CHAPTER 4

RESEARCH OUTPUT AND INTERNATIONAL RESEARCH COOPERATION IN AFRICAN FLAGSHIP UNIVERSITIES

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Research internationalisation processes

Following global trends, the internationalisation in Africa's higher education landscape is driven by a range of interconnecting new developments: an increase in the numbers of students and institutions; more mobility of students and staff across national boundaries; the growing role of the English language in classrooms and research environments; improved internet connectivity; and a host of policy initiatives such as centres of excellence, quality assurance frameworks, and programmes to enhance institution collaboration. Africa's leading 'flagship' universities are looked upon as role models, and perhaps sources of inspiration, for how to learn and benefit from these processes. The concept 'flagship university', recently introduced by Douglass (2014), implies that each less-developed country or emerging economy should have at least one of these universities. In addition to their scientific research and teaching activities, the flagship university is expected to engage in 'third mission'-type activities, such as regional economic engagement, technology transfer, links with secondary schools and other tertiary institutions, and providing leadership in national governance and management structures.

Research-intensive flagships are often engaged in international research cooperation, and in doing so follow international standards of scientific quality and research productivity. Internationalisation processes may provide many other gains and benefits to Africa's leading research universities. It enables access to knowledge, skills, facilities, infrastructures and funding from elsewhere, which may contribute to improved quality of teaching, training and learning. At the level of individual researchers and their research programme managers, being exposed to international contacts is likely to contribute to the acquisition of new knowledge, interpersonal and intercultural communication skills (e.g. English language), and mediation skills, but also

the ability to engage in networking and teamwork-based problem-solving effectively. These professional competencies are assets that may enhance mobility, employability and transferable skills (of both students and staff) across borders within world science. Extensive international contacts and successful long-term collaborative activities with foreign research partners are bound to have significant impacts, such as the increased production of research publications, attracting foreign academic staff and foreign PhDs, and acquiring funding from international sources.

All of these are amenable to systematic data collection and comparative data analysis. This chapter, however, restricts its attention to their impacts on the output of the knowledge production process and, in particular, the contributions to research output published as articles in scientific journals, in the eight flagship universities[1] in the Higher Education Research and Advocacy Network in Africa (HERANA) project.

Research publication output and international visibility

Research publications in peer-reviewed scholarly and technical journals are often seen as the prime output of high-quality scientific knowledge production. One might assume that these 'international research publications' are preceded or followed up by a string of other publications, such as research reports, working papers, book chapters or research articles in 'local' journals. In almost all cases, these other 'non-international' publications are not (sufficiently) captured by the international bibliographical databases – notably Thomson Reuters' Web of Science (WoS) database and Elsevier's Scopus database.[2] As a result, they tend to remain under the radar – inaccessible and unavailable for comprehensive and systematic studies of research performance. Moving up from low levels of visibility in previous decades (see, e.g., Tijssen et al. 2006), the last three to four years have seen more African science journals being indexed by both databases, while other sources such as African Journals Online are also expanding their coverage of Africa's scholarly literature. However, the content and coverage is still insufficient for large-scale systematic comparisons of African flagship universities.

Given its analytical objective, this study therefore restricts its scope to international publications, and more specifically to counts of WoS-indexed publications. This database currently contains only 101 African journals (of which 87 are South African),[3] which constitutes less than 1% of the estimated 14 000 journals in the total WoS coverage of worldwide scientific literature. The WoS-indexed publications produced by African universities represent merely a tip of the iceberg – but an interesting tip nonetheless, since this is what internationalisation may lead up to in African flagship universities: producing high-quality science with publications

