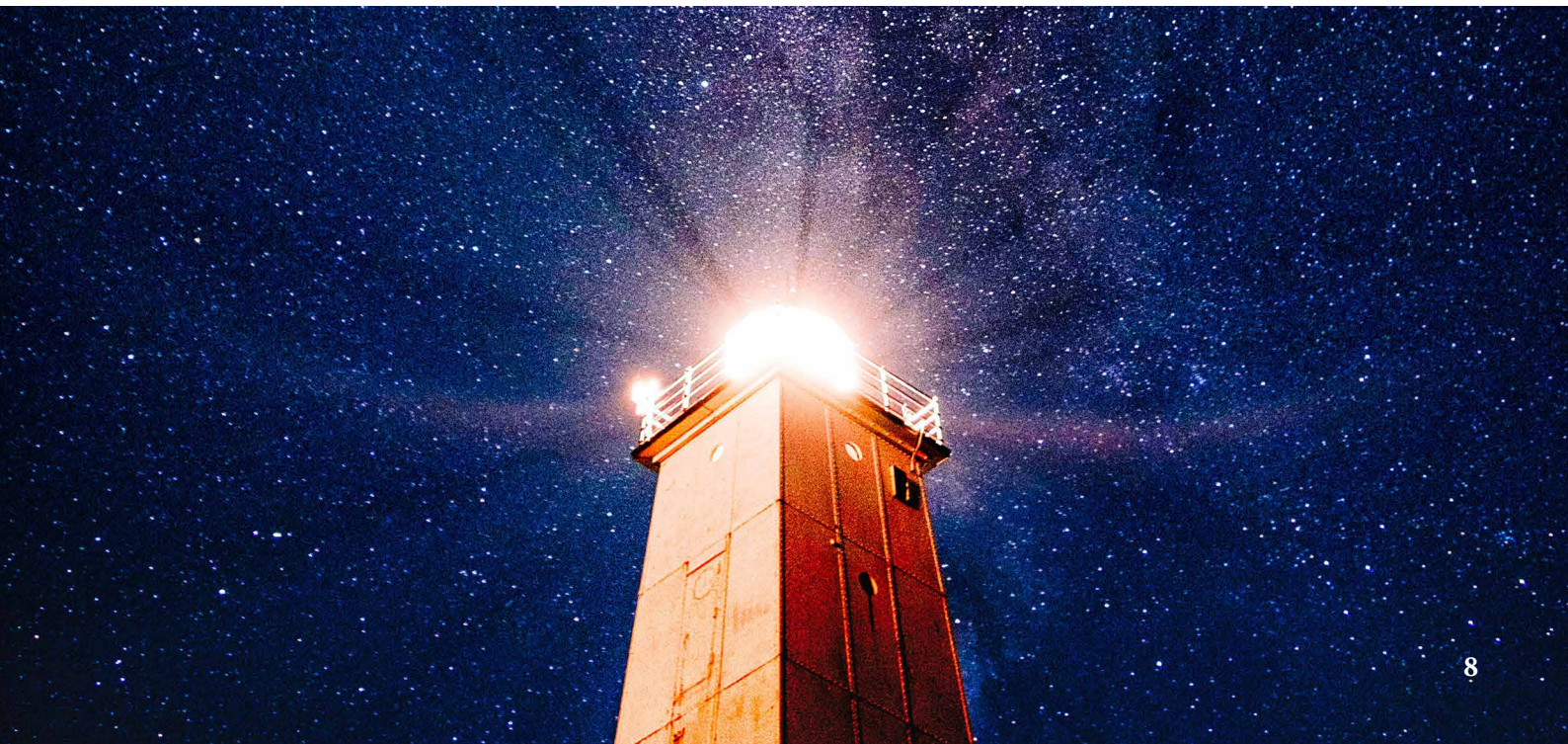


Table Seven: For New Zealand stars in 2002-2004 and in 2011-2013, the share of their publications affiliated with New Zealand over time and by field.

