Researcher Mobility in Taiwan, 1996-2014

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Executive summary
Researcher Mobility in Taiwan, 1996-2014

Taiwan’s researcher mobility is marked by relatively high numbers of researchers staying within the country, offset by highly impactful transitory mobility. It shows a net inflow of researchers that is the second highest amongst its comparators, and a researcher circulation that focuses on Asia Pacific.

One of the things that stand out when examining Taiwan’s researcher mobility is the high share of researchers that have not published with affiliations outside of Taiwan throughout 1996-2014. Such researchers – categorized as ‘sedentary’ in this report – account for 61.1% of Taiwan’s total researcher base. These sedentary researchers publish less than half as much as the average researcher from Taiwan, and they tend to be relatively new, at least in terms of their publication history in Scopus. Nevertheless, their field-weighted citation impact (a proxy for research impact) is practically at the same level as the world average.

Taiwan’s second largest category of researcher mobility, accounting for 29.2% of Taiwan’s researcher base, is radically different from the sedentary researchers. These are researchers displaying so-called transitory mobility – short stays of less than two years abroad or in Taiwan. Overall, they are highly productive (79% above the Taiwanese average), and highly impactful, with a field-weighted citation impact (FWCI) of 1.98. That is almost twice as high as the world average FWCI.

Overall, Taiwan sees a 3.4% outflow of researchers in the period of 1996-2014. The relative productivity of these researchers is close to the average of Taiwan and their publications are fairly impactful. Outflow researchers score a FWCI of 1.40, meaning they are cited 40% more than the world average. Splitting the outflow into the regular outflow researchers and returnees, the former are relatively ‘younger’ and less productive but show a higher FWCI of 1.60.

Nevertheless, Taiwan does not need to worry about ‘losing’ research talent. Aside from the potential return of outflow researchers, Taiwan shows a 6.3% inflow of researchers, resulting in a net 2.9% inflow in 1996-2014. While the inflow researchers overall are a little less productive than the average researcher in Taiwan, their FWCI is marginally higher (1.42). As is the case with the outflow, the regular inflow researchers are relatively younger, less productive, and more impactful than the returnees. However, the differences in these indicators between the two groups of inflow researchers are smaller than those between the outflow groups.

In terms of the actual moves made by researchers between countries, we see that a lot of mobility to and from Taiwan comes from countries in Asia Pacific: 5 out of 10 inflow countries are in APAC, as are 6 out of 10 outflow countries, though the majority of these are the same.

Among the selected comparators, South Korea is the country that most resembles Taiwan’s researcher mobility. China is the only other comparator to have a net inflow of researchers in 1996-2014, but shows very little mobility. The Netherlands, Singapore and Switzerland on the other hand all have low (<35%) sedentary shares, combined with high (>50%) transitory shares. However, these countries’ outflow is higher than their inflow of researchers, resulting in net outflows between -1.0% and -2.4%.
Key Findings

HIGH SEDENTARY SHARE

- 61.1% of authors publish in Taiwan only

NET RESEARCHER INFLOW

+ 2.9% more inflow than outflow

HIGHLY IMPACTFUL SHORT TERM MOBILITY

🌟 FWCI of 1.98: nearly twice the world average

HIGH MOBILITY IN ASIA-PACIFIC COUNTRIES

👥 APAC forms over half of in-/outflow countries
Preface

Researcher mobility has become a key area of interest for the potential enhancement of a country’s research performance. While such migration has traditionally been discussed in terms of losers (Brain Drain) and winners (Brain Gain), current research suggests that researcher mobility results in win-win situations both in the short-term and the long-term.

One the one hand, an inflow of researchers enables the flow of ideas and knowledge to a country, despite some of them staying only for short or infrequent periods. On the other hand, although a country or institution may ‘lose’ some of its research talent to elsewhere, many researchers come back with stronger skills. Even permanent migration out of a country is not necessarily a bad thing, as those abroad often maintain strong ties to their previous place of study or employment. Through such connections, researchers have the ability to strengthen collaboration ties between countries and institutions and to improve the quality of their research.

The availability of comprehensive publication databases containing articles with complete author affiliation data, such as Scopus®, has enabled the development of a systematic approach to researcher mobility analysis through the use of authors’ addresses listed in their published articles as a proxy for their location.

With this report, Elsevier’s Analytical Services aims to provide insights to various aspects of the researcher mobility in Taiwan and comparator countries.