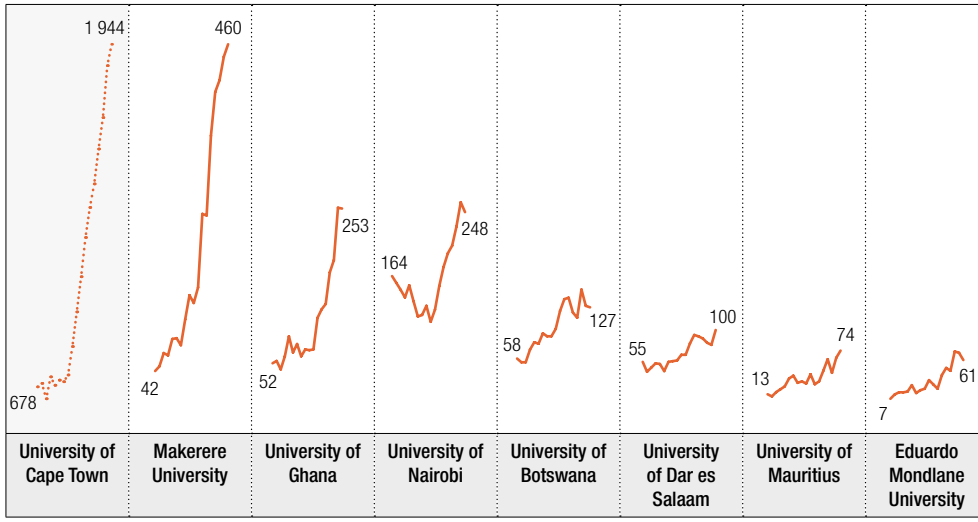
1 The universities of Botswana, Cape Town, Dar es Salaam, Eduardo Mondlane, Ghana, Mauritius, Makerere and Nairobi.

2 Web of Science website: http://thomsonreuters.com/thomson-reuters-web-of-science/; Scopus website: http://www.elsevier.com/online-tools/scopus

3 Personal communication, Nelius Boshoff, Centre for Research on Evaluation, Science and Technology (27 November 2014).

that deserve and gain international visibility. However, we cannot assume that this particular top slice of a university's publication output is actually representative of all their international collaborative research, if only because some of the joint research projects fail and thus produce nothing worthwhile for publishing, or because sometimes the findings are disseminated elsewhere (either in print or online). In other cases, the work is still ongoing without any written output for outside readerships.

Figure 4.1 Annual trends in publication output of African flagship universities (1996–2013)



Compiled by Robert Tijssen
Source: CWTS/Thomson Reuters Web of Science database

Figure 4.1 shows the overall trends in annual publication output of each of the HERANA universities since 1996. All eight universities show an upward trend in recent years, some from low baseline levels. The rise of the University of Cape Town and Makerere University is particularly significant. There was a considerable percentage increase in publication output, particularly beyond 2010, with Makerere and Ghana in the lead (whereas the University of Nairobi and University of Botswana were slowing down). These growth rates result from the interplay between contributing factors. They are not directly comparable across institutions, if only because each university operates within a unique environment (or 'local ecosystem') of national and institutional determinants, incentives and obstacles. Notably, in the case of the University of Cape Town, part of the upsurge most likely resulted from the publication-boosting national subsidy system that was implemented in South Africa in the mid-2000s. Nonetheless, in the ensuing analysis we assume that all these university-specific growth trajectories are at least also partly driven by international collaboration and the increased production of internationally co-authored publications. Moreover, one might expect that these international partners have

been part of local research capacity-building, and creating effective organisational and managerial structures, which enabled the production of these co-publications.

Many of those WoS-covered research publications are co-productions between African-based researchers and their foreign research partners. The author affiliation lists in the publications are the telltale sign. Here one finds the author names and institutions from countries elsewhere – sometimes on the African continent, but more often of colleagues in Europe, Asia or the United States. Straightforward counts of these 'international co-publications' provide empirical data as to the relative magnitude of international cooperation within African science and, more importantly, general trends over time (AOSTI 2014; Boshoff 2009; Sooryamoorthy 2009; Tijssen 2007).

International cooperation and co-authored research publications

Not only does this kind of quantitative data allow for institutional comparisons across African universities, it also enables us to compare scientific fields within each university. These fields are usually defined according to a classification of the publications' content, or the scholarly journals in which they were published. Often, for the sake of simplicity, the wide range of fields is aggregated into the four 'STEM' domains (Science, Technology, Engineering and Mathematics) and non-STEM remainder (Social Sciences, Humanities, Law and Arts). A recent study conducted by the World Bank investigated the state of STEM research in sub-Saharan Africa (Lan et al. 2014). According to their Scopus-based trend analysis, across the years 2003–2012, some 60% of the STEM publications produced by these countries were internationally co-authored. Less than 10% of all publication output in sub-Saharan Africa relates to international collaboration between sub-Saharan Africa countries. The vast majority of co-authoring partners is non-African. The African Observatory of Science, Technology and Innovation (AOSTI 2014: xvi) states in a recently published Scopus-based indicators report:

> *Collaboration between AU members is infrequent, occurring in only 4.1% of AU scientific papers in 2005–2007 and in 4.3% of the papers in 2008–2010. Although having a high percentage of external collaboration (with non-African countries) is usually interpreted as a positive aspect in scientific knowledge production, too high a level of external collaboration may denote a situation of dependence. Mostly, external funding and the related grant conditions, compounded with the scarcity of significant funding sources from within Africa, may drive the high weight of international collaboration found in this study. Furthermore, the lack of strong collaboration frameworks in S&T to foster cooperative research within Africa is another drawback.*

In the comparative trend analysis of the eight flagships' performance profiles, the state of affairs at the level of scientific fields is unpacked and explored. The publication output and citation impact scores relate to fields such as Clinical Medicine, Physics and Materials Science, Agriculture and Food Science, and Psychology. The descriptive analysis provided later in this chapter focuses its attention on the largest fields of research within each university. But first we need briefly to introduce a second analytical tool for assessments of internationalisation: the citation impact of research publications.

Citations to publication and international scientific impact

Each international co-publication obviously defines a unique piece of knowledge in terms of how it came about. It leaves its own fingerprint in the science literature, differing from others in terms of their content matter ('what' – the sub-field) and institutional frameworks ('who' – co-authors and institutional partners), but also their knowledge production objectives and dissemination strategies ('why'). Depending on the publication's quality and topicality, and some degree of chance, the work may become acknowledged and utilised among researchers. Such impacts on the work of fellow researchers are partially captured by the reference list of follow-up research publications on the same or related topics. These 'citations' – from either the authors themselves (self-citations) or from colleagues and peers at other institutions (external citations) – reflect the 'scientific impact' of research. Applying the method of citation-analysis to WoS-indexed international co-publications enables us to gauge that impact in world science. Counting the number of citations measures the degree of impact as well as citation impact trends over time. The 'fingerprint' creates an 'impact path' through the time-space fabric of world science.

However, simply counting citations is not enough. Citation impact analyses should take into account the publication propensities, communication practices and citation characteristics within fields. There are large differences between those fields – some are slowly evolving (few publications per researchers, few citations); others are much faster and dynamic (many publications and citations) (e.g. Mathematics is seen as slow and Biomedicine as fast). To correct for these disparities, 'field-normalised citation impact scores' are applied. Basically, the accumulated number of citations to a paper, or set of papers, is compared to the average citation numbers in the respective field(s). This enables the comparison of citation impact scores across fields and sub-fields. A score of 1.0 indicates a world average impact rate; a score of 2.0 is twice the world average; 0.5 is half that average; and so on. Scores above 2.5 or 3.0 are often seen as representing very high impacts, in some cases reflecting institutionalised niches of 'international excellence'. The AOSTI report, focusing its analysis on African Union countries, clearly shows that internationally co-authored research publications tend to be much higher-cited than single-country publications, especially if at least one of the co-authoring partners is based outside of Africa (AOSTI 2014: 36).

Comparisons across high-profile fields of science

Table 4.1 indicates the largest research field in each university in terms of international co-publications, as well as the associated citation impact score of those publications, for the period 2006–2012. These large fields of international collaborative research are often areas where the flagship has, over the years, accumulated a 'critical mass' of international-level resources and capabilities to engage successfully with a variety of research partners abroad. The majority of the cases reveal areas of strength within Clinical Medicine; research areas related to tropical diseases; and trials of new medicines that involve many international research partners. Environmental Sciences and Technology are important at the Universities of Dar es Salaam and Botswana. The University of Mauritius has Chemistry and Chemical Engineering as an area of international strength. The corresponding citation impact scores are relatively high in Clinical Medicine. Some of this research is highly cited in the international scholarly literature (citation scores above 2.0) or at the very least significantly above the world average (i.e. above 1.25).