Field	2002-2004 New Zealand Stars		2011-2013 New Zealand Stars	
	2002-2004	2011-2013	2002-2004	2011-2013
Multidisciplinary	0.80	0.48	0.85	0.89
Agricultural & Biological Sciences	0.90	0.89	0.80	0.93
Arts & Humanities	0.95	0.92	0.68	0.70
Biochemistry, Genetics & Molecular Biology	0.92	0.85	0.81	0.88
Business, Management & Accounting	0.80	0.54	0.99	0.88
Computer Science	0.96	0.92	0.83	0.93
Chemical Engineering	0.99	0.20	0.91	1
Chemistry	0.95	0.72	0.66	1
Decision Sciences	0.95	1	1	1
Earth & Planetary Sciences	0.95	0.63	0.76	0.91
Economics, Econometrics & Finance			0.22	0.35
Energy	1	1	0.87	0.96
Engineering	0.95	0.95	0.71	0.87
Environmental Science	0.87	0.77	0.85	0.97
Immunology & Microbiology	0.85	0.87	0.88	0.98
Materials Science	0.98	0.78	0.41	0.84
Mathematics	0.92	0.97	0.80	0.99
Medicine	0.92	0.86	0.79	0.93
Neuroscience	0.98	1	0.98	0.99
Nursing			0.91	0.93
Pharmacology, Toxicology & Pharmaceutics			0.96	0.75
Physics & Astronomy	0.83	0.77	0.47	0.89
Psychology	0.98	0.98	0.96	0.95
Social Sciences	0.90	0.74	0.93	0.87
Veterinary			0.98	0.99
Dentistry	0.96	0.99	0.04	0.44
Health Professions	1		0.45	0.80

OVERVIEW AND CONCLUSIONS

Our study was motivated by the global observation that a relatively small number of scientists with high impact seem to be responsible for a disproportionate share of research with high impact, combined with a concern that international mobility of these global stars might render New Zealand's science system fragile. Overall, we find little evidence of such fragility.

It is true that a relatively small number of outstanding New Zealand researchers have been responsible for a disproportionate share of New Zealand publications, citations and home-runs. But the concentration is not extreme: just over 300 researchers produced about 5 percent of New Zealand-affiliated papers, 15 percent of citations and 25 percent of home-runs, on a fractionalized basis, over the period 2002-2013. And within this group, the concentration is also not extreme; the top 10 percent of this group produces about 20 percent of its output.

The apparent resilience of the system is reinforced by the fact that the identity of these top researchers changes considerably over time: roughly two-thirds of these stars were stars for only one of the four three-year periods we examined. Looked at from the other side, approximately three-quarters of the home-run publications in any given field are fractionally attributed to researchers who were not among our identified stars in the previous three-year period.

Of course, it remains true that the vast majority of New Zealand researchers will never see their name on a paper in the top 1 percent of the citation distribution for their field. So, the fraction of all New Zealand researchers that produce work with high impact on the global scale is small. But this relatively small share still represents hundreds who are involved in highly impactful research at any moment in time. And because those producing home-runs changes quite a bit over time, there are probably thousands who are associated with such research over the span of a decade.

The final piece of good news is that we do not see a large exodus of researchers from New Zealand after their publication of home-runs. While there is some ambiguity because we don't know what happened to people who no longer appear in Scopus, there was a reduction of at most 10-25 percentage points in the share of New Zealand-affiliated publications associated with those researchers who were stars in 2002-04 by 2013. Conversely, there was an increase of around 15-35 percentage points in New Zealand-affiliated publication share for the 2011-13 stars over the 2002-2013 period. This means that whatever 'brain drain' New Zealand may have suffered early on, it was more than offset by an influx of new or transplanted stars.

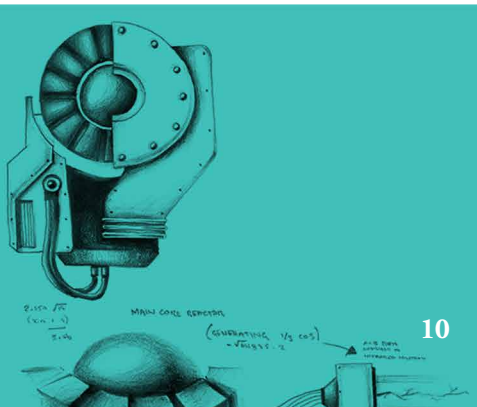
We should note that our definition of stars as those with at least a total of 0.5 fractionalized publications in the top 1 percent of the citation distribution is somewhat arbitrary. We are confident, however that our qualitative conclusions would not be affected by other definitions. If one chose a less strict definition (e.g. anyone with any share of a home-run paper), their share of New Zealand research output would be larger by definition, but a group of putative 'stars' much greater than 300 does not really correspond to what most people think of as stars, and it is hard to see how a picture of the New Zealand science system powered by such a large group would create concerns about fragility. Conversely, if one chose a stricter definition (e.g. 1.0 home-runs in a three-year period), these 'superstars' would by definition be individually more important, but their collective share of New Zealand research output would be smaller, so it seems unlikely that their movements would threaten the system, even if they were more mobile overall than the somewhat larger group studied here.