“(...) in order for knowledge-based societies to develop both in societal and economic terms they need to make most of the potential that researchers and research results offer in different disciplines. For this potential to materialize on equal terms, the global research community needs brain circulation (...).”

NordForsk Policy Paper 3 - 2014
Crossing Borders - Obstacles and incentives to researcher mobility

STEVEN SCHEEROOREN
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Introduction

This report has been commissioned by Taiwan’s Science & Technology Policy Research and Information Center (STPI), for the purpose of inclusion in its Taiwan Research Report. The report studies the mobility of researchers, answering questions such as whether the country is attractive to researchers and how various mobility classes contribute to Taiwan’s research output and impact.

In order to measure researcher mobility, Elsevier’s Analytical Services make use of the affiliations registered in author profile data in Scopus. Taking into account the publication data of 1996 to 2014, we look at the different affiliations an author has published with during this period to calculate the number of ‘moves’ a researcher makes. For our analyses, we divide researcher mobility into the following categories:

- **Sedentary**: this covers researchers that— based on their publication history in Scopus – have not published with affiliations outside of Taiwan.
- **Inflow**: researchers coming to Taiwan and not leaving. This is divided into regular inflow and ‘Returnees’; researchers from Taiwan who have stayed abroad for 2 or more years, after which they returned.
- **Outflow**: researchers leaving Taiwan and not returning. This is divided into regular outflow and ‘Returnees’; researchers from abroad who have stayed in Taiwan for 2 or more years, after which they departed.
- **Transitory**: researchers who stay either abroad or in Taiwan (measured separately) for less than 2 years, after which they depart again.

For the full methodology, please see Appendix A.

Leaving out the sedentary category, this report highlights the top ten countries that researchers coming to Taiwan have moved from, as well as the ten countries to which Taiwan’s researchers move. In addition to an analysis of Taiwan’s researcher mobility, the report aims to provide some context by including high-level mobility indicators for five comparator countries selected by STPI; China, the Netherlands, Singapore, South Korea, and Switzerland.
This report first examines in detail the brain circulation of Taiwan’s researcher base over the period 1996-2014, divided into a number of categories and metrics. Additionally, it looks at the top countries where Taiwan’s researchers migrate from, as well as where they migrate to. Lastly, the report presents a few basic mobility indicators for five selected comparator countries.
1. Taiwan’s researcher mobility

To measure researcher mobility, researchers are divided into four main categories, with a few subdivisions, given below.

- **Sedentary**: researchers who do not appear to have ever left Taiwan. i.e. they have only published with Taiwanese affiliations from 1996 to 2014.
- **Inflow**: researchers coming to Taiwan. This is divided into:
  - Inflow: researchers who have moved to Taiwan and remained there.
  - Returnees Inflow: researchers who had left Taiwan for more than two years, but thereafter returned.
- **Outflow**: researchers leaving Taiwan. This is divided into:
  - Outflow: researchers who leave Taiwan and donot return.
  - Returnees Outflow: researchers who had come to Taiwan from other countries and stayed for more than two years, but thereafter left to other countries again.
- **Transitory**: researchers who stay in Taiwan or abroad for less than two years before moving to other countries or returning to Taiwan, respectively. This is divided into:
  - Mainly Taiwan based: researchers for whom the count of Taiwanese affiliations is greater than the count of non-Taiwanese affiliations.
  - Mainly non-Taiwan based: researchers for whom the count of non-Taiwanese affiliations is greater than the count of Taiwanese affiliations.

For each of these categories, the analysis looks at four metrics to answer the following key questions:

- **Group size**: what percentage of Taiwan’s total researcher base belongs to each category?
- **Relative Productivity**: how much research is being published by researchers in each category, compared to Taiwan’s average? This indicator compares the articles per year since the first appearance of each researcher as an author (during the period 1996-2014), relative to all Taiwan’s researchers in the same period. A value above 1.0 means that a group is relatively more productive than the average researcher, while a value below 1.0 means they are less productive than the average.
- **Relative Age**: how ‘old’ are the researchers, comparatively? This is not an actual age in years, but rather the length of their publishing history, as measured by the appearance of their first publication in Scopus. While not a definitive answer, it can be used to gauge whether they are early-career researchers or more established ones. Here a value above 1.0 means that a group is relatively older than the average researcher in Taiwan, while a value below 1.0 means they are younger than the average.
- **Field-Weighted Citation Impact (FWCI)**: how impactful is the research, as measured by relative citation rates? FWCI is a normalized measure of citation impact that accounts for differences in citation behavior between fields, document types, and publication years. This metric is benchmarked against the global average, set at 1.0, meaning that a FWCI of more than 1.0 indicates that the group’s publications have been cited more than would be expected based on the global average for similar publications. E.g. a FWCI of 1.5 would mean that a publication is cited 50% more often, whereas an FCWI of 0.5 would mean that it is cited 50% less often. For more details on this indicator, please see Appendix A.