Table 4.1 Largest research fields of international cooperation (2006–2012)

University	Field of science	International co-publications	Citation score
Cape Town	Clinical Medicine	1 779	2.06
Makerere	Clinical Medicine	1 016	1.61
Nairobi	Clinical Medicine	461	1.45
Ghana	Clinical Medicine	292	1.41
Eduardo Mondlane	Clinical Medicine	134	2.46
Dar es Salaam	Environmental Science and Technology	111	0.91
Botswana	Environmental Science and Technology	99	0.87
Mauritius	Chemistry and Chemical Engineering	42	0.47

Table 4.2 presents the most highly cited fields in each flagship university. These fields contain 20 international co-publications or more, on average almost three papers per year, thus constituting a sufficiently large volume of international cooperation outputs to enable meaningful comparisons across the eight universities. One cannot help but notice a considerable overlap between Tables 4.1 and 4.2: international research activities and citation impact are clearly positively correlated. Again, most of the highly cited international cooperation occurs within Clinical Medicine – with the University of Cape Town being the main exception, being a partner in (highly cited) international research networks and consortia dealing with (high energy) Physics or related domains such as Materials Science. Botswana has a remarkably low score (but scores 2.26 in Mathematics with 19 international co-publications). The top position of Eduardo Mondlane University suggests high-quality science, perhaps even the presence of a local 'centre of excellence'. However, statistics can be deceiving and require closer

scrutiny; this University might well be just one of many co-authoring institutional partners (not necessarily the leading partner), and one should keep in mind that citation impact scores are time-dependent and often based on just one or two highly cited papers. Strong claims about scientific excellence require strong evidence.

Table 4.2 Most highly-cited fields of international cooperation (2006–2012)

University	Field of science	International co-publications	Citation score
Eduardo Mondlane	Clinical Medicine	134	2.46
Cape Town	Physics and Materials Science	463	2.35
Makerere	Clinical Medicine	1 016	1.61
Dar es Salaam	Clinical Medicine	42	1.45
Nairobi	Clinical Medicine	461	1.45
Ghana	Clinical Medicine	292	1.41
Mauritius	Biological Sciences	21	1.40
Botswana	Clinical Medicine	53	0.99

Collectively, these findings indicate very substantial levels of international research cooperation in some fields in at least five of these universities, with fairly high-citation impact levels alongside. Clinical Medicine is clearly a key focal point and research strength in international research partnerships.

Profiling at a glance

Focussing on recent changes at the level of fields, we now examine general patterns and trends within and across the eight flagships. The summary findings are presented in a graphical framework in which international co-publication output counts and citation impact scores are compared. It applies to each university's major fields of science; that is, those with more than 20 international co-publications in the period 2006–2012. (In the case of Makerere University and the University of Cape Town the threshold is set at 30 or 50, respectively, because of their larger total research output volumes in the WoS.) The framework presents the university's research specialisation profile insofar as international collaboration is concerned. The recent trends in both publication output and citation impact refer to a series of overlapping four-year windows: 2006–2009, 2007–2010, 2008–2011 and 2009–2012. The dynamics (if any) are crudely phrased in terms of either 'Noticeable decline' or 'Noticeable growth'. Lack of either is denoted as 'Steady state'.

Table 4.3a profiles the University of Mauritius, one of the smallest of the eight in terms of its international co-publications, with just two fields of sufficient size. The largest stride forward

has occurred within Chemistry and Chemical Engineering, where the number of international co-publications has increased – although this has not (as yet) resulted in a higher number of citations. The other field, Biological Sciences, shows no significant changes either way.

The profiles of the other seven universities, presented in order of the total number of fields presented in the graph, show much more dynamic and distinctly different profiles (see Tables 4.3b to 4.3h). Empty rows or columns are omitted from these graphs. The large internationalised fields in each university – those comprising more than 50 international co-publications in any of those four time-windows – are highlighted in *italics*. The results are presented below without attempts to describe or interpret individual profiles; this level of analysis requires in-depth studies by others with insider knowledge (or is left to the insights of the reader).

