



**RECOGNISING INDIVIDUAL
CONTRIBUTIONS TO COLLABORATIVE RESEARCH:**
*Limitations of Proportional Publication Counts
and Proposals for Alternatives*



science & innovation

Department:
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Recognising Individual Contributions to Collaborative Research: *Limitations of Proportional Publication Counts and Proposals for Alternatives*



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The Academy of Science of South Africa (ASSAf) was inaugurated in May 1996. It was formed in response to the need for an Academy of Science consonant with the dawn of democracy in South Africa: activist in its mission of using science and scholarship for the benefit of society, with a mandate encompassing all scholarly disciplines that use an open-minded and evidence-based approach to build knowledge. ASSAf thus adopted in its name the term 'science' in the singular as reflecting a common way of enquiring rather than an aggregation of different disciplines. Its Members are elected on the basis of a combination of two principal criteria, academic excellence and significant contributions to society.

The Parliament of South Africa passed the Academy of Science of South Africa Act (No 67 of 2001), which came into force on 15 May 2002. This made ASSAf the only academy of science in South Africa officially recognised by government and representing the country in the international community of science academies and elsewhere.

TABLE OF CONTENTS

FOREWORD	8
EXECUTIVE SUMMARY.....	10
CHAPTER 1. INTRODUCTION	14
CHAPTER 2. LITERATURE REVIEW	18
2.1 Scope and Methodology of the Review.....	18
2.2 Theories of Performance Management and Incentives	19
2.3 Co-Authorship Trends in Research.....	21
2.3.1 Authorship Patterns: 2002 to 2016.....	21
2.3.2 Drivers of Collaboration and Co-Authorship.....	26
2.3.3 Present Approaches to the Ethical Assignment of Authorship	29
2.3.4 Summary of Trends and Drivers.....	30
2.4 General Overview of Performance Management in the Research Sector.....	31
2.4.1 Introductory Comments (Normative Principles)	31
2.4.2 Performance Management of Institutions	32
2.4.3 Performance Management of Individuals.....	34
2.4.4 Performance Management of Teams.....	38
2.5 Existing Approaches to Recognising Contributions of Individuals within Large Teams.....	38
2.6 Potential System Revisions to Allow Greater Recognition	38
2.6.1 Non-Proportional Publication Units: the Korean Model	39
2.6.2 Contribution Matrix: Improving the Meaning of Co-Authorship	41
2.6.3 Non-Bibliometric Methods.....	42
2.7 Conclusion	42
CHAPTER 3. STUDY ON THE ATTITUDES OF RESEARCHERS TOWARDS PUBLICATION INCENTIVE: IS PROPORTIONAL COUNTING A FAIR SYSTEM?	44
3.1 Methodology of the Assignment.....	44
3.2 Responses to the Survey Questions.....	45
3.2.1 Demographics of the Respondents.....	45
3.2.2 Respondent's Evaluation of the System	46
3.2.3 Disaggregation by Research Field	48
3.2.4 Disaggregation by Number of Publications.....	51
3.3 Qualitative Responses.....	52

3.3.1	Comments on the Overall System.....	52
3.3.2	Comments on Alternative Approaches	54
3.4	Conclusion	56
CHAPTER 4. QUALITATIVE SURVEY ON THE USE OF PROPORTIONAL PUBLICATION COUNTS IN PUBLIC RESEARCH AND HIGHER EDUCATION INSTITUTIONS AS A RESEARCH INCENTIVE		57
4.1	Methodology of the Assignment	57
4.1.1	Population and Sample.....	57
4.1.2	Data Collection and Analysis	57
4.1.3	Analytical Framework	58
4.2	Responses to the Questionnaire	62
4.2.1	Awareness and Implementation	62
4.2.2	Distribution	63
4.2.3	Use of Proportional Count in Performance Management.....	64
4.2.4	Strategic and Operational Management	64
4.3	General Perceptions.....	66
4.3.1	Impact on Research Output.....	66
4.3.2	Misappropriation	66
4.3.3	Fairness and Equitability.....	67
4.3.4	Treatment of Proportionality vis-a-vis Promotion	68
4.4	Perception of the Impact of Proportional Counting on Collaboration	68
4.5	Need and Recommendations for Changes.....	70
4.6	Discussion	72
4.6.1	Overall System for Incentivising Scholarly Publications.....	72
4.6.2	Impact on Large Collaborations	74
4.7	Conclusion	74
CHAPTER 5. RESULTS OF SIMULATION STUDIES ON ALTERNATIVE ALGORITHMS FOR THE CALCULATION OF PUBLICATION UNITS.....		76
5.1	Background	76
5.1.1	Present DHET System	76
5.1.2	Proposal 1: Modified Korean Model.....	77
5.1.3	Proposal 2: Mesnard Model	78
5.1.4	Proposal 3: Modified DHET	78

5.1.5	Proposal 4: Minimum Units with Upper Bound	79
5.1.6	Proposal 5: Modified Arithmetic Sequence	79
5.1.7	Proposal 6: Contribution Matrix.....	79
5.2	Methodology of the Simulation	80
5.3	Data Sources.....	81
5.3.1	Institutional Data.....	81
5.3.2	Baseline System Data.....	82
5.4	Results of the Simulation	83
5.5	Conclusion	85
CHAPTER 6. FINAL CONCLUSIONS AND RECOMMENDATIONS		86
REFERENCES		90
APPENDICES.....		98
A.	Terms of Reference for the Expert Panel	98
	Aim	98
	Introduction	98
	Problem Statement.....	100
	Methodology.....	102
	Deliverables.....	102
B.	Appendix for Chapter 2: Details of the SciSTIP Survey	103
	Overview.....	103
	Covering Letter	103
C.	Appendix for Chapter 3: Details of the Questionnaire	105
	Overview.....	105
	Questions	105
D.	Appendix for Chapter 4: The San Francisco Declaration on Research Assessment	109
	Selected Relevant Recommendations from DORA	109
	SAIP and the PU	110

LIST OF TABLES

Table 1. Subject areas and keywords applied in the literature review	18
Table 2. Example calculation of institutional publication units.....	32
Table 3. Contribution matrix for assignment of co-authorship credits.....	41
Table 4. Structure of coding with examples of questions.....	60
Table 5. Institutional guidelines for payment of publication incentive.....	71
Table 6. Summary of existing funding of selected HEIs for research publications (2016)	76
Table 7. HEIs selected for inclusion in the modelling study	80
Table 8. Assumed average number of authors per South African institution as a function of X	81
Table 9. Annual outputs and funding of publication units.....	82
Table 10. Results of simulation on total publication units and funding levels	84

LIST OF FIGURES

Figure 1. Comparison of publication outputs: physicist vs. 'average' academic	17
Figure 2. Comparison of publication units: physicist vs. 'average' academic	17
Figure 3. The actors in agency theory (including teams).....	20
Figure 4. Average number of authors per paper (mathematics, physics and chemistry)	22
Figure 5. Total number of articles and publication units	23
Figure 6. Frequency plot showing numbers of articles per level of co-authorship.....	23
Figure 7. Single, national and international co-authorships as a proportion of total articles	24
Figure 8. Increases in maximum and median author counts	25
Figure 9. Bimodal pattern to frequency distribution of co-authorships (2015).....	25
Figure 10. Academic productivity (outputs/FTE: 2009 to 2014)	26
Figure 11. Drivers of collaboration and co-authorship	27
Figure 12. Total article counts and publication units (2005 to 2014)	34
Figure 13. Proposed correction to PU for co-authorship at varying levels of E.....	40
Figure 14. Comparison of de Mesnard correction factor with this study	41
Figure 15. Gender profile of respondents.....	45
Figure 16. Profile of respondents by age and number of publications	45
Figure 17. Profile of respondents by research field.....	46
Figure 18. Response to the statement on 'fair and equitable'	47
Figure 19. Response to the question on 'barrier to co-publishing'	47
Figure 20. Response to the question on impact on 'large collaborations'	48
Figure 21. Responses to 'fair and equitable' by research field (Q1)	49
Figure 22. Responses to 'prevents co-publication' by research field (Q2)	50

Figure 23. Responses to 'unfair to large collaborations' by research field (Q3).....	50
Figure 24. Agglomerated responses to Q1, 2 and 3 by research field	51
Figure 25. Responses to Q1 disaggregated by number of publications.....	52
Figure 26. Publication units for South African HEIs (2015)	57
Figure 27. Stages of the Precaution Adoption Model	58
Figure 28. Institutional and individual performance management/funding system for HEIs	59
Figure 29. Research outputs and grant value per output (2015/16 to 2017/18)	73
Figure 30. Institutional-level histograms (co-authorship frequency vs. number of authors)	82
Figure 31. Impact of different models on total and HEI publication units.....	83
Figure 32. Value of a single publication unit for each scheme (ZAR/unit).....	83
Figure 33. Fractional (%) changes to funding allocations to HEIs arising from publication outputs.....	84

LIST OF ACRONYMS AND ABBREVIATIONS

ALICE	A Large Ion Collider Experiment
ASCB	American Society for Cell Biology
ASSAf	Academy of Science of South Africa
ATLAS	A Toroidal LHC Apparatus
CHET	Centre for Higher Education Transformation
CERN	European Organization for Nuclear Research
CMS	Compact Muon Solenoid
CREST	Centre for Research on Evaluation, Science and Technology
DHET	Department of Higher Education and Training
DORA	Declaration on Research Assessment
DUT	Durban University of Technology
DVCs	Deputy Vice Chancellors
FTE	Full time equivalent
HEIs	Higher education institutions
HESS	High Energy Stereoscopic System
IBSS	International Bibliography of the Social Sciences
PRHEIs	Public research and higher education institutions
PU	Publication unit
R&D	Research and Development
SAAO	South African Astronomical Observatory
SALT	Southern African Large Telescope
SciSTIP	Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy
SKA	Square Kilometre Array
SU	University of Stellenbosch
UCT	University of Cape Town
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UP	University of Pretoria
UWC	University of Western Cape
Wits	University of Witwatersrand
WoS	Web of Science

DEFINITIONS

Authorship (Academic): academics generally publish their scholarly work and by definition become authors. Authorship is ascribed to or claimed by those who have been involved in the research and have made a substantive contribution to the completion of the work. Many journals have specific definitions of legitimate claims to authorship. For instance, according to the International Committee of Medical Journal Editors (Hoey, 2000) "each author should have participated sufficiently in the work to take public responsibility for appropriate portions of the content. One or more authors should take responsibility for the integrity of the work as a whole, from inception to published article". The committee also recommended that "authors should provide a description of what each contributed, and editors should publish that information. All others who contributed to the work who are not authors should be named in the Acknowledgements, and what they did should be described".

Co-authorship: two or more authors on a research publication are described as co-authors. Such a publication may be described as being multi-authored.

Collaboration (in research): work done towards a common aim by a group of individuals, or by a number of research groups or institutions, or work performed across disciplines or between countries, or any combination of these. Collaboration in small teams is defined as joint work involving between 5 and 50 participants. Large teams are defined as > 50 people. More detailed definitions of collaboration, and discussion of its essential aspects, are given by Katz and Martin (1997), and Laudel (2002).

Research publication: this term is used in its broadest sense to include those forms of publications (articles, papers, conference proceedings, book chapters and books) which are recognised by the Department of Higher Education as accredited forms of research output. A research publication includes and is mostly synonymous with peer-reviewed scientific academic publications where scientific refers to evidence-based as opposed to dealing exclusively with the natural sciences.

FOREWORD

The Academy of Science of South Africa (ASSAf) is mandated to provide evidence-based science advice to government on matters of critical national importance; this consensus report contributes to fulfilment of this mandate.

The report covers the results of a study undertaken by an ASSAf panel on the ways in which the contribution of individuals to the outputs of large scale (>100 participants) collaborative research projects could be more appropriately recognised and rewarded in South Africa. The study was motivated by the increasing participation of individual researchers in large national and international collaborations and reports from these team members that their specific contribution is generally under-recognised by the existing performance appraisal systems within tertiary educational institutions. In particular, individual outputs are assessed using the simplistic proxy measure of research publication units, based on the Department of Higher Education and Training (DHET) formula, which assigns a value of zero to any publication with more than 100 co-authors. The latter practice is referred to in this report as hyperauthorship.