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2 For the analyses in this report, only “active” researchers have been taken into account. i.e. those that produced 10 or more papers in 1996-2014 and at least 1 paper in the last 5 years OR those who produced 4 or more papers in last 5 years.
Figure 1 presents all of the above in a single image, with subdivisions shown in the middle and summary stats on the right-hand side. The below explanation will highlight a number of key findings for these categories, starting with the largest group of researchers.

**TAIWAN ONLY**
Taiwan has a rather high share of so-called ‘sedentary’ researchers; those who have not published with affiliations outside of Taiwan between 1996 and 2014. They form well over half (61.1%) of Taiwan’s active researchers. Although this is high compared to the rest of the world, it is of a similar level to other major countries in Asia, such as Japan and South Korea. Despite being numerous, the sedentary researchers only account for about a quarter (24.3%) of the total publication output by active researchers. In fact, the sedentary researchers are less than half as productive as the average researcher in Taiwan, giving them the lowest Relative Productivity of the aforementioned groups, at 0.47. On top of this, their publications have the lowest field-weighted citation impact (FWCI) among Taiwan’s researchers, at 0.99. However, this is still practically on par with the world average FWCI of 1.0, and one should keep in mind that these sedentary researchers are also the youngest by far (15% younger than the average researcher in Taiwan).

**TRANSITORY**
The second largest group is formed by researchers who move either from or to Taiwan for periods of less than two years (transitory mobility). In contrast to those who stay in Taiwan only, these researchers make up less than a third (29.2%) of the active researchers, but produce closer to two-thirds (63.3%) of Taiwan’s publications, indicating a much higher productivity. Researchers in the overall transitory category publish 79% more than the average researcher in Taiwan. The majority of this is due to the researchers affiliated mostly with non-Taiwanese institutions, who show a high productivity of over 2.5
times the average. The researchers affiliated mainly with Taiwanese institutions actually have a relative productivity that is 11% below the average. Similarly, while the transitory category has the highest overall FWCI (almost twice the world average, at 1.98), there is a considerable difference between the mainly non-Taiwanese and the mainly Taiwanese groups. The former has the highest FWCI by far – nearly 2.2 times the world average – whereas the latter has the second lowest FWCI among Taiwanese researcher groups. Coincidentally, the transitory category has the lowest Relative Age after the sedentary group. Most transitory researchers are younger than researchers in other categories, both as a whole and when split by mainly Taiwan or mainly non-Taiwan. Only the non-returnees outflow researchers are even younger, with a Relative Age of just 1.10.

IN/OUTFLOW
Regarding inflow and outflow, we can see there is a higher percentage of researchers in the former category, resulting in a net brain gain of 2.9%. While the inflow researchers are a little older (by 0.13) and slightly less productive (by -0.07) than the outflow researchers, their publications barely show a difference in FCWI (a mere 0.02 in favour of the inflow researchers). Within both of these categories, researchers who have been away for more than 2 years – the returnees – are somewhat older and have a higher Relative Productivity than the regular inflow/outflow researchers, who appear to publish about a fifth less than the average researcher in Taiwan. Conversely, in both categories the regular inflow/outflow researchers produce papers with a higher average FWCI than the returnees. This difference is bigger between the outflow and returnees outflow groups (1.60 vs 1.27, resp.) than it is between the inflow and returnees inflow (1.45 vs 1.39, resp.).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Highest scoring group</th>
<th>Lowest scoring group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researchers</td>
<td>Taiwan only: 61.1%</td>
<td>Returnees Outflow: 1.5%</td>
</tr>
<tr>
<td>Relative Productivity</td>
<td>Transitory (mainly non-Taiwan): 2.53</td>
<td>Taiwan only: 0.47</td>
</tr>
<tr>
<td>Relative Age</td>
<td>Returnees Inflow: 1.39</td>
<td>Taiwan only: 0.85</td>
</tr>
<tr>
<td>FWCI</td>
<td>Transitory (mainly non-Taiwan): 2.19</td>
<td>Taiwan only: 0.99</td>
</tr>
</tbody>
</table>