Table 4.3a Research internationalisation profile of the University of Mauritius

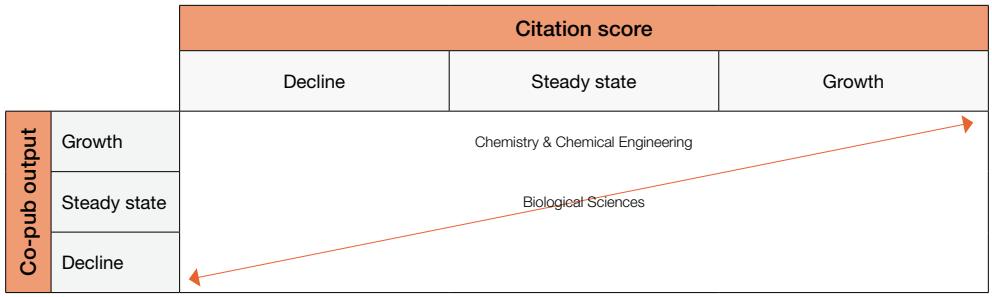


Table 4.3b Research internationalisation profile of Eduardo Mondlane University

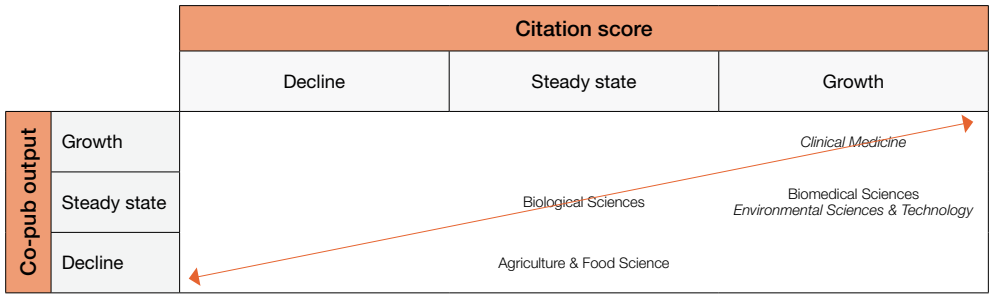


Table 4.3c Research internationalisation profile of the University of Dar es Salaam