The DHET formula is the basis on which one component of its funding to public research and higher education institutions (PRHEIs) is calculated, and these institutions have thereby been incentivised to increase the output of annual publications by their staff. In many PRHEIs, the proportional publication unit calculation has also been used within the university internal management processes to incentivise faculties, departments and individual researchers to increase their publication outputs. A primary conclusion of this study is that the use of the proportional publication unit for assessing the performance of individuals is simplistic, misleading and should not be used.

Considering the limitations of the present system, five alternative publication count schemes, based on international practices and literature reports, were investigated as part of the study. In each case, the impact of the alternative formula on the assessed output of individual researchers, and the overall institutional subsidy, assuming the ongoing use of the DHET framework, was determined. The simulations led to the following conclusions:

- The impact on the alternative schemes, with the exception of the Modified Korean Model and the Mesnard Model, which include a more extreme version of non-proportional counting, is minimal (<.5%). This result is to be expected considering that hyperauthorship is a small proportion of the total number of scientific publications (<3%).
- Similarly, the impact of the alternatives on the net DHET subsidy per PRHEI, relative to the present values as calculated using the DHET formula, is minimal (~2%), even though the institutions have diverse levels of hyperauthorship.
- However, the impact at an individual level will be considerable. For instance, a physics researcher working in a large team, who may not unreasonably be expected to publish about 200 hyperauthored papers per year, will receive a unit score of about two vs the previous value of zero.

In view of these results, and the overall comments from a diverse range of respondents within the research system to the study questions, the panel makes the following recommendations.

A. Recommendations to PRHEs on the assessment of Individual researchers

There should be a greater awareness within PRHEs of the phenomenon of hyperauthorship and the associated bimodal distribution of publication authors (see Figure 7 in the main report), especially in disciplines such as physics, genomics, medicine and statistics, where this practice is more prevalent. Individual performance appraisal should not be based on the DHET publication unit framework, which represents a misleading proxy for individual research productivity. Neither should it be used as a means of appointing or promoting academics. Publication counts are generally a poor proxy for the assessment of research quality and are highly misleading when used at the level of the individual.

B. Recommendations to the DHET on its funding and performance management relationship with Institutions

Although the incentive has been effective in achieving its intended outcome (increasing scientific publications by the PRHEs), it should be modified in two important ways. First, the formula for the calculation of units should be amended to include hyperauthored publications. At present, such units are rounded to zero.

Secondly the subsidy should be refinanced in order to ensure that the real value per publication unit is not allowed to decline any further. It is noted that the actual value of the award has declined by 19% in actual and 45% in real terms over the period 2011 to 2018 (the estimated value for 2018 is R104,000 per unit) and a larger allocation of funds is required in order to maintain a constant real value per publication unit.

We note that the algorithms for the counting of publications, that have been tested in this study, are not the only possible approaches that could be used; the intention was not to be exhaustive, but rather to explore alternatives to the present system. In the light of the objective of this study it was considered that a non-proportional approach would be a better alternative to the current system of incentive funding. We also note that the assessment and evaluation of research output, particularly at the level of the individual, is the subject of global debate and that new practices are currently being explored and tested.

EXECUTIVE SUMMARY

Within the digital era, the landscape of publishing research is changing rapidly. Many more journal titles are now available, and most journals are available online. Research fields are rapidly expanding, and few researchers can claim to be experts across even one discipline. This trend has dictated the need for large multidisciplinary teams, rather than individuals working in isolation, to undertake research projects. Publications from these large groups of necessity have many authors and in fact some publications have many hundreds of authors.

This report was undertaken to determine whether researchers in South Africa who publish within these large consortia are appropriately recognised in the South African context, including the systems by which authors are evaluated and rewarded, with specific reference to multi-authored publications. The study sought to establish the current practices in South Africa and compare these with international best practice. Lastly the report provides a number of recommendations to improve this aspect of the current system.

The panel initially undertook a review of the literature regarding co-authorship. The review confirmed that there has been an increase in co-authorship globally over the last fifty years and that in some fields the maximum number of co-authors has increased dramatically. What is noteworthy is that in terms of recognition and co-authorship, there are no universal standards and the allocation of authorship credits can vary between fields. It is clear that examples of publication incentives have been used as part of performance management in many parts of the world. The review also provided a summary of the funding formula used by the South African DHET in the allocation of its performance-based block funding to the HEIs.

It was also apparent that there were many individual histories with regard to individual rewards and recognition for published research. In order to get a clearer idea of the perceptions across the country, the panel undertook a survey in collaboration with the Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy (SciSTIP). This resulted in the section titled 'Study on the Attitudes of Researchers towards Publication Incentive: Is Proportional Counting a Fair System?'. Almost 1,000 respondents completed the survey. Only 40% of the respondents felt that the current system was "fair and equitable". The majority were neutral on the issue as to whether the current incentives were a barrier to co-publishing. There were some inherent contradictions within the responses to some of the questions, and the individual comments reflected the diverse perceptions of the respondents. The final statement at the end of this section summarises the current state of affairs: "it is also clear that the system is inconsistently implemented and that there are varying degrees of understanding in terms of its actual operation. Both issues could be beneficially addressed at institutional level given a willingness to support the research system and the way in which co-authorship patterns are changing".

Given the diversity of practices and perceptions within the research community in the country, the panel decided that it was also necessary to interview executives at a number of South African universities and research-performing science councils on how the reward and recognition of multi-authored publications were being managed at their own institutions. Due to the impracticality of exhaustive interviews, a sample of institutions based on publication unit output was identified. In all the institutions interviewed, researchers received some funding linked to publication units. Most of the executives interviewed were of the opinion that the current system is effective at incentivising publication outputs.

From the interviews of the executives it appears that despite the lack of DHET incentive for participation in large collaborations, researchers are increasingly taking part in such collaborations for other reasons. Institutions are responding to the problem by ensuring that such people are not disadvantaged in terms of their career development and, at least in some cases, their effort is recognised and rewarded in other ways. Some useful suggestions as to how the system could be improved are included in the conclusions to this section of the report.

The DHET approach, referred to as proportional counting, has a number of weaknesses including two concerns of the panel, namely that the system discourages collaboration and fails to recognise the contribution of individuals within large research teams (>100 authors). As a result, five alternative models were proposed by the panel models and tested using institutional-level data on publication outputs sourced from CREST. A more thorough scope, extending beyond the five alternatives, was considered to lie outside the panel's initial Terms of Reference. The selected models were chosen as examples of the types of analyses that could be done should DHET wish to consider an alternative approach.

Heavier weightings for collaborative publications, as used in model 1 (Modified Korean Model) and model 2 (Mesnard Model), significantly increase the total publication unit count (by 36% and 104% respectively), and hence decrease the value of each publication unit. In other words, the impact of these models at the institutional level would be considerable, with research funding to the more productive institutions being reduced. Models 3, 4 and 5, all of which use a modified DHET approach and allow for a more accurate rendition of proportional counting on articles for which the number of authors exceeds 100, have little impact on the level of funding for individual higher education institutions (HEIs), with the predicted changes being less than ~2%, even for the most prolific institutions. However, the impact on individual scores would be appreciable, since single researchers with a high output (>50) of multi-author publications could move from a publication unit count of zero to 0.5.

The occurrence of hyperauthorship is challenging the use of existing performance appraisal systems and requires the revision of such systems in the interests of what could be described as 'performance justice', which can be loosely defined as the principle that two academics who achieve equally, but work in different disciplines, should be equally rewarded or acknowledged. The impact of the widely used DHET 'publication unit'-based approach to performance appraisal is well illustrated by a comparison of the publication outputs from two academics, the one working in the engineering field, and the other in particle physics. The 'average' professor could be expected to generate 5 to 10 publications per year, equivalent to 2 to 5 publication units. However, a physicist working within several large research teams might (co-) author 50 to 100 publications per year, which will be measured as zero publication units (publications with more than 100 co-authors are rounded to zero). It is apparent, in these circumstances, that the proportional counting metric is misleading.

Chapter 1. Recommendations to HE Institutions on to their treatment of Individuals

1. There needs to be a greater awareness within HEIs of the 'bimodal distribution' in the numbers of co-authors (Fig. 7, p 24), particularly in the case of disciplines such as physics, genomics, medicine and statistics, where large numbers of co-authors are becoming more prevalent.
2. In the disciplines identified in Recommendation 1, the appraisal of an individual's performance should take cognisance of these developments.
3. The DHET publication unit system should not be used as a metric to measure the publication output of individuals for the reasons articulated in the San Francisco Declaration on Research Assessment (DORA) (see appendix D).
4. The use of the publication unit system is a poor proxy for the assessment of research productivity and should not be used in the selection and promotion of academics.

Chapter 2. Recommendations to the DHET on its Funding and Performance Management Relationship with Institutions

1. The DHET formula for allocation of units should be modified to include publications with in excess of 100 co-authors. The funding formula is suggested in Proposal 5, p 79.
2. The funding per publication unit should be increased. Its real value has fallen as a result of inflation and as a function of the doubling of the number of recognised units produced. The incentive has been effective in achieving its intended outcome, but a larger allocation of funds is required in order to maintain a constant real value per publication unit to continue the successful trend.

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A very special thank you goes to Dr David Walwyn who conducted the research and wrote up much of the report in a most professional, scientific and succinct way.

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The assistance of the Centre for Research on Evaluation, Science and Technology (CREST) with the background data for Phases 1 and 4 of the study, and with the researcher survey undertaken in Phase 2, is gratefully acknowledged. The insights into the mechanism and impact of the present system would not have been possible without this assistance.

ASSAf also wishes to acknowledge all the respondents to both the researcher survey (as reported in Chapter 3) and the more detailed questionnaire (see Chapter 4).

CHAPTER 1. INTRODUCTION

Early in 2016, the ASSAf agreed to initiate a multi-disciplinary study of the ways in which collaborative research could be appropriately recognised and rewarded in South Africa (ASSAf, 2016). The study was motivated by the increasing participation of individual academics and researchers in large national and international collaborations (Castelvecchi, 2015), and reports from these team members that their specific contribution was generally under-recognised by the existing performance appraisal systems within public research institutions (for further details, see section below on “What are the consequences of hyper-authorship for performance appraisal?”).

Given the important role of collaboration as a means of enhancing the local research capability and as catalysing innovation, ASSAf undertook to review South Africa's systems for recognising individual contributions to high quality collaborative research, and hence to provide a basis for informed decision-making on the appropriate recognition for such individuals in the future. The detailed Terms of Reference for the review are included in Appendix A. It was intended that the outcomes of the study would provide research institutions, HEIs, policymakers and funders with recommendations and guidelines for implementing policies that will promote, support and encourage excellence in research, particularly excellence in collaborative research, while at the same time providing the appropriate recognition for the participating individuals.

The study has been undertaken in four separate phases. In the first phase, a literature review was undertaken in order to develop the necessary background material for the study including information on the extent and drivers of collaboration and co-authorship; present systems for the evaluation and recognition of contributions of individual authors in research papers; the consequences of such systems; and alternative systems, particularly for multi-author publications, which are presently being proposed or implemented. The results of this phase are reported in Chapter 2.

In the second phase, ASSAf has endeavoured to survey the perceptions of the research community within South Africa's public research institutions towards the present system of proportional counting and publication units. The survey was undertaken as a joint project between ASSAf and SciSTIP, with the key question being whether the system can be considered as 'fair and equitable', or whether it is inequitable and therefore acts as a barrier to collaboration and co-authorship. The results of the survey are presented in Chapter 3.

In the third phase of the study, the panel interviewed the Deputy Vice Chancellors: Research (DVCs) of several public research universities in South Africa on the institutional response to, and impact of, the present system. In broad terms, this phase sought to clarify the perspectives of the DVCs on the general approach and impact of publication counts as a performance metric, the

use of proportional counting, the allocation of rewards, the ASSAf-defined understanding of the problem statement (that proportional counting fails to adequately recognise participation in large collaborations) and possible recommendations for alternative systems. The details of these interviews are reported in Chapter 4.