*Table 1 — Highest and lowest Taiwan researcher mobility group per indicator*
2. Top inflow and outflow countries

Tables 2a and 2b shed some light on where Taiwan’s researchers come from, and where they go when they leave. Note that these rankings are based solely on the total number of moves made by researchers in the period 1996-2014, and do not account for multiple moves by the same researcher. For example, a researcher who comes to Taiwan for however long a period and then leaves again, would here be counted in both the ‘inflow’ and ‘outflow’ groups.

<table>
<thead>
<tr>
<th>country</th>
<th>no. of moves into Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>2,708</td>
</tr>
<tr>
<td>China</td>
<td>504</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>279</td>
</tr>
<tr>
<td>Japan</td>
<td>259</td>
</tr>
<tr>
<td>India</td>
<td>135</td>
</tr>
<tr>
<td>Canada</td>
<td>126</td>
</tr>
<tr>
<td>Germany</td>
<td>113</td>
</tr>
<tr>
<td>Australia</td>
<td>81</td>
</tr>
<tr>
<td>France</td>
<td>76</td>
</tr>
<tr>
<td>Singapore</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>country</th>
<th>no. of moves out of Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>874</td>
</tr>
<tr>
<td>China</td>
<td>386</td>
</tr>
<tr>
<td>India</td>
<td>136</td>
</tr>
<tr>
<td>Japan</td>
<td>61</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>37</td>
</tr>
<tr>
<td>Germany</td>
<td>33</td>
</tr>
<tr>
<td>Canada</td>
<td>32</td>
</tr>
<tr>
<td>Singapore</td>
<td>32</td>
</tr>
<tr>
<td>Australia</td>
<td>26</td>
</tr>
<tr>
<td>South Korea</td>
<td>24</td>
</tr>
</tbody>
</table>

**+ Table 2a**—Top 10 inflow countries for Taiwan, on total moves in 1996-2014; source: Scopus

**+ Table 2b**—Top 10 outflow countries for based Taiwan, based on total moves in 1996-2014; source: Scopus

As can be seen from these tables, most of Taiwan’s researcher migration involves countries in North America, Europe, and Asia. Probably — or at least partially — due to its size, the US clearly ranks as the number one source of and destination for Taiwan’s researchers in 2010-2014. Despite being geographically and linguistically/culturally much closer, researcher migration between Taiwan and China is less than a fifth of the US moves when it comes to inflow, and less than half in terms of outflow. Interestingly, while many researchers come to Taiwan from the UK (3rd largest inflow, with 279 moves), far fewer go to the UK after leaving Taiwan (5th largest outflow, with only 37 moves). Instead, Taiwan’s researchers go to Japan (almost twice as often, with 61 moves), or India (136 moves). Somewhat similarly, France is in the top 10 inflow countries, but does not appear in the outflow countries. In its place we find South Korea as one of the more popular destinations for Taiwan’s researchers. For almost all of these countries, more moves are made to than from Taiwan, hence the net ‘brain gain’ for Taiwan. The only exception to this is India, which has a nearly neutral level of researcher migration with Taiwan, showing 135 moves ‘in’ and 136 moves ‘out’ over the period of 2010-2014.

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*We should note however, that the discrepancies between the UK in/outflow may be due to immigration policy rather than choice.*
3. Comparator countries

To put things into perspective, Table 1.3 provides the basic mobility indicators for five comparator countries: China, the Netherlands, Singapore, South Korea, and Switzerland.