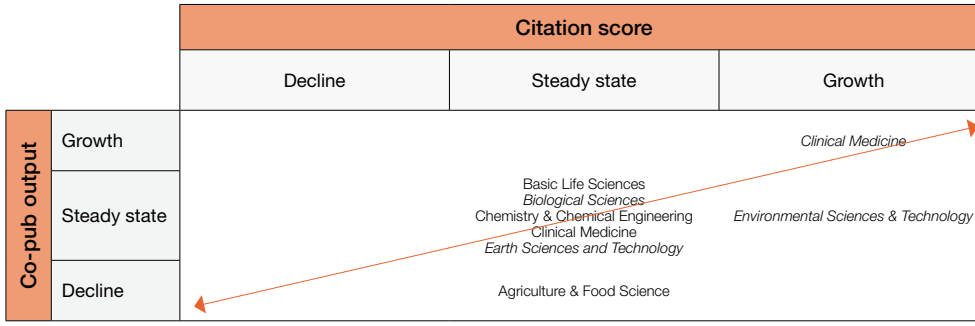


Table 4.3d Research internationalisation profile of the University of Ghana

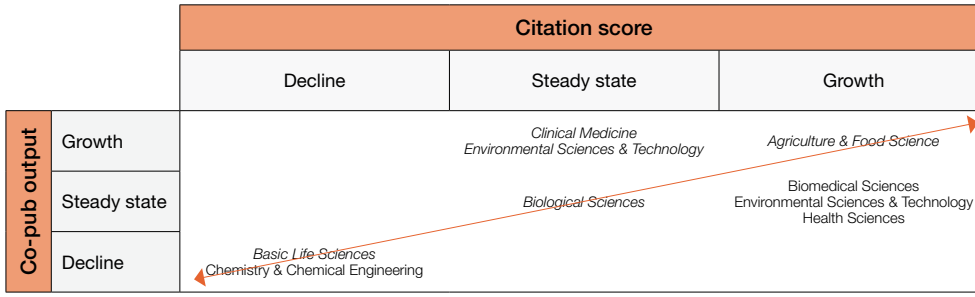


Table 4.3e Research internationalisation profile of the University of Botswana

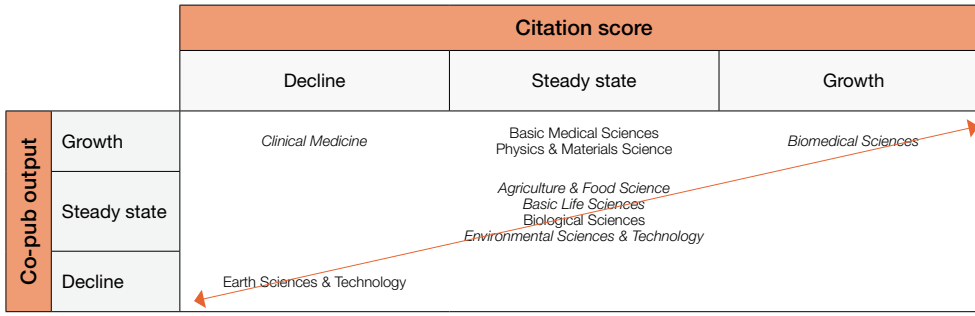
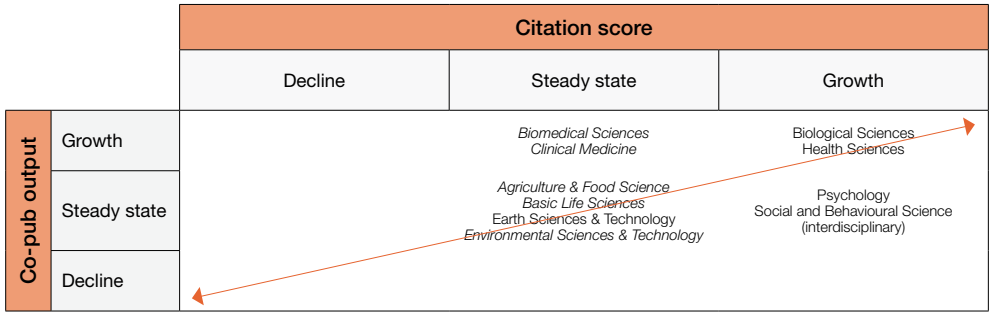


Table 4.3f Research internationalisation profile of Makerere University*



* Minimum threshold for a field's inclusion: 30 international co-publications in 2006–2012

Table 4.3g Research internationalisation profile of the University of Nairobi

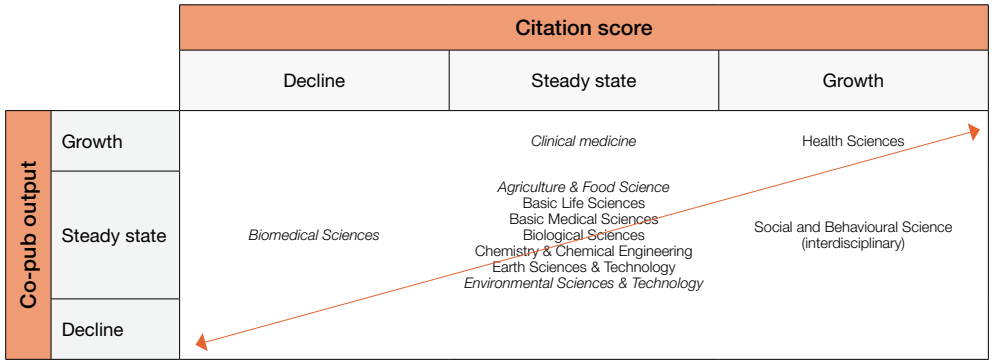
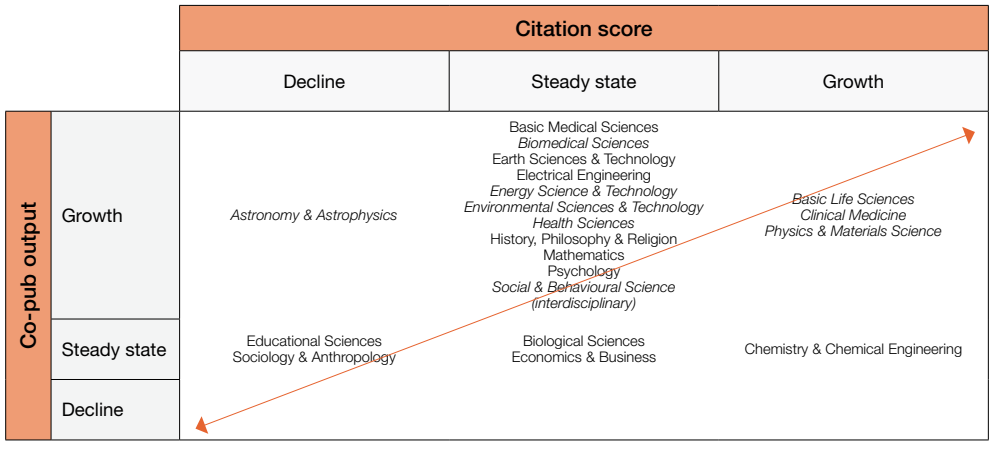