This research suggests both cautions and opportunities for future work. The problems that we discovered with multiple Scopus profiles for the same author are sobering. This is a particularly difficult issue with respect to any work where movement of researchers across institutions and/or countries is of interest, because such movement seems to be a major factor in creating the ambiguities in the Scopus data. The kind of incomplete manual author checking we did here would not be feasible for wider sets of authors or authors from larger countries. There is ongoing work on using artifical intelligence techniques to improve author disambiguation, so as time goes by this problem should become less severe.

With that caveat, the study suggests a number of further lines of exploration relevant for New Zealand science policy. The overall dominance and persistence of New Zealand stars seems low relative to the conventional wisdom regarding the disproportionate importance of stars for the research network. This raises the question of whether New Zealand is different from other countries in this regard, or whether the conventional wisdom has over-emphasized the dominance of stars. While the imperfections of the Scopus author profiles make this potentially difficult, it would be interesting to compare New Zealand to other countries in this regard.

A second set of questions revolve around the broader role of the stars in the New Zealand science system. We have focused here only on their own output, but what about their effect on students and colleagues? Are the students of stars more likely to become stars, and where do they end up? Do stars improve the research output of their co-authors, or their non-co-author institutional colleagues? These questions are very difficult to answer in a strictly causal way, but even examining whether there are positive associations would help us understand the system.

Finally, it would be interesting to examine what other behaviours are associated with stardom. In particular, for policy it would be useful to understand the interaction of stars with the research funding system. It is almost surely true that stars are more successful than most in attracting funding, but how do these interactions play out over time? To what extent does funding precede success and to what extent does it follow it? Does brief stardom seem to lead to permanent research funding success? Are there researchers whose funding looks similar to that of stars who never do much with it, and are there stars who are in fact not as successful as one might expect in attracting funding? If so, what attributes seem to characterize these outliers?



DATA APPENDIX

The data came from Scopus Custom Data 2002-2017, extracted in June 2018. This dataset provides details on academic publications and their citations from 2002 to 2017. We focus on the years 2002 to 2013. The data from 2014 to 2017 was removed from our analysis as we believed there was not enough time for these publications to accrue citations for accurate representation in the dataset. Scopus links the publication sets of individual authors with unique author IDs, and publications are allocated to disciplines according to a mapping of the journals in which they are published to various fields. Publications can have multiple authors and be assigned to multiple fields.

For each publication with a New Zealand affiliation, we constructed a fractional home run score between zero and one. Publications are assigned a value of one if it is not in the top 1 percent for its field, publication type and publication year, and zero otherwise. Publications with citations equal to the threshold to be in the top 1 percent are given a value between zero and one following the methods of Waltman and Schreiber (2013). For publications spanning multiple fields, the indicator is calculated separately for each field and then averaged across all fields.

Included in the fields in Scopus is a Multidisciplinary category, which covers journals that are not specific to any field. The category covers top journals such as Science and Nature, resulting in it having a relatively high threshold for being in the top 1 percent of the citation distribution. Hence, for publications assigned to the Multidisciplinary field, we compared them to the top 1 percent threshold for all publications published in the same year and publication type, rather than only to publications in the multidisciplinary group.

We then summed the home run score across their authors with New Zealand affiliations, weighting the home-runs fractionally if they had multiple authors. That is, papers with two authors were treated as half of a paper for each New Zealand author. If authors had both New Zealand and non-New Zealand affiliations, we further fractionalised.

For each author, we then weight their home run scores by their New Zealand contribution. Our assumption is that each author makes an equal contribution to the publication, and where an author has multiple affiliations, their contribution is divided equally across those affiliations. So if a publication has two authors, each author contributes half of the publication. If one of those authors has both a New Zealand and an overseas affiliation on that publication, the publication counts as just 0.25 of a New Zealand home run for that author.

For all of the analysis done, we attributed publications to authors under the assumption that all authors contribute equally to the publication and we then divide author's contributions equally across their affiliations. Where analysis is completed by field, publications are treated as a fraction of a paper in each field. The home run score of a publication is always calculated for each field and then averaged. However, when we analyse home runs by field, the same averaged home run score is applied to all fields.

This paper refers to the Mean Normalised Citation Score (MNCS) which is the number of citations normalised relative to the average for all publications for the same year, discipline, and publication type, as defined by Waltman et. al. (2011).

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