<table>
<thead>
<tr>
<th>Comparator</th>
<th>Sedentary</th>
<th>Total Transitory</th>
<th>Total Outflow</th>
<th>Total Inflow</th>
<th>Net Total Inflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>77.0%</td>
<td>16.2%</td>
<td>2.7%</td>
<td>4.1%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>33.9%</td>
<td>48.6%</td>
<td>9.5%</td>
<td>8.0%</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Singapore</td>
<td>25.9%</td>
<td>48.8%</td>
<td>13.1%</td>
<td>12.1%</td>
<td>-1.0%</td>
</tr>
<tr>
<td>South Korea</td>
<td>59.1%</td>
<td>27.7%</td>
<td>4.4%</td>
<td>8.8%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Switzerland</td>
<td>14.4%</td>
<td>59.8%</td>
<td>14.1%</td>
<td>11.7%</td>
<td>-2.4%</td>
</tr>
</tbody>
</table>

Table 3 — Percentage of active researchers per mobility group for 5 comparators, 1996-2014; source: Scopus

As one might expect, the smaller countries among these five have fewer researchers who stay put. After all, small countries tend to have a limited number of research institutes, making its researchers more likely to look for collaborations or positions abroad. Switzerland shows the greatest mobility, with only 14.4% of the researchers not having left the country throughout 1996-2014. A considerable majority of Swiss researchers (almost 60%) has spent short periods abroad or — if they came from abroad to begin with — short periods in Switzerland. That is a full 11 percentage points higher than the next largest transitory researcher base, that of Singapore. Switzerland's high inflow rate of 11.7% is the second-highest amongst the comparators, and would suggest a high attractiveness for researchers. However, Switzerland also has the highest outflow, resulting in a net 2.4% of its researchers leaving the country without returning.

The largest comparator, China, shows the opposite pattern, with a very high sedentary share more than 3 out of 4 Chinese researchers have not published with non-Chinese affiliations in the period 1996-2014. As a result, other mobility groups are relatively small. For example, a mere 16.2% of its researchers go on short-term stays in other countries, or come for short-term stays in China. Amongst these five comparators, even the second-smallest transitory mobility group—that of South Korea—is at least over 25%. Furthermore, China has the lowest total outflow (2.7%) and the lowest total inflow (4.1%). Nevertheless, it is one of only two comparators showing a net 'brain gain', in this case 1.4%.

Of these comparators, South Korea comes closest to the mobility levels of Taiwan. The main difference—in terms of researchers' shares—is that South Korea's sedentary and transitory totals are slightly lower, whereas the outflow and inflow totals are a little higher. Although South Korea's inflow is only the 3rd highest amongst the comparators, its low outflow gives it the highest net total inflow amongst the comparator countries, at 4.4%.

The Netherlands and Singapore both show a negative net total inflow in 1996-2014, albeit with fairly low percentages of -1.5% and -1.0% respectively. Singapore actually has the highest total inflow amongst the comparators: at 12.1%, its share of researchers entering the country is nearly twice as high as that of Taiwan. However, this is negated by it also having the 2nd highest total outflow: at 13.1%, this is almost four times as high as Taiwan's outflow share (a modest 3.4%). The percentage of researchers showing transitory mobility is nearly identical for the Netherlands and Singapore: close to half of their researchers spend short terms abroad.
Appendix A
Methodology and Data Sources

Methodology and rationale

Our methodology is based on the theoretical principles and best practices developed in the field of quantitative science and technology studies, particularly in science and technology indicators research. The Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems (Moed, Glänzel, & Schmoch, 2004) gives a good overview of this field and is based on the pioneering work of Derek de Solla Price (1978), Eugene Garfield (1979) and Francis Narin (1976) in the USA, and Christopher Freeman, Ben Martin and John Irvine in the UK (1981, 1987), and in several European institutions including the Centre for Science and Technology Studies at Leiden University, the Netherlands, and the Library of the Academy of Sciences in Budapest, Hungary.

The analyses of bibliometric data in this report are based on recognized advanced indicators (e.g., the concept of relative citation impact rates). Our base assumption is that such indicators are useful and valid, though imperfect and partial measures, in the sense that their numerical values are determined by research performance and related concepts, but also by other, influencing factors that may cause systematic biases. In the past decade, the field of indicators research has developed a best practices which state how indicator results should be interpreted and which influencing factors should be taken into account. Our methodology builds on these practices.

Year range

All analyses in this report are based on data that range from 1996 to 2014. To measure trends in publication output over time, it is customary to group publications (and other indicators based on publication outputs, such as citations or co-authorships) based on the calendar year in which they were published.

Article types

For all bibliometric analysis, only the following document types are considered:

- Article (ar)
- Review (re)
- Conference Proceeding (cp)

In bibliometric studies, these article types are generally considered to be article types with scholarly content that has been peer-reviewed. That is, such article types have been scrutinized by experts in the same field and were determined by said experts to be suitable for publication. In contrast, our analyses exclude document types such as letters, notes, editorials, etc. that are also published in journals and other serials titles, but are not necessarily peer-reviewed.