Table 4.3h Research internationalisation profile of the University of Cape Town*



* Minimum threshold for a field's inclusion: 50 international co-publications in 2006–2012

The empirical findings show that a marked upward shift is clearly visible across most fields of science – often in publication output and sometimes in output and citation impact. This leads to the general conclusion that these eight flagships are internationalising their research efforts, and are doing so across a wide range of fields. This positive development would, in turn, imply that the required financial and human resources, and research infrastructures, within those universities are improving and/or expanding. This suggests the presence of sustainable organisational units, research environments and international networks to support and drive such growth processes – in which, hopefully, talented PhD students or indigenous researchers have been recruited or trained to become Africa's new generation of elite scientists and scholars. Citation impact analysis of Africa's top 500 most highly cited researchers shows that half of the current elite 'have more than 50% of their publications internationally co-authored, primarily with researchers outside Africa' (AOSTI 2014: 38). Is this a cause or effect of internationalisation? That is an open question waiting for further studies. Either way, it is the mix of research internationalisation and of effective resources development that constitutes two indispensable key ingredients for boosting the scientific power of African research universities.

Summarising these profiles in terms of general characteristics, each one defines its own distinctive research specialisation profile, with areas of research strength and their growth trajectories. Wide diversity is to be expected: it reflects the different historical backgrounds, local governance and national policy environments, and institute-specific aspirations and ambitions of each university. It also underscores the necessity for caution when attempting to compare university performance profiles. These graphs are not suited for 'like with like' benchmarking; they require further in-depth information-gathering and extensive contextualised analysis.

From statistical data to strategic intelligence

Viewing scientific knowledge production and research internationalisation through the WoS lens of quantitative data presents university administrators with an empirical evidence base for a closer look at general patterns and trends – notably within their own university, but perhaps also in comparable research-intensive universities. Adopting this vantage point comes with a cautionary note, a disclaimer of sorts, because these numbers and statistics have limited analytical value when separated from their underpinning knowledge-creation processes. They only become informative narratives when placed in the proper context, notably the social, cultural, institutional or even economic determinants that influence new knowledge production in these flagship universities. The HERANA project, and its series of empirical studies, provides such a context. Interested readers are referred to Chapter 2 and its references to further reports from the HERANA project.

These trend data are certainly indicative of changes within and across these flagships but

need closer scrutiny to draw any firm conclusions for strategic management. The seven-year time frame (2006–2012) is relatively short and should be expanded, both backwards and forwards, in order to produce more robust observations and to draw more definitive conclusions as to the extent and nature of internalisation processes. Moreover, growth in international publication output might have gone up because of one or more 'structural' institutional factors, such as more research activity; increased efficiency in running and finalising projects; improved technical facilities and equipment; incentives to publish in WoS-indexed sources; more effective methods of getting publications into these sources; the composition and size of research teams; the introduction of new (local) journals into the WoS; and/or changes in (co-)authorship practices. One might assume that during this short time span any of these determinants may have played a minor or major role. Owing to the lack of evidence otherwise, this study assumes that the growth (or decline) is mainly because of corresponding changes in research activity levels. In-depth case studies are required to examine this critical assumption, and to identify each university's unique interplay of institutional factors and main driving forces.

Such follow-up studies should also closely examine the various university-specific developmental trajectories that seem to emerge from the graphs, provided one is willing to assume that the combined growth of international co-publications and the rise of citation impact in a field reflects a certain 'best case' measure of success in becoming more acknowledged and more visible internationally. Zooming in on the upper right hand corner of each graph, we find nine fields (distributed across six universities) where such growth patterns have occurred. Most of these growth areas related to the medical and life sciences, and in most cases they already represent quite substantial numbers of international co-publications. The remainder seem to be in 'catching-up' processes. The general impression is that several of these flagships are mainly expanding on, and gaining from, strengths in pre-existing high-quality fields; in other words, the strong are getting stronger. As for 'worst case' trajectories, very few fields are found where both output and citation impact is declining – all of which are fairly small fields in terms of international co-publications to start with, and now appear to be sliding backwards.