In the fourth and final phase of the study, the consequences of adopting five alternative models (algorithms) for the calculation of publication units have been assessed using simulations based on actual publication outputs at both system and institutional level for the years 1996 and 2016. The results of the study are covered in Chapter 5.

THE RISE AND RATIONALE OF HYPERAUTHORSHIP

How has hyperauthorship arisen?

Hyperauthorship is a consequence of changes in the practice of modern science in certain disciplines, particularly astronomy and high-energy physics. It is a global, not just a developed country, phenomenon which changed co-authorship practices across a range of countries, including South Africa, e.g. the initial paper on the Higgs boson, with more than 2,000 co-authors, contained a substantial number of South African authors (Aad et al., 2012).

The approach of hyperauthorship is an attempt to address the difficulty of recognising the contribution of individuals working within large teams, where each member may play only a small, but still significant part, in the overall research effort. Rather than attempt the impractical task of accrediting individuals, these teams agreed to adopt collaborative authorship lists, and to publish as a team rather than as sub-groups of authors.

Among the first to acknowledge the contribution of teams through hyperauthorship was the European Organization for Nuclear Research (CERN), and its associated ATLAS (A Toroidal LHC Apparatus), CMS (Compact Muon Solenoid) and ALICE (A Large Ion Collider Experiment) collaborations¹. Examples of collaborative authorships and even collaboration of collaborations include the following:

- two separate papers covering the discovery of a new particle (the Higgs) and the proof that it fits the Standard Model (Aad et al., 2012; Chatrchyan et al., 2012);
- subsequent work, jointly authored by ATLAS and CMS, which announced the measurement of the Higgs boson mass (Aad et al., 2015);

¹ Further details on CERN and the collaborations are available at <https://home.cern/>, <https://atlas.cern/>, <https://home.cern/science/experiments/cms> and <https://home.cern/science/experiments/alice>.

- an example of a collaboration of collaborations covers the discovery of a binary neutron star merger or kilonova (Abbott et al., 2017). The publication signalled the beginning of a new scientific discipline, multi-messenger astronomy; this founding study involved not only observations of gravitational waves, but also radio, infrared, optical, ultraviolet, X-ray, gamma-ray, and neutrino observations. A significant number of South Africans are amongst the authors, including people from the Southern African Large Telescope (SALT), South African Astronomical Observatory (SAAO), High Energy Stereoscopic System (HESS), and the SA Square Kilometre Array (SKA)/MeerKAT groups as well as individuals from five South African Universities.

These examples serve to illustrate the acceptance of major discoveries by extended teams working under collaborative authorship lists, and the standing of the journals reviewing the publications. The experiments involved are global collaborations requiring considerable investment in scientific resources that include computation, theory and instrumentation. In the case of ATLAS, the ATLAS Publications Committee and the ATLAS Authorship Committee provided the policy on General Publications and on Scientific Notes, which then formed the basis for the authorship lists of the first two of the above examples.

In the astronomical community, authorship lists vary according to the publication. Publication by the Gravitational Wave community and the SAAO, for example, was governed by a memorandum of understanding and related policies. The content of such agreements and policies will cover whether data or announcements may be embargoed until joint publication is enabled, how publications are submitted to the collaborative leadership before publication, when work may be published separately, acknowledgement requirements, and how observing time will be allocated in the minutes and hours after a trigger. In some cases, policies also state that authorship will be agreed by the specific members of a collaboration contributing to a paper.

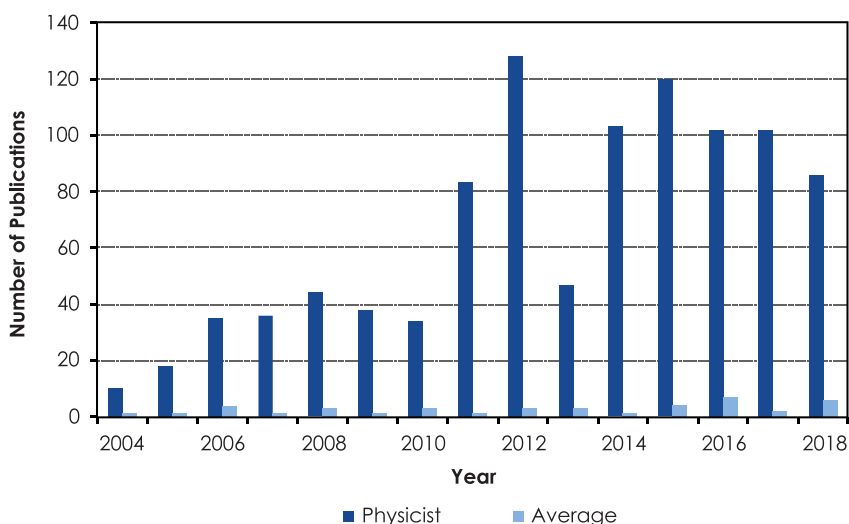
What are the consequences of hyperauthorship for performance appraisal?

The occurrence of hyperauthorship is challenging the use of existing performance appraisal systems and requires the revision of such systems in the interests of what could be described as performance justice, or the principle that two academics who achieve equally, but work in different disciplines, should be equally rewarded or acknowledged.

The impact of the widely-used DHET approach to performance appraisal is well illustrated by a comparison of the publication outputs from two academics, the one working in the engineering field, and the other in particle physics. The 'average' professor could be expected to generate 5 to 10 publications per year, equivalent to 2 to 5 publication units (see Figure 1). However,

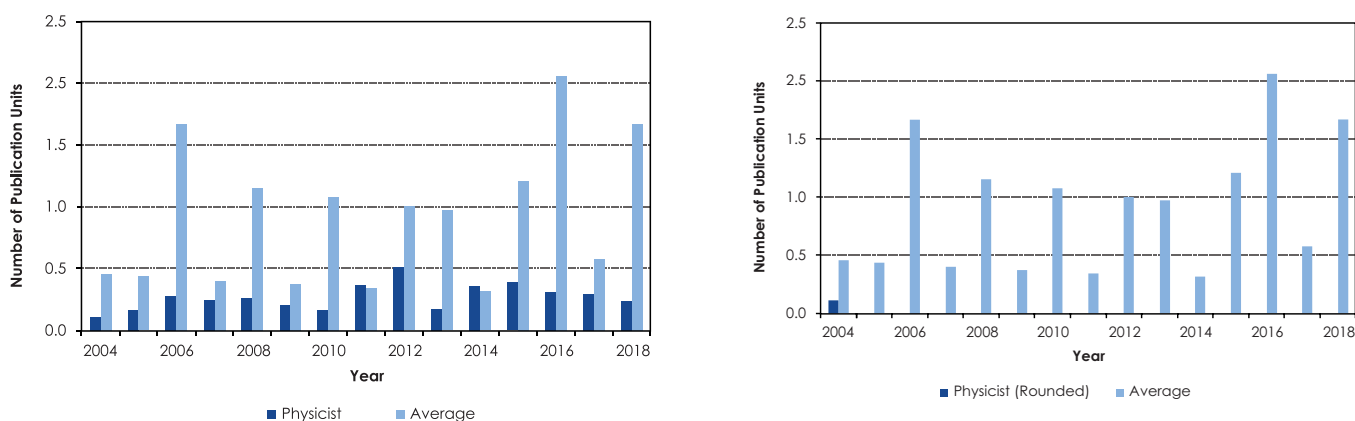
a physicist working within several large research teams might (co-) author 50 to 100 publications per year, also shown in Figure 1.

Figure 1. Comparison of publication outputs: physicist vs. 'average' academic



Using the DHET system, the publication unit scores for the two professors are shown in Figure 2 (A indicates the score where the publications are initially counted and the final score is rounded; B is the case where the publication units are rounded first and then summed):

Figure 2. Comparison of publication units: physicist vs. 'average' academic



The comparison is insightful; there is a big difference between the two scores, and it is apparent that the proportional counting approach is misleading (particularly where the score is first rounded and then summed). It is this discrepancy which formed the basis for the ASSAf study.

CHAPTER 2. LITERATURE REVIEW

2.1 SCOPE AND METHODOLOGY OF THE REVIEW

The approach of a narrative review has been followed (Cronin et al., 2008), the intention of which has been to provide a summary of the topical and relevant literature on the main subject (recognising the contribution of individual researchers within large teams). The narrative review differs from the systematic review in that it is not designed to be as comprehensive or rigorous. Whereas a systematic review is usually a meta-analysis which is characterised by the separate steps of formulating the research question, defining the inclusion criteria, accessing and selecting the literature, coding and finally synthesising the results, a narrative review starts with a more broadly phrased research question, uses a more limited set of primary data, does not prescribe to an initial set of tightly defined exclusion criteria and avoids the use of coding or quantitative analysis of the primary data (Enferm, 2007).

The review was divided into five main areas, as shown in Table 1; in each case a set of keywords was developed and then translated into a search string. The suggested references were compiled into a single list and then individually accessed through the University of Pretoria (UP) library site. In cases where the actual article was not available as open access, the abstract was screened, and the full article only retrieved when the content as described in the abstract was considered to be relevant to the subject.

This initial screen was tailed by a standard snowball technique in which further relevant articles were identified from a more detailed study of all the references through the keyword search. The second-generation articles were in turn studied and another generation of references obtained if key issues emerged; the third-generation articles were then read and used to identify a fourth generation.

Table 1. Subject areas and keywords applied in the literature review

Section	Title	Sub-Heading	Keywords
1	Definitions	None	collaboration; co-authorship; authorship; large team; small team; recognition
2	Trends in Research and Development (R&D) (Single Author vs. Collaboration)	Inter and Multi-Disciplinary	trends; R&D; interdisciplinary; multidisciplinary; review
		General Overview of Growth in Co-Author Publications	growth; distribution; co-author; authorship publications ²

² Actual search string: trend* and (R&D or research*) and (inter-disciplin* or multi-disciplin* or collabor* or co-author*)

Section	Title	Sub-Heading	Keywords
3	General Overview of Performance Management in R&D	Performance Management at Policy Level (management of institutions)	policy; institutional performance management; public research institutions; universities ³
		Performance Management within Performance Agencies (management of individuals)	performance management; performance agencies; public research institutions; recognition
		Performance Management of Teams	performance management; team
		Variations in Performance Management Systems	performance management; country differences; discipline differences ⁴
4	Existing Approaches to Recognising (Large) Teamwork	None	researcher performance management systems; multi-authorship; large teams ⁵
5	Policy Conflicts in Performance Management	None	policy conflict; researcher performance management ⁶

Altogether more than 200 references were identified, from which 137 relevant articles were retrieved and then grouped into separate folders according to the structure provided in Table 1. Each article was read, and the main points summarised. If the article was considered to be highly relevant to this study, it was labelled for further analysis and referencing.

2.2 THEORIES OF PERFORMANCE MANAGEMENT AND INCENTIVES

It would be misleading to consider that all behaviour is driven by the single-minded and highly individualistic pursuit of maximum reward for minimum effort. Behaviour is the result of complex interactions between multiple systems, only some of which could be described as causal antecedents. Sociologists and psychologists, seeking to explain patterns of human behaviour, have developed a number of models and theories, all of which have limitations in certain contexts and aspects.

In this review, the framework of principal-agent theory has been used as a means of providing a structure for the study and hence a more logical approach to the various articles than would otherwise have been possible (Ross, 1973). The framework considers the relationship between two actors, namely the agent, who is able to make decisions on behalf of the other actor, known as the principal (see Figure 3). The relationship is common to all contractual arrangements, including those between an employee (agent) and an employer (principal).