Counting

All analyses make use of whole counting rather than fractional counting. For example, if a paper has been co-authored by one author from Taiwan and one author from The Netherlands, then that paper counts towards both the publication count of Taiwan, as well as the publication count of The Netherlands. Total counts for each country are the unique count of publications.

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Field-weighted citation impact (FWCI)

Field-weighted citation impact (FWCI) indicates how the number of citations received by an entity’s publications compares with the average number of citations received by all other similar publications in the data universe: how do the citations received by this entity’s publications compare with the world average? A field-weighted citation impact of 1.00 indicates that the entity’s publications have been cited exactly as would be expected based on the global average for similar publications; the FWCI of “World”, or the entire Scopus database, is 1.00. A FWCI of more than 1.00 indicates that the entity’s publications have been cited more than would be expected based on the global average for similar publications; for example, 2.11 means 111% more cited than world average. A FWCI of less than 1.00 indicates that the entity’s publications have been cited less than would be expected based on the global average for similar publications; for example, 0.87 means 13% less cited than world average.

Similar publications are those publications in the Scopus database that have the same publication year, publication type, and subject sub-area or discipline, as represented by the Scopus journal classification system (see Appendix C).

The Field-Weighted Citation Impact (FWCI) for a set of N publications is defined as:

\[ FWCI = \frac{1}{N} \sum_{i=1}^{N} \frac{c_i}{e_i} \]

\( c_i \) = citations received by publication \( i \)
\( e_i \) = expected number of citations received by all similar publications in the publication year plus up to following 5 years.

Measuring International Researcher Mobility

The approach presented here uses Scopus author profile data to derive a history of active ‘Taiwan’ author affiliations recorded in their published articles and to assign them to mobility classes defined by the type and duration of observed moves.

How are individual researchers unambiguously identified in Scopus?

Scopus uses a sophisticated author-matching algorithm to precisely identify articles by the same author. The Scopus Author Identifier gives each author a unique ID and groups together all the documents published by that author, matching alternate spellings and variations of the author’s last name and distinguishing between authors with the same surname by differentiating on data elements associated with the article (such as affiliation, subject area, co-authors, and so on). This is enriched with manual, author-supplied feedback, both directly through Scopus and also via Scopus’ direct links with ORCID (Open Researcher & Contributor ID).8

What does a ‘Taiwanese researcher’ mean?

To define the initial population for this study, Taiwanese authors were identified as those that had listed a Taiwanese affiliation on at least one publication (articles, reviews and conference papers) published across the sources included in Scopus during the period 1996-2014. It is important to note that thusly defined ‘Taiwanese authors’ are not necessarily born in Taiwan or retain citizenship with the country. Authors of other countries are defined similarly.

What is an ‘active researcher’?

The 62,000+ Taiwanese authors identified includes a large proportion with relatively few articles over the entire 18-year period of analysis. As such, it is assumed that they are not likely to represent career researchers, but individuals who have left the research system. A productivity filter was therefore implemented to restrict the analysis to those authors with at least 1 article in the 5-year period 2010-2014 and at least 10 articles in the entire period 1996-2014, or those with fewer than 10 articles in 1996–2014, but at least 4 articles in 2010-2014. After applying the productivity filter, a set of 62,062 active Taiwanese researchers was defined and formed the basis of the study.

How are mobility classes defined?

The measurement of international researcher mobility by co-authorship in the published literature is complicated by the difficulties involved in teasing out long term mobility from short-term mobility (such as doctoral research visits, sabbaticals, secondments, etc.), which might be deemed instead to reflect a form of collaboration. In this study, stays overseas of 2 years or more were considered migratory and were further subdivided into those who remained abroad or where they subsequently returned to their original country. Stays overseas of less than 2 years were deemed transitory, and were also further subdivided into those who mostly published under a Taiwanese or a non-Taiwanese affiliation. Since author nationality is not captured in article or author data, authors are assumed to be from the country where they first published (for migratory mobility) or from the country where they published the majority of their articles (for transitory mobility). In individual cases, these criteria may result in authors being assigned migratory patterns that may not accurately reflect the real situation, but such errors may be assumed to be evenly distributed across the groups and so the overall pattern remains valid. Researchers without any apparent mobility based on their published affiliations were considered sedentary.