Currently many areas of growth are in the medical and life sciences. Given the urgency of local socio-economic problems, research universities obviously must devote considerable resources to indigenous disease-related problems in Africa. But they must also broaden their knowledge-/skills-base to other fields and other domains of societal relevance, where international cooperation can boost scientific performance and research capabilities. Under the right conditions there is a fair chance that this will eventually happen, if only because research internationalisation tends to leverage 'spill-over' effects beyond the rapidly internationalising field itself – either in supporting adjacent fields of science; promoting international quality standards; or transferring new insights and innovative technologies from scientific research into science-based education or community services.

Opportunities and threats

Research internationalisation opens up opportunities but poses threats as well. With regard to the latter, indigenous African scholars might be tempted to leave for better circumstances and opportunities outside the continent. However, African universities might benefit from internationalisation in terms of staff development and providing new opportunities for junior staff to obtain PhDs. African universities can 'fast forward' by effectively connecting to global research networks. The findings in this chapter show that several African universities are already heavily engaged in this process. Linking up with colleagues in the world's advanced economies will no doubt strengthen their research capacity; enhance university information and communication technology infrastructures; develop a new generation of African academics and reverse the brain drain; and help forge strategic alliances with high-quality research partners. It is also crucial in educating globally competent graduates. Ultimately, many African research universities will become full members of the global knowledge society and, in the process, contribute more and more to socio-economic development in their respective countries.

The benefits of research internationalisation require investments that may come with risks and at a cost. The risks include the perpetuation of brain drain; commodification and commercialisation of research outputs; and unfair collaborative arrangements dominated by hegemony of universities in the advanced economies. Although internationalisation attracts foreign research funding and opens up opportunities for additional funds, emphasising and prioritising the drive towards further internationalisation might also draw away scarce resources that could perhaps have been better deployed for other important (and often contradictory) institutional roles of research universities within Africa (see Chapter 1). University management should develop institutional policies and strategies for internationalisation so that it is not treated as an incoherent and uncoordinated activity. The choices made by university administrators, and their reasons for doing so, raise a host of questions as to how far and how rapidly internationalisation of research is allow to spread within a university before perceived short-term disadvantages are seen to outweigh the anticipated longer-term benefits. There has also been a lack of institutional dialogue about the realities and consequences of research internationalisation, which may have emerged despite of (or because of?) weak governance structures and regulatory frameworks, poor planning and inadequate financial support. Further empirical studies, at the heart of each university, could shed more light on this research management dilemma.

The quantitative data and metrics presented in this chapter provide input for university research performance indicators. Developing targeted and customised indicators (i.e. designed and shared amongst a group of African institutions) might not only create a much greater awareness and appreciation of their possible use in university research management and planning, but may also create a 'regional standard' for benchmarking. In that sense, it

has the potential to be much more informative and useful than the current world university rankings. Such a level of transparency might also help to get African governments and development agencies to support struggling research-active universities, on a continent where most universities are still teaching-orientated.

References

AOSTI (2014) *Assessment of Scientific Production in the African Union 2005–2010.* Malabo (Equatorial Guinea): The African Observatory of Science, Technology and Innovation (AOSTI)

Boshoff N (2009) South-South research collaboration of countries in the Southern African Development Community (SADC). *Scientometrics* 84(2): 481–503

Douglass J (2014) Profiling the flagship university model: An exploratory proposal for changing the paradigm from ranking to relevancy. *Research & Occasional Paper Series*, CSHE.5.14

Lan G, Blom A, Kamalski J, Lau G, Baas J & Adil M (2014) *A Decade of Development in Sub-Saharan African Science, Technology, Engineering and Mathematics Research.* Washington DC: The World Bank

Sooryamoorthy R (2009) Collaboration and publication: How collaborative are scientists in South Africa? *Scientometrics* 80(2): 419–439

Tijssen RJW (2007) Africa's contribution to the worldwide research literature: New analytical perspectives, trends, and performance indicators. *Scientometrics* 71(2): 303–327

Tijssen RJW, Mouton J, Van Leeuwen TN & Boshoff N (2006) How relevant are local scholarly journals in global science? A case study of South Africa. *Research Evaluation* 15(3): 163–174