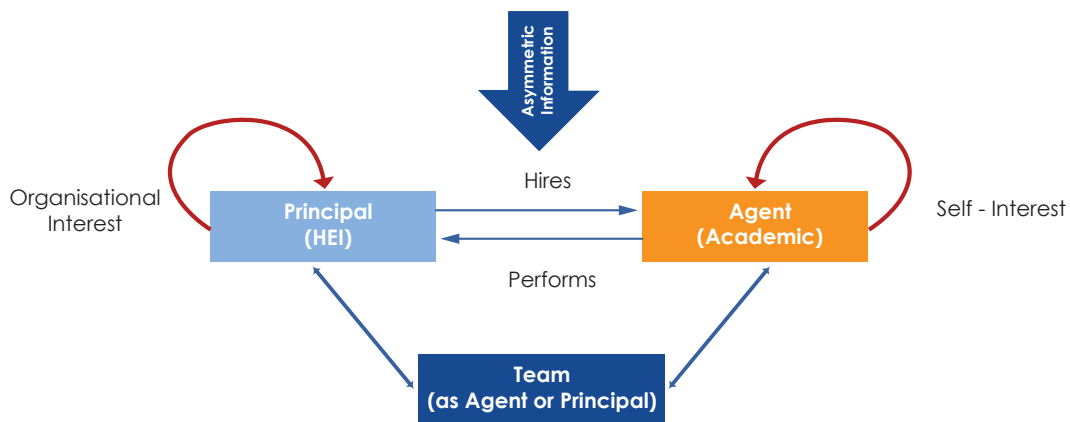
³ Actual search string: (performance manage*) and (polic* or fund* or team*). Also used approach* and (r&d or research*) and polic*

⁴ Actual search string: (performance management system or researcher performance manage*) and variation*

⁵ Actual search string: (recogni* or acknowledge* or reward* or incentiv* or encourage* or approach*) and (collaborat* or partner* or team* or "working together") and (research or r&d)

⁶ Actual search string: (performance manage*) and (polic* or fund* or team* or institution*) and conflict*

Figure 3. The actors in agency theory (including teams)



In cases of common interest between the principal and the agent, and hence mutual benefit, there is synergy between the actions or decisions of the agent, and the goals of the principal. However, in a situation of 'asymmetric information', the objectives of the two actors do not align and the decisions of the agent may adversely affect the interests of the principal. In this case, the classic principal-agent problem or dilemma arises, with the extent of the deviation between the two interests being measured as 'agency costs'.

In order to prevent this dilemma, principals act to incentivise individual performance and thereby minimise agency costs. Furthermore it is clear that agents respond strongly to pay-for-performance schemes (Prendergast, 1999). However, this action can be counter-productive in a workplace setting which requires teamwork or collaboration and it has been shown that within such systems, the efforts made by employees to help co-workers are reduced and collaboration is minimised (Drago and Garvey, 1998). The challenge for organisations or principals is to maintain a balance between incentives which reward individual performance and those which recognise the contribution of teams. In essence, such a challenge goes to the core of the issue covered in this study.

In addition to the tension between individual effort and teamwork, which is an inherent consequence of the standard structure of employment contracting, there is also ambiguity in the literature on the relationship between productivity and reward. Although this relationship ought to be transparent and linear, it is claimed that there are persistent earnings inequalities which are the product of confounding factors such as gender, specialisation and visibility (Leahey, 2007). Clearly such factors undermine the just or fair functioning of a performance management system; in the event that the implementation of the system is poor, the achievement of the desired results will be unlikely.

2.3 CO-AUTHORSHIP TRENDS IN RESEARCH

In this section, patterns and drivers of co-authorship are reviewed. The discussion assumes that co-authorship is a useful proxy for collaboration, and that by considering patterns of authorship, more fundamental trends in respect of collaborative relationships between researchers can be inferred. Such an assumption is not without its critics, who argue that not all co-authors may have been active collaborators, and that not all researchers who collaborate become co-authors (Laudel, 2002; Katz and Martin, 1997; Melin and Persson, 1996). Indeed there are several types of collaboration which are unrecognised within standard authorship practices, including service collaboration (generally the input of technicians), access to research equipment and sharing of know-how (Laudel, 2002).

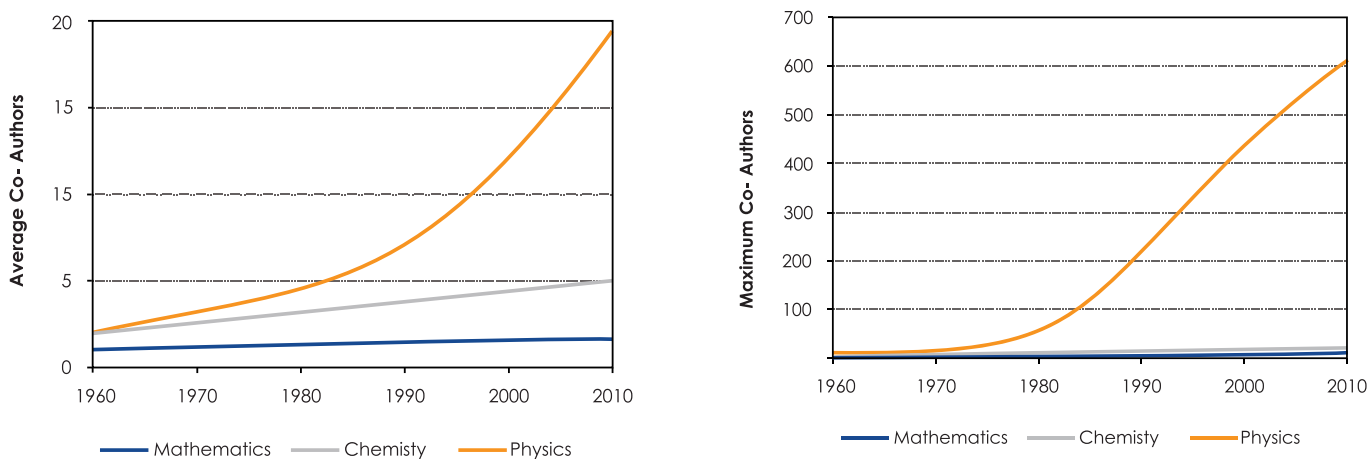
However, the limitations of co-authorship as a proxy for collaboration is beyond the scope of this study. A number of factors have led to an increase in research collaboration and this pattern is perhaps imperfectly reflected by changes in authorship. In the next sections these patterns and the drivers thereof, are discussed.

2.3.1 Authorship Patterns: 2002 to 2016

International

Patterns of co-authorship in academic publications have changed very significantly over the last four decades. Firstly collaboration, and hence levels of co-authorship, has increased in most disciplines, but particularly in astronomy (Ware and Mabe, 2015), physics (Huang, 2015; Merali, 2015), biomedicine (Bourret et al., 2006; Cambrosio et al., 2004), molecular biology (Nabout et al., 2015), economics (Andrikopoulos et al., 2016; Nowell and Grijalva, 2011) and mathematics (Glänzel and Schubert, 2004), as shown in Figure 4. Furthermore, this trend is expected to continue, supported by a number of factors including the prerequisites of funders, advances in communication and networking tools, the cost of scientific infrastructure, and the development are improved project management tools.

Figure 4. Average number of authors per paper (mathematics, physics and chemistry)



Source: Huang, 2015

Secondly a new phenomenon of 'mega' co-authorship, also known as hyperauthorship and defined as levels of co-authorship in excess of 2,000, has emerged relatively recently and is particularly prevalent in high energy physics, molecular biology and biomedical research (Castelvecchi, 2015; Beaver, 2001). In May 2015, a paper published in *Physical Review Letters* set a new record of 5,154 co-authors (Aad et al., 2015). If the current growth continues, it is predicted that the number of co-authors could surpass ten thousand in the 2020s.

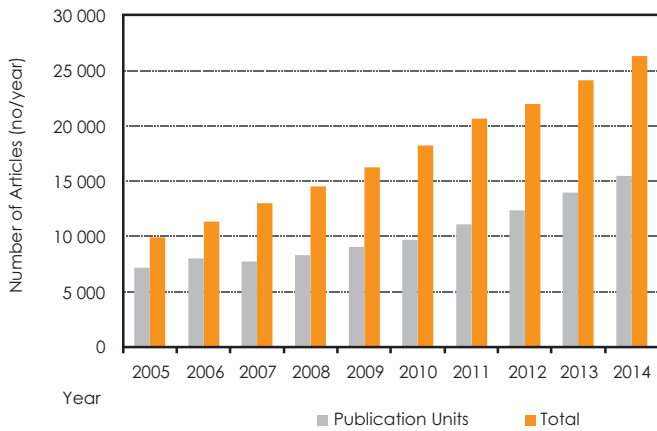
Finally, the number of research articles has increased at a compound average growth rate of about 8% per year, correlating with an inherent increase in the absolute numbers of co-authored publications. Although the data is difficult to compare between various sources due to differences in the inclusion criteria, Plume and van Weijen (2014) report that in 2014 about 2.5 million research articles were published by about 28,100 peer-reviewed English-language journals, of which 1.5 million articles from 2,550 publishers were listed in the Thomson Reuter's Journal Citation Reports database (Ware & Mabe, 2015).

South Africa

Similar trends have been observed in South Africa. Based on data from the CREST, the total number of research articles⁷ has increased by 354% over the period 1996 to 2015, and by 257% between 2005 and 2015, as shown in Figure 5. The compound average growth rate over the latter period has been about 10%, which exceeds the global growth rates as noted in the previous section on international trends. As a result, the South African share of Web of Science (WoS) articles has increased from about 0.5% to 0.75% (Jammie, 2015).

⁷The total article count includes all articles which are recognised by DHET and includes the listings in WoS, *International Bibliography of the Social Sciences (IBSS)* and local DHET-accredited journals.

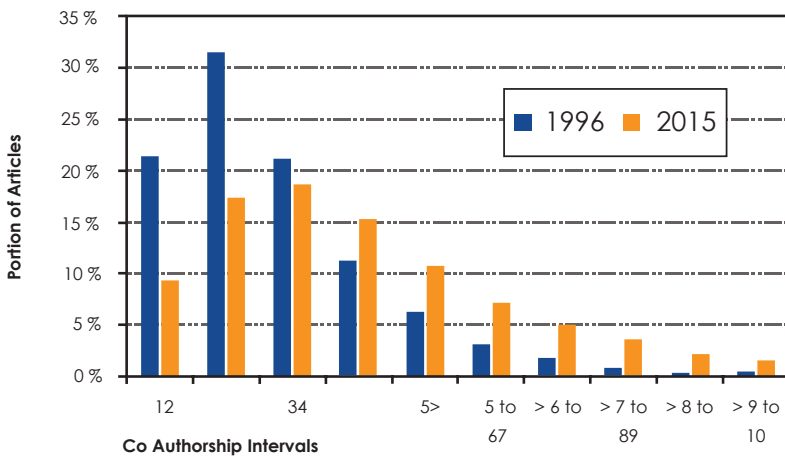
Figure 5. Total number of articles and publication units



Source: Mouton et al., 2019

Although the number of single-authored articles has increased slightly from 1,506 to 2,374 between 1996 and 2015, their proportion of total articles has fallen from 21% to 9%, as shown in Figure 6. In this period the highest incidence number (of co-authors) shifted from 2 to 3 co-authors and the median rose from 2 to 4.

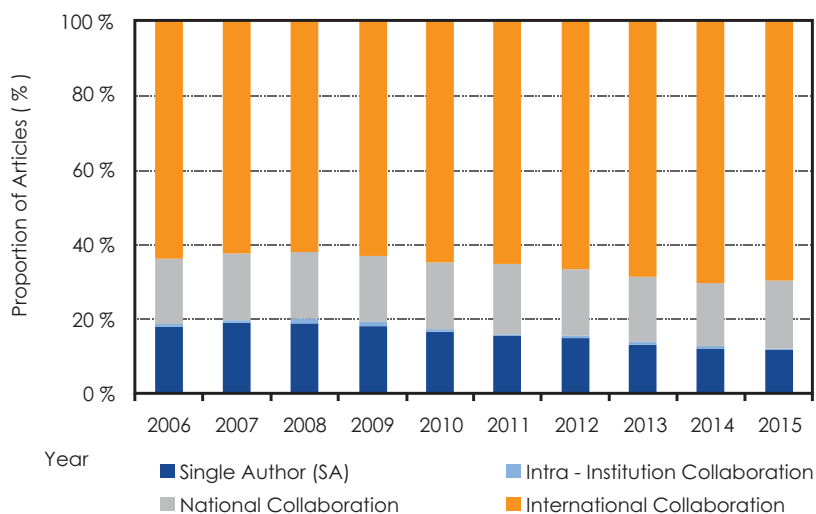
Figure 6. Frequency plot showing numbers of articles per level of co-authorship



Source: CREST

There are two interesting aspects to this rising trend in the numbers of co-authors; firstly, publications are increasingly co-authored with authors who are located in other countries, a pattern which is loosely referred to as international collaboration. As shown in Figure 7, international co-authorship has increased from 60% to 70% of all research articles.

Figure 7. Single, national and international co-authorships as a proportion of total articles

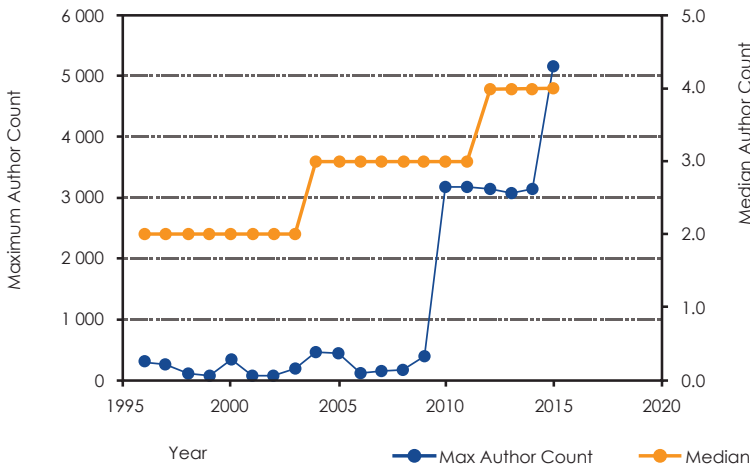


Source: CREST

Secondly the median number of authors on South African publications has risen from 2 to 4, as shown in Figure 8. The increase has been driven by two distinct and important trends, namely the increase in co-authored papers in the category 4 to 10 authors and a sudden increase post-2010 in the number of papers with author levels exceeding 2,000, referred to as the 'physics/astronomy bulge'.

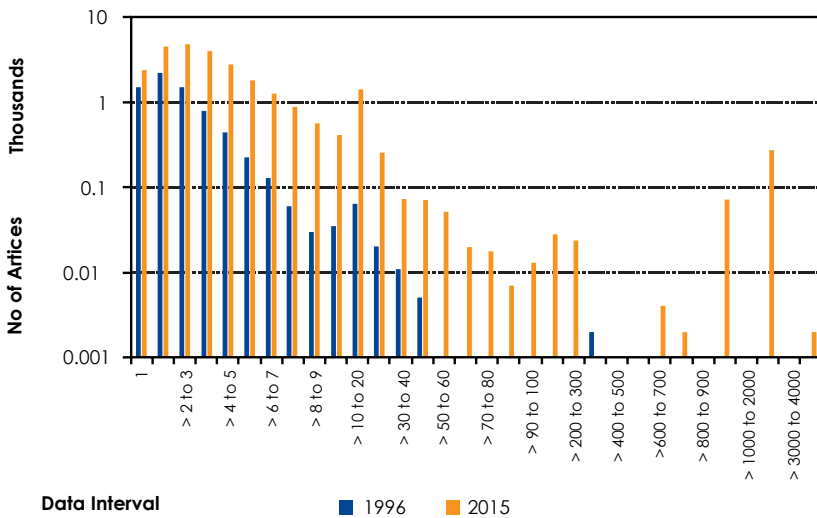
This bulge can be seen very distinctly on a log plot of the overall frequency distributions for co-authorship levels. It is noted that co-authorship patterns are log-normally distributed, hence the use of median as opposed to average values of co-authorship. However, the emergence of the physics/astronomy bulge has resulted in a clear bimodal distribution to the frequency plot, as shown in Figure 9. For instance, in 1996 there were only 6 papers out of a total of 7,000 papers with the number of co-authors exceeding 50, and no papers at all with co-authors exceeding 500. In 2015, however, there were 511 articles with the number of co-authors exceeding 50 and 272 exceeding 2,000, of which 271 were in the fields of physics and astronomy. In other words, the growth of the hyperauthored papers can be ascribed to a new pattern of co-authorship which has emerged in a very specific set of disciplines and is not widespread within the system.

Figure 8. Increases in maximum and median author counts



Source: CREST

Figure 9. Bimodal pattern to frequency distribution of co-authorships (2015)



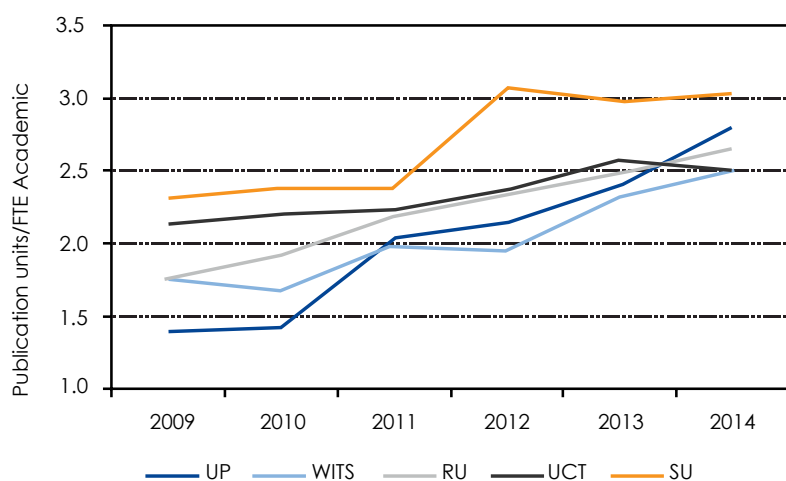
Source: CREST

Even though such hyperauthorship now accounts for about 20% of all publications in these two fields, the total number is small relative to the overall output. For instance, in 2015 only 1% of total publications fall in the >1,000 category, and over the whole period from 1996 to 2015, the figure is 0.5%. The low incidence of such publishing practice has implications for this study; considering the limited prevalence of the pattern, it is not clear whether there is a need for a system-wide response to the new trend.

Although academic productivity is not core to this study, it is included in this section as an example of how a performance management system can change the behaviour of academics. Levels of academic outputs per full time equivalent (FTE) academic have been rising, as shown in Figure 10,

an increase which has been ascribed to the implementation of a new funding framework for South African universities (Butler-Adam, 2015), as discussed in Section 2.4.2. The combined effect of an increase in publication units per researcher and levels of co-authorship indicates that collaborations involving South African academics are multiplying, a statement that is supported by recent work on patterns of co-authorship with international research teams (Sooryamoorthy, 2015; Pouris and Ho, 2014). This trend is considered to be highly beneficial for the country's research system since it extends access to critical resources, improves research quality and builds regional alliances focussed on shared problems. The authors of these studies argue that the rising trends in terms of co-authorship and collaboration need to be encouraged by dedicated funding and the redesign of present performance measurement systems which act as a disincentive (Pouris and Ho, 2014).

Figure 10. Academic productivity (outputs/FTE: 2009 to 2014)

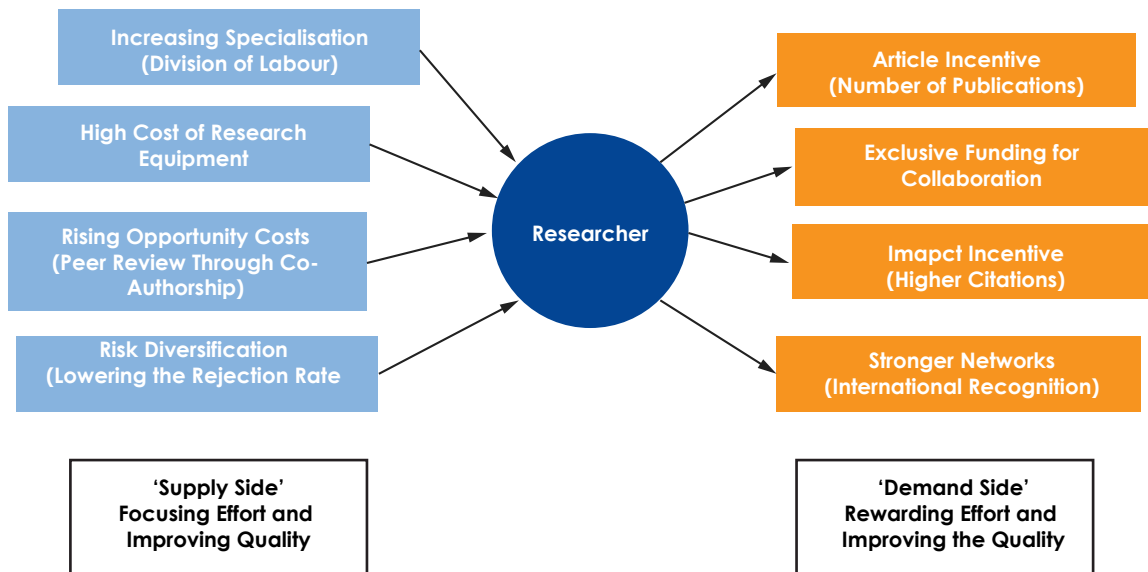


Source: <http://chet.org.za/data/sahe-open-data#>.

2.3.2 Drivers of Collaboration and Co-Authorship

Given the theoretical framework presented in Section 2.2, it is unsurprising that demand side incentivisation is responsible at least in part for the reported increases in collaboration and multiple co-authorship, with such incentives including reward for numbers of publications, impact of publications and the international recognition through co-authorship networks (see Figure 11). However, the advent of demand side incentives is only part of a broader set of drivers, with other important factors being increasing specialisation; the use of co-authorship as a form of peer review due to rising opportunity costs; and risk diversification (Bruno, 2014). All these drivers are now discussed in more detail.

Figure 11. Drivers of collaboration and co-authorship



Supply Side Management

The first four drivers are grouped together as 'supply side' factors and relate to reducing or minimising individual effort to achieve a higher quality standard within a context of rising opportunity costs and an increase in the complexity and depth of knowledge.

Increasing Specialisation and Division of Labour: the division of labour as a result of increased specialisation has been considered as the most influential driver, with the broader issue being that it is more practical for an individual to obtain the necessary expertise for a research project through collaboration than through de novo self-learning (Bruno, 2014; Laband and Tollison, 2000; McDowell and Melvin, 1983). Although collaboration may increase input costs, "authorship fosters higher quality by exploiting complementarities between multiple authors" (Bruno, 2014).

High Costs of Research Equipment: the costs of scientific equipment and experiments conducted on this equipment is a second important driver of collaboration (Katz and Martin, 1997). In an effort to contain these costs, countries, institutions and researchers seek to work in large, international teams where a common research platform is shared across multiple sites. Examples of such facilities include CERN, the international telescopes and the various synchrotrons.

Rising Opportunity Costs: increasing pressure on researchers to publish their work has eroded the tradition of collegiality and informal review within public research and higher education institutions (jointly referred to as PRHEs), despite the important role that this input has played in raising the overall quality of a publication. As a result, academics have adopted the practice of

offering their colleagues co-authorship opportunities as a means of incentivising a higher level of effort on the detailed review of a publication. Within this context of rising opportunity costs, academics and researchers use offers of co-authorship as a means of guaranteeing quality and reducing the risk of rejection. To some extent this trend has been supported by the lower costs and greater ease of personal communication.

Risk Diversification: a related driver is the use of mutual co-authorship as a means of managing the stochastic or random nature of journal rejection risk. Most scientific or academic journals adopt a peer review process in which a submitted article is subject to double or single blind review by specialists in a relevant knowledge domain. This process carries an unpredictable element; articles rejected by one reviewer may be accepted by another. Assuming that quality is improved through co-authorship, as shown in a number of studies (Kim and Bak, 2016; Chung et al., 2009), and accepting that there is a random element to the peer review system, the likelihood of a single author having a certain number of publications accepted within a defined period of time is increased with larger numbers of submitted articles. This effect is referred to in this review as 'risk diversification' (Bandodkar and Grover, 2016; Bruno, 2014).

Demand Side Incentivisation

Demand side incentives act in multiple ways to drive a behaviour of co-authorship. In general, institutional and individual performance management systems within the research sector consider co-authorship to be beneficial to either the system (of innovation) or the institution. As a result, incentives are structured in order to drive co-authorship through the standard metrics of the number of articles (N), total citations per individual (C) and the strength of international networks.

Number of Articles: if papers with X authors are not counted as 1/X papers, the benefit from co-authorship is straightforward. Researchers choosing whether to work on a single-authored paper or on two dual-authored papers, exerting the same effort, will prefer the second option because it doubles the probability of a higher reward (Bruno, 2014). In practice, systems may adopt the 1/X approach in which case the benefit of dual-authorship is minimal. However, as has already been noted, two submitted publications have a higher chance of acceptance than one single publication even if the article quality and potential benefit is equivalent.

Number of Citations: the number of citations per article is used as a measure of an article's impact. This measure is frequently augmented by the h-index, which is defined as the unique and largest number of papers (h) ascribed to an author or organisation, which have been cited at least h times, and is an approximate measure of both quantity and quality of an author's output

(Hirsch, 2005). There are several extensions to the h-index, including the h-bar index, which takes into account the effects of multiple co-authorship (Hirsch, 2010), the i10 index (the number of publications with at least 10 citations) and the g-index, which is defined as the largest number such that the top g articles received at least g^2 citations (Egghe, 2006).

International Networks: the third incentive, which may be unique to the incentive structure for South African researchers, is the notion of international recognition. Given the long period of international isolation and its impact on the international stature of South African research, the NRF, through its evaluation system, has pursued a policy of rewarding 'considerable international recognition', which uses a variety of metrics including invitations to publish chapters or reviews in international books, invitations to act as a keynote speaker, awards by international organisations and leading roles in international collaborative research projects.

Funding Allocations: funding agencies, alerted to the benefits of collaboration and multi-disciplinary research, have sought to stimulate this behaviour through their funding instruments, in some cases adding collaboration as a separate evaluation category (alongside quality of the research idea, expertise in the team, relevance of the research problem) or in other cases, launching funding instruments which focus almost exclusively on building research networks. Examples of the latter include funds for building international links or networking with industry.

All of the demand side incentives rely on the validity of principal-agent theory in their design and application. As a consequence of the performance management system within which they are located, researchers act in ways that maximise their individual interests whilst at the same time (hopefully) assisting their institution to achieve its goals and performance targets. On the supply side, researchers can shape the way in which they utilise their available resources in response to environmental pressures; on the demand side, organisations can design incentive structures to reward suitable behaviours. In the following sections, these performance management systems are discussed in more detail, beginning with institutional management and then looking at the management of individuals.

2.3.3 Present Approaches to the Ethical Assignment of Authorship

The ethics of authorship credit and assignment have been discussed and reviewed in this literature, with authors noting the lack of universal standards, the increasing difficulty of ensuring a fair distribution of credit given the changes to co-authorship, and the rising levels of disputes over authorship (Marušić et al., 2011; Feeser and Simon, 2008). One of the main ethical concerns

is the prevalence of underserved or ghost authorship, where authors are included in publications for reasons other than their direct contribution to the work.

Although there appears to be a common understanding within the research community about the most important qualifying contributions which can lead to a claim for authorship, there are reports of widespread abuse of such principles, particularly within the university structure and its unequal power relations between researchers and senior academic staff. Although these cases do not constitute examples of research misconduct, reported in the literature at a prevalence of 2%, ethical problems arise in as many as 29% of research collaborations (Marušić et al., 2011). It appears that there is a general lack of universal standards in the assignment of authorship even though such guidelines are necessary. It is therefore important that educational programmes for researchers stress the development of moral judgement in the allocation of authorship credits.

The discussion on the ethics of authorship assignment go beyond the scope of this study. However, it is noted that the growth of co-authored papers may be the consequence of the absence of a set of normative standards relating to authorship credits. In the absence of such standards and in order to avoid any potential disputes, it may be easier to include all claims to authorship, regardless of whether these have been fully tested.

2.3.4 Summary of Trends and Drivers

In this section, the trends in respect of research collaboration and co-authorship of research publications, and the reasons for the changes, have been reviewed. It is evident that collaboration between researchers, as measured by levels of co-authorship, has increased in most disciplines over the last 40 years, but particularly in physics (Huang, 2015; Merali, 2015), biomedicine (Bourret et al., 2006; Cambrosio et al., 2004), molecular biology (Nabout et al., 2015), economics (Andrikopoulos et al., 2016; Nowell and Grijalva, 2011) and mathematics (Glänzel and Schubert, 2004). Furthermore, given the advances in communication and networking tools, and the development of improved management tools, it is likely that the size of collaborations will continue to grow.

Mega collaborations (> 1,000 authors), which are a relatively new phenomenon in research, are particularly prevalent in high energy physics, molecular biology and biomedical research (Beaver, 2001). In May 2015, a paper published in *Physical Review Letters* set a new record of 5,154 co-authors (Aad et al., 2015). If current growth continues, the number of co-authors could surpass 10,000 in the 2020s.

There are a number of factors driving these increases in co-authorship and collaboration, including the need to reduce input costs, to improve the quality and impact of research publications, to access specialised expertise, and in response to the growing use of performance metrics which are based on publication outputs and the strength of research networks. In the next section, the general structure of such systems is reviewed.

2.4 GENERAL OVERVIEW OF PERFORMANCE MANAGEMENT IN THE RESEARCH SECTOR

2.4.1 Introductory Comments (Normative Principles)

Although there are unresolved debates and conflicting claims in the literature, it is useful at this stage to distil a set of normative principles which emerge from the research on performance management in PRHEs. These principles follow:

On Benefits of Collaboration

- Inter-institutional and international cooperation, as reflected by the number of co-authored publications, correlates strongly with research excellence and fractional count productivity¹ (Mali et al., 2016; Ductor, 2015)
- The positive impact of multiple co-authorship on productivity is enhanced or amplified for authors occupying a central position within a research network (De Stefano and Zaccarin, 2016), scholars who are connected to many different scholars, authors with repeated co-authorships (Abbasi et al., 2011) or in the case of researchers who already have a high output (Ductor, 2015). In all cases, these researchers can exploit the externalities obtained from collaboration to a greater extent (Ductor, 2015).
- For researchers in developing countries, co-authoring with international collaborators can increase research productivity by as much as 40% and can improve a researcher's prospects of being involved in large international research projects (Ordóñez-Matamoros et al., 2010).
- Journal articles with multiple authors generally achieve higher citation counts (and hence impact); however, there is a report to the effect that the enhancement may plateau at 3 to 5 authors, with the addition of further authors being of lower impact (Avkiran and Alpert, 2015). In this study, it is assumed that the latter report has covered only a limited field and that it is not substantiated across all collaborations.
- Social network theory has been used to explain the positive effects of co-authorship and collaboration on productivity; in particular, the networks are assumed to bridge structural gaps and facilitate knowledge exchange (Kuzhabekova, 2011).

¹ Fractional count productivity refers to the calculation of productivity where the number of publications is divided in each case by the number of authors.

- Agents (researchers) respond strongly to pay-for-performance schemes (Prendergast, 1999).
- Although imperfect proxies for performance, bibliographic metrics including number of publications, number of citations, and h-factors are widely used in the assessment of researcher productivity and academic value.
- Whilst quantitative indicators can serve as reflections of research productivity and excellence, they should be supplemented by qualitative approaches where feasible (Mali et al., 2016).
- A non-proportional reward for co-authorship (a paper with X authors is counted as $> 1/X$ publication units) is the optimal solution for a PRHEI which wants to maximise researchers' efforts, if high rewards are available (Bruno, 2014).

2.4.2 Performance Management of Institutions

A comprehensive review of the existing performance management frameworks for PRHEIs has not been possible within the scope of this review. Instead, the review has focussed on the approach of the DHET, which implemented a new framework for the allocation of funding to HEIs in 2004 (Madue, 2007; Ministry of Education, 2004). The framework describes the procedures which are followed by the DHET in the allocation of its performance-based block funding to the HEIs.

The block grant consists of four sub-grants, namely the teaching input grant, the teaching output grant, the research output grant and the institutional factor grant, the values of which are calculated using a set of formulae and performance targets (Walwyn, 2008). The most relevant component of the block grant to this review is the research output grant, which is based on the output of research publications, research masters and doctorates. Research publications are counted using the approach of 'publication units' in which all research publications are assigned a value based on the type of publication (book, book chapter, article in a DHET accredited journal, or conference proceedings), authorship and in the case of books, the number of pages (DHET, 2015). The total number of publication units is then obtained from the sum of the individual components, as shown in Table 2 and in Equation 1.

Table 2. Example calculation of institutional publication units

Item	Number	Authorship	Publication Unit
Book	1 (>300 pages)	Single	10
Book Chapter	1	Dual (each from a different institution)	$2 * 0.5 = 1$
Research Article	5	2 single; 3 dual from different institution)	$2 + 1.5 = 3.5$
Refereed Conference Proceedings	10	Dual (all from same institution)	$10 * 0.5 = 5$
Total			19.5

Equation 1:
$$PU = \sum_{i=1}^N P_i / X$$

Where PU = publication units
 P_i = maximum publication units for publication i
 X = number of authors

The research output grant is then calculated according to the following process (Walwyn, 2008):

- Each institution is set a target for research output, based on the total research and teaching staff and a benchmark output per FTE staff member; in the case of the universities of technology this is 0.5 publication unit/FTE and for universities 1.25;
- The subsidy per research output is then calculated by dividing the total budget by the total target research output;
- The grant is calculated by multiplying the actual output units by the subsidy per expected output unit (to give the non-weighted grant);
- This value is then adjusted for the under-performing institutions by adding a development grant which is proportional to the output shortfall (difference between actual and target outputs; the sum of the non-weighted grant and the development grant is referred to as the total grant).

There are a number of problems with this approach to the research output grant as follows:

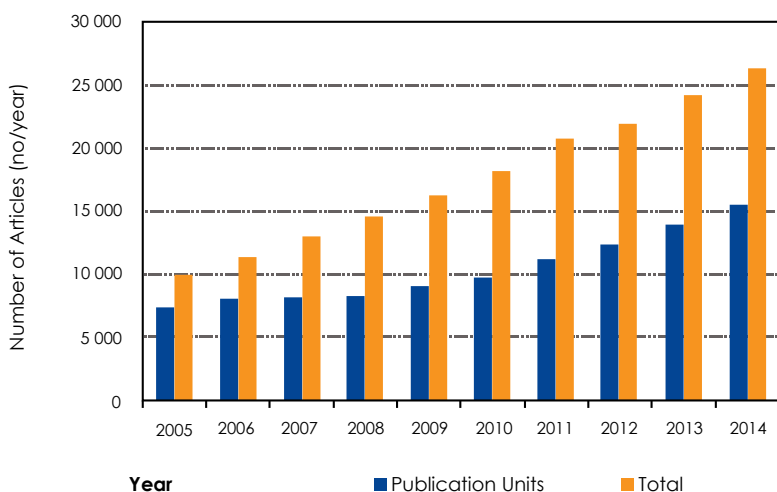
- It is a 'zero sum game'; if the outputs of all the HEIs are higher than the benchmarks, the actual allocation per unit of research output decreases (Walwyn, 2008).
- The system is not a level playing field; high performance institutions are set high targets and vice-versa. This aspect exists despite a number of other corrective measures to ensure that the weaker institutions have sufficient development funds, such as the institutional factors and the restructuring grants. As a result, poor performing institutions are rewarded rather than penalised for their performance.
- In the case of co-authorship, the publication unit becomes rapidly and discouragingly small; for instance, when the number of authors exceeds 100, the assigned publication unit is zero since all values are truncated to two decimal places.
- The publication unit does not address the issue of quality, only quantity, and may even discourage quality (Harley et al., 2016).

A previous ASSAf study has also highlighted an additional issue, as follows (ASSAf, 2019:131):

“The second major problem with the DHET policy is its inherent bias against collaboration arising from the fractional allocations of output units to the institutions of the South African authors involved. This means, for example, that a significant collaborative paper written by a first-author South African with three other collaborators who work abroad, is awarded 0.25 of a unit, while a paper by a single South African author in a local journal will ‘earn’ 1.00 unit. Collaboration obviously has its own rewards of different kinds, but the policy could readily be modified by ignoring the foreign authorships and awarding units only to local authors, in which case the units awarded in the collaboration example would also be 1.00. Alternatively, and less controversially, only first local authorships of international collaborative papers might be recognised in this way.”

Despite these shortcomings, the funding formula has been successful in increasing the number of publications, with the number of research publications, as measured by publication units, growing from 6,660 in 2004 to 15,316 in 2014 (Butler-Adam, 2015), as shown in Figure 12. Interestingly the divergence between total article counts and publication units has also increased over the period due to the growing numbers of authors per publication (see Section 2.3) and hence the increasing extent of discounting due to the DHET’s approach of proportional measurement.

Figure 12. Total article counts and publication units (2005 to 2014)



Source: <http://chet.org.za/data/sahe-open-data#> and CREST

2.4.3 Performance Management of Individuals

International Practice

A thorough review of performance management systems for individual researchers presently

being applied within PRHEs of other countries is beyond the scope of this study. However, the following important points are noted with respect to the contribution of publication counts to performance management systems:

- Performance-based rewards relating to salary and promotion have been used in universities of the United States of America (USA) for many years (Stephan, 2012)
- European and Asian universities have followed the USA example by implementing similar systems with mixed results (Kim and Bak, 2016; Andersen and Pallesen, 2008)
- The range of incentives includes cash-per-paper payments, salary increases and cash bonuses (Andersen and Pallesen, 2008)
- In South Korea, the universities have adopted a partial discount or non-proportional system for co-authored papers (Kim and Bak, 2016). For example, the author of a double-authored paper may receive 80% of the credit of a single-authored paper, or more recently, the first or corresponding author of a double-authored paper receives the same full credit as the author of a single-authored paper.
- Also, in South Korea, the results of combining a non-proportional approach to co-authored publications, with an increase in the minimum publication requirements for promotion ensured an increase in the collaboration and hence co-authored publications. The influence of the cash bonus, however, was not considered to be significant (Kim and Bak, 2016). It was concluded from this study that scientists respond to organisational demands as may have been predicted by principal-agent theory and do not act as autonomous agents. In other words, a “well-designed team-based reward system could encourage organisational members to make extra effort to collaborate” (Kim and Bak, 2016:11).

Although the existing literature does reflect positive benefits to collaboration and co-authorship, there is also growing evidence of publication clubs and gift authorship, also known under the less complimentary terms of ghost authorship and by-line banditry (de Mesnard, 2017; Mouton, 2017). These unethical practices, which are designed to exploit present incentive structures in the interest of maximising personal gain, are clearly an unintended and unfortunate outcome. A separate ASSAf study (ASSAf, 2018) is covering this topic.

South African Systems

Individual performance management at South African universities is a relatively recent and contentious phenomenon (Seyama and Smith, 2015; Ngcamu, 2013; Mapesela and Strydom, 2007), although such systems have been used within the public research institutions (science councils) for more than 40 years. Academic staff within the universities are critical of such systems, their major concern being that performance management is a managerial practice developed for the business sector and highly unsuitable to the more collegial environment of

higher education. The critics consider its introduction to be a manifestation of the deepening culture and ideology of new public management, rather than a need to address productivity and performance weaknesses within their institutions.

One important criticism made in a recent case study of a single university is the absence of a customised system more closely aligned to the organisation's strategic plan. This aspect is important to our discussion since it links to the question of publication counts. It has been noted in Section 2.4.2 that South Africa PRHEIs are measured using publication units and not counts. The inference of this study is that the metric has been cascaded to the individual level, such that individual performance measurement depends on a fractional/proportional rather than integer-based count of publications.

No evidence in support of this inference can be found in publicly available literature. However, based on documents obtained from the separate institutions, it has been possible to establish that in cases where at least a portion of the research output grant is transferred to faculty level, and then to departmental level, and finally to the research accounts of individual academics, such payments are made in proportion to publication units, as calculated by the DHET formula. It is likely that this approach is widespread within the PRHEIs although further research will be required to confirm this assertion.

The present system can be summarised as follows:

- Publication units for individual authors, departments and faculties are rigorously counted, based on the subsidy formula as outlined in Section 2.4.2 for the submission of the data to the DHET.
- The Research Office then uses these units to calculate the sum of money to be given to each faculty; the amount of money transferred depends on the institution but is usually between R10,000 and R50,000 per publication unit (this is about 10% to 50% of the original DHET payment per publication unit to the PRHEI).
- The faculty may or may not then take a percentage of the payments in order to promote research activities in their faculties.
- The remainder is transferred to the departments, the heads of which can decide how it is, and how much is, transferred to the individual authors. In most cases, it appears that a portion is used to support young researchers and the final remainder is transferred to the research accounts of the authors by whom the publication units were earned.
- In some institutions, the individuals are allowed to draw the money as part of their taxable income, but this practice is not generally considered to be ethical within the system. Instead it is used to support the research needs of the individual academics.

There are variants of the system which have been surfaced through this study. For instance, in its management of the National Facilities, the NRF uses an incentive instrument known as the 'Research and Innovation Reward Programme'. Each publication unit is allocated an amount of R60,000 (adjusted every few years), and the National Facility is then granted funding, additional to its core funding, in proportion to the number of publication units. According to the guidelines, the Managing Director of the facility is required to give an "undertaking that the award made for a specific output benefits the research of that individual or group, and that the money is used to support research activities relevant to the activities of the facility. At least 60% of the funds must directly benefit the individual researcher or research group and 40% of the funds may be allocated as discretionary funds for research activities relevant to the activities of the facility by the Managing Director". (NRF, 2015)

However, there is one important and fundamental difference between the NRF instrument and the PRHEIs as outlined above. The NRF calculation applies the DHET formula of proportionality in that the calculation of the publication units is proportional to the number of authors, but only up to the level of 4 authors or 25% of the incentive. For publications by 5 authors and more, it is assumed that only 4 authors are involved. In other words, the value of the grant does not reduce below 25% of the initial grant of R60,000 per publication unit. This approach seems to deal more equitably with the issue of multiple co-authorships than the PRHEI approach, although it is clearly more expensive and more open to abuse with the use of ghost authorships and similar practices.

It is apparent from the above that the present system as adopted by many South African PRHEIs, with the exception of the National Facilities, for rewarding individual authors of research publications, uses proportional counting in the calculation of the value of the award. This system has the limitation that the value of the award becomes meaningless above a level of 5 to 10 authors.

The use of this system at the level of individuals is itself not supported by the DHET, whose Research Output Policy makes a number of relevant statements (DHET, 2015). This document notes that the:

"policy serves as a tool for the distribution of research subsidy to public HEIs in South Africa. The Department subsidises institutions and not individual authors or academics. Institutions should be cautious of directly incentivising individual authors as this practice is promoting perverse behaviour in some cases."

The South African Institute of Physics has also noted its concern at the loss of publication units for papers involving the use of large-scale research infrastructure, work in large groups, research collaboration between groups, the development of international networks, and interdisciplinary research, where several research groups may combine (see Appendix D).

2.4.4 Performance Management of Teams

Unfortunately, no data could be found on systems relating to the performance management of teams which would be of relevance to this study.

2.5 EXISTING APPROACHES TO RECOGNISING CONTRIBUTIONS OF INDIVIDUALS WITHIN LARGE TEAMS

In Section 2.3, it has been noted that levels of co-authorship have risen significantly over the last half-century. In particular, there has been a shift from a median of 2 to a median of 4 co-authors in South African research publications with the major changes being a decrease in single/dual authorship and an increase in publications having between 4 and 10 co-authors. In addition, there has been the emergence of hyperauthorship, particularly in physics and astronomy, where papers containing more than 2,000 authors now comprise 20% of all publications in these two fields, although only 1% of the total annual publications.

Furthermore, Section 2.4 has indicated that the use of publication units as a measure of individual research performance, where the latter is linked directly to salary and promotion, may have become more widespread. These two trends, acting alongside each other, have resulted in the problem statement for this study, namely that publication units compute to minimal levels for large co-authorships and as a result the contribution of researchers to such projects or teams may be undervalued or poorly recognised.

In this section, existing approaches to the problem were reviewed. Unfortunately, on the main topic of the ASSAf study, namely the recognition within performance management systems of the contribution of individuals to the work of *large* teams, there is limited literature. However, there are some published studies on the utility and outcomes of incentives which have been aimed more broadly at the encouragement of collaboration, as discussed in Section 2.4.3.

Furthermore, there appears to be a similar dearth of publications on any organisation-specific standard procedures which may exist in organisations that routinely conduct research in large teams. It is therefore recommended that a phase of primary research should be undertaken in the event that ASSAf considers this topic to be worthy of further expenditure and investigation.

2.6 POTENTIAL SYSTEM REVISIONS TO ALLOW GREATER RECOGNITION

In this section, a number of new approaches as solutions to the problem statement of this study

are proposed. These ideas have emerged from the literature and from a deeper consideration of the parameters of the problem itself, based on information accessed through the literature.

Editors of journals and other authors have suggested several ways of improving the present system (Clement, 2014; Frische, 2012). These proposals can be divided into two main categories, namely the use of non-proportional publication units in performance measurement, and secondly more open disclosure of the role and responsibility of the different authors as listed on a publication. The two categories are now discussed in separate sections.

2.6.1 Non-Proportional Publication Units: the Korean Model

The Korean model, which uses non-proportional publication units for incentivising collaboration in Korean universities, has already been discussed in Section 2.4.3 (Kim and Bak, 2016). This approach acknowledges that collaborations enhance the quantity and quality of research outputs, and hence it follows that it is in the interests of organisations to reward such collaborations in a non-proportional manner, where the extent of the adjustment will depend on the perspectives and experience of the research organisation. Literature suggests that the enhancement is as high as 40% on the average impact of non-collaborative publications (Ordóñez-Matamoros et al., 2010). In other words, the correction factor applied to the calculation of publication units will vary from 1 to 1.4 as shown in Figure 13 (in this case a maximum enhancement of 80% has been assumed).

Although this approach does increase the reward for co-authorships of publications having between two and ten authors, it does little for the main problem being considered in this study, namely the issue of large teams and publications with greater than 50 authors. In this case, a flat rate of publication units could be applied. In other words, the number of assigned units could be calculated on the following basis:

$$\text{For } X = 1 \quad PU = \sum_{i=1}^N P_i$$

$$\text{For } X \leq 10 \quad PU = \sum_{i=1}^N \frac{P_i}{X} * (1 + E) * (1 - e^{-X})$$

$$\text{For } X \geq 10 \quad PU = \sum_{i=1}^N \frac{P_i}{X_i} * (1 + E)$$

where:

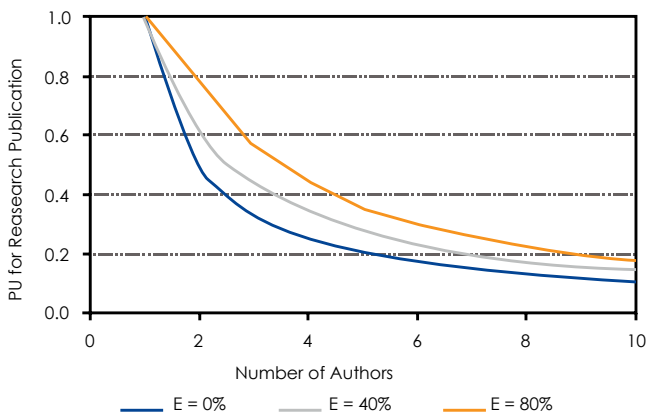
PU= publication units

X = number of authors

P_i = maximum publication unit for publication i

E = assumed level of enhancement (40% to 80%)

Figure 13. Proposed correction to PU for co-authorship at varying levels of E



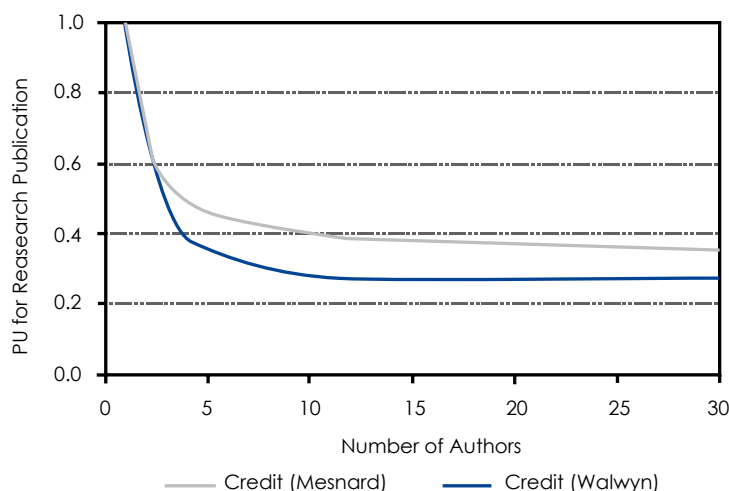
A similar approach to non-proportional assignment of publication credits has recently been proposed by de Mesnard (2017). Arguing that a proportional allocation is too harsh, but that a system with no adjustment is too generous, de Mesnard proposes a “maximum parallelization credit” rule based on the following:

$$PU = \sum_{i=1}^N P_i \frac{(X + 2)}{3X}$$

A comparison of the two methods is shown in Figure 14; the main difference is that the de Mesnard approach asymptotes to a higher ceiling value as the number of authors increases (0.35 vs. 0.27). Evidence in support of, and hence rationale for the adoption of, either value is still slim and further studies will be needed on the degree of enhancement which is afforded by large co-authorship for a choice to be made between the two values, or indeed any other value.

Although the approach of a minimum publication unit could be open to abuse, in practice the latter will be difficult in the presence of large teams and the growing practice of contribution disclosure. The adoption of a full disclosure approach as a means of assigning credits in a publication is outlined in the next section.

Figure 14. Comparison of de Mesnard correction factor with this study



2.6.2 Contribution Matrix: Improving the Meaning of Co-Authorship

One of the central problems in the use of authorship as a performance metric is the interpretation of author lists and the lack of a uniform standard (Frische, 2012). It is evident that different disciplines and journals use different standards, with the list of authors sometimes being alphabetical, sometimes being in order of contribution and sometimes a mixture of both (Clement, 2014). A possible solution which has been explored and proposed in the literature is to include in the publication a matrix in which the contributions and responsibilities of an author to a specific article are listed.

Table 3 lists such an approach. Each author is required to define his/her level of input for the requisite article within the designated categories. These entries are then weighted using a set of institutional guidelines or the weightings as agreed between the authors. The final weighted contributions are then published with the list of authors; examples of possible values are given in Table 3. This approach also has the advantage that a minimum level of contribution can be assigned based on standard values or a pre-agreed threshold. For instance, a contribution level of less than 5% would not be sufficient to be listed as an author.

Table 3. Contribution matrix for assignment of co-authorship credits

Author	Ideas	Work	Writing	Stewardship	Net Contribution/Responsibility
Weighting	20%	30%	35%	15%	100%
A (Graduate Student)	10%	70%	50%	10%	42%
B (Post Doc)	20%	30%	25%	20%	25%
C (Professor)	70%	0%	25%	70%	33%
Total	100%	100%	100%	100%	100%

Such a system could have multiple impacts on the functioning of performance management systems and the recognition of research contributions in large teams. For instance, the transparency of the system may induce greater honesty, and improve the ethics culture of research (Frische, 2012). It may also allow for the allocation of publication units in proportion to the scale of effort, thereby reducing the level of under-recognition (or even over-recognition) in performance management.

2.6.3 Non-Bibliometric Methods

During the study, the panel's attention was directed to the San Francisco DORA, developed by the American Society for Cell Biology (ASCB) in 2012 (see Appendix D). The guidelines rely on two themes, namely the need to eliminate the use of journal-based metrics, such as Journal Impact Factors, in funding, appointment, and promotion considerations; and the need to assess research on its own merits rather than on the basis of the journal in which the research is published.

Subsequently, the DORA movement has suggested methodologies for performance evaluation of researchers which do not rely on bibliometrics and is included in this section on account of its more authentic approach.

2.7 CONCLUSION

The literature review has confirmed that levels of publication and co-authorship are indeed rising across all disciplines and countries. The number of research publications has increased by 354% over the period 1996 to 2015, and by 257% between 2005 and 2015. Over the latter period the pattern of authorship has changed in three major respects. Firstly, the number of single-authored papers has fallen from 21% to 9% of the total output, and the median number of authors per paper has risen from 2 to 4. Secondly the incidence of international co-authorship has risen from 60% to 70% of all publications, a trend which can only be described as a positive sign for a small research system. Finally, and of particular importance to this study, the log-normal distribution has shifted to a bimodal pattern with the emergence of a relatively large number of publications in the category of 1,000 to 5,000 co-authors.

It is also apparent that the growth of hyperauthored papers has emerged in a very specific set of disciplines and is not widespread within the system. Furthermore, there is limited published evidence that proportional measurement is a widely-used approach within South African HEIs. Different institutions, and within each institution, different disciplines adopt different measures and targets for salary adjustments and promotion.

Researchers are not autonomous agents as may be asserted by some perspectives of this sector; they are influenced by recognition-for-performance systems in a similar way to that reported for other employees (Bak, 2016; Stephan, 2012). The framework and insights of principal-agent theory are as applicable to the research sector as for other environments and the structure of performance management systems is important in the optimal contribution of researchers to the objectives of their institutions. It is therefore of critical importance that such systems are both fair and well-directed. They must drive the most desirable behaviours and provide an environment which meets the needs of both the researchers and the institutions within which they are employed.

Based on initial information, it was apparent to the panel that the principles of fairness and direction were presently not the case. In the next chapter of this study, the opinions of researchers on the existing system were surveyed in order to inform the panel as to whether and what type of response was required.

CHAPTER 3. STUDY ON THE ATTITUDES OF RESEARCHERS TOWARDS PUBLICATION INCENTIVE: IS PROPORTIONAL COUNTING A FAIR SYSTEM?

3.1 METHODOLOGY OF THE ASSIGNMENT

The survey was undertaken by the SciSTIP as part of a broader study on 'researcher's experiences of academic and scientific authorship in South Africa', with the partial support of ASSAf. Further details are available in Appendix B.

The questions which were included in the survey as part of this project are given in the text box. Full details on the methodology and the conclusions for the broader study will be published separately by SciSTIP (date of publication has not been released).

RESPONDENTS' VIEWS OF PROPORTIONAL REWARDS FOR PUBLICATIONS

Currently in South Africa the DHET administers a system of incentivising and rewarding peer-reviewed publications by university-affiliated authors. One of the key aspects of the system is that the subsidy amounts for a specific publication unit (journal article or book chapter) is proportionally allocated to individual authors (for example, three authors from three different SA universities each qualify for 0.33 of the subsidy amount)

Question	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
The present system of proportional reward is fair and equitable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Proportional reward prevents researchers from co-publishing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Proportional reward is unfair to large collaborations (> 50 co-authors)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3.2 RESPONSES TO THE SURVEY QUESTIONS

3.2.1 Demographics of the Respondents

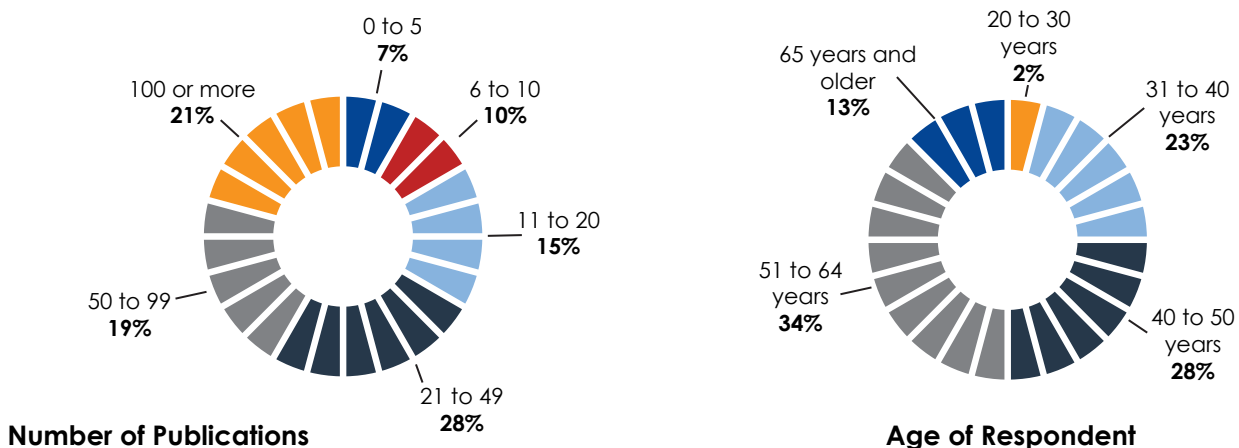
967 responses were obtained from a database of more than 20,000 authors. In general, the profile of respondents appears to reflect a high response from senior level researchers within the universities (few responses were received from science councils or other public institutions, such as the museums). As shown in Figure 15, the gender balance (58% male) was considered to be reasonable in the light of the present demographics of the academic population.

Interestingly, the majority of respondents had more than 20 publications and were more than 40 years old, reflecting a disproportionate commitment to participating in the survey (the older and more experienced academics are more invested in the outcome?) as shown in Figure 16. In other words, responses were received from a cohort of experienced academics with interest in the publication incentive, or perhaps more broadly in the university/science council system.

Figure 15. Gender profile of respondents

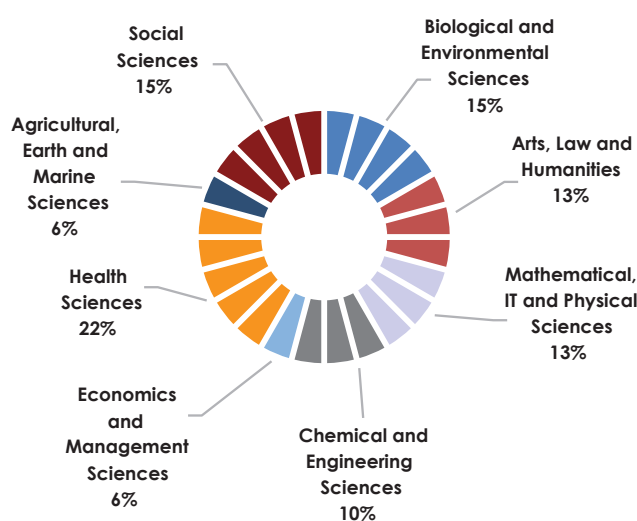


Figure 16. Profile of respondents by age and number of publications



Interestingly, the responses were evenly distributed by discipline or research field, as shown in Figure 17. Due to the large number of reported research fields (67), the data was agglomerated into eight broader categories; the latter categories were based on the conventional faculty structures within universities, with the exception of the category 'Chemical and Engineering Sciences' which covered both chemical sciences and engineering. The reason for not including chemical sciences in the category of 'Mathematical, IT and Physical Sciences' was to isolate a single group where it is understood from the initial literature review that the practice of multiple or large co-authorship is more prevalent.

Figure 17. Profile of respondents by research field



3.2.2 Respondent's Evaluation of the System

In answer to the statement 'the present system of proportional reward is fair and equitable', 79% of the respondents did not disagree with the statement, as shown in Figure 18 (55% agreed or strongly agreed with this statement). This result is somewhat surprising, given the rationale and problem statement for the ASSAf study and the perceived level of dissatisfaction with the present system across the respondents was low). However, some of the respondents who agreed with the statement that the present system is fair, also considered, somewhat contradictory, that the system acts as a barrier to co-publication or is unfair to large collaborations. In order to elucidate in more detail the disciplinary profile of respondents who held such contradictory views, or indeed which disciplines may feel the present system to be unfair, the responses were further analysed.

Figure 18. Response to the statement on 'fair and equitable'