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8 http://orcid.org/
Migratory

- Outflow: active Taiwan researchers whose Scopus author data for the period 1996-2014 indicates that they have migrated from the UK to another country (or countries) for at least 2 years without returning to the Taiwan.
- Returnees Outflow: active Taiwan researchers whose Scopus author profile data for the period 1996-2014 indicates that they have migrated to the Taiwan from another country (or countries) for at least 2 years, and then subsequently migrated to another country (or countries) for at least 2 years.
- Total Outflow: the sum of Outflow and Returnee Outflow groups.

- Inflow: active Taiwan researchers whose Scopus author data for the period 1996-2014 indicates that they have migrated to the Taiwan from another country (or countries) for at least 2 years without leaving the Taiwan.
- Returnees Inflow: active Taiwan researchers whose Scopus author data for the period 1996-2014 indicates that they have migrated from the Taiwan to another country (or countries) for at least 2 years, and then subsequently migrated back to the Taiwan for at least 2 years.
- Total Inflow: the sum of Inflow and Returnee Inflow groups.

Transitory

- Transitory (mainly non-Taiwan): active Taiwan researchers whose Scopus author data for the period 1996-2014 indicates that they are based in the Taiwan for less than 2 years at a time but are predominantly based in another country (or countries).
- Transitory (mainly Taiwan): active Taiwan researchers whose Scopus author data for the period 1996-2014 indicates that they are based in another country (or countries) for less than 2 years at a time but are predominantly based in the Taiwan.
- Total Transitory: the sum of Transitory (mainly non-Taiwan) and Transitory (mainly Taiwan) groups.

Sedentary

- Sedentary: active Taiwan researchers whose Scopus author data for the period 1996-2014 indicates that they have not published outside the Taiwan.

What indicators are used to characterise each mobility group?

To better understand the composition of each group defined on the map, three aggregate indicators were calculated for each to represent the productivity and seniority of the researchers they contain, and the field-weighted citation impact of their articles. Relative Productivity represents a measure of the articles per year since the first appearance of each researcher as an author during the period 1996-2014, relative to all Taiwan researchers in the same period.

Relative Seniority represents years since the first appearance of each researcher as an author during the period 1996-2014, relative to all Taiwan researchers in the same period. Field-weighted citation impact is calculated for all articles in each mobility class. All three indicators are calculated for each author's entire output in the period (i.e., not just those articles listing a Taiwanese address for that author).

Data Sources

Scopus is Elsevier's abstract and citation database of peer-reviewed literature, covering 62 million documents published in over 22,500 journals, book series and conference proceedings by some 6,000 publishers. Reference lists are captured for nearly 39 million records published from 1996 onwards, and the additional 23.3 million pre-1996 records reach as far back as the publication year 1823.

Scopus coverage is multi-lingual and global: approximately 15% of titles in Scopus are published in languages other than English (or published in both English and another language). In addition, more than half of Scopus content originates from outside North America, representing many countries in Europe, Latin America, Africa and the Asia Pacific region.

The database contains titles from more than 120 different countries and over 50 languages in all geographic regions. Scopus covers approximately 11,800 active titles from Europe (18,000 total), 6,400 from North America (10,500 total), 2,500 from Asia-Pacific (3,600 total), 700 from Central and South America (900 total), and 800 titles from the Middle East and Africa (1,050 total).

Scopus coverage is also inclusive across all major research fields, with 11,700 titles in the Physical Sciences (7,500 active), 12,900 in the Health Sciences (6,800 active), 6,300 in the Life Sciences (4,500 active), and 9,800 in the Social Sciences (8,100 active) (the latter including some 3,200 Arts & Humanities related titles [2,800 active]). Titles which are covered are predominantly serial publications (journals, trade journals, book series and conference material), but considerable numbers of conference papers are also covered from stand-alone proceedings volumes (a major dissemination mechanism, particularly in the computer sciences). Acknowledging that a great deal of important literature in all fields (but especially in the Social Sciences and Arts & Humanities) is published in books, Scopus has begun to increase book coverage in 2013, and currently covers more than 121,000 books.

More information can be found on [www.elsevier.com/online-tools/scopus](http://www.elsevier.com/online-tools/scopus).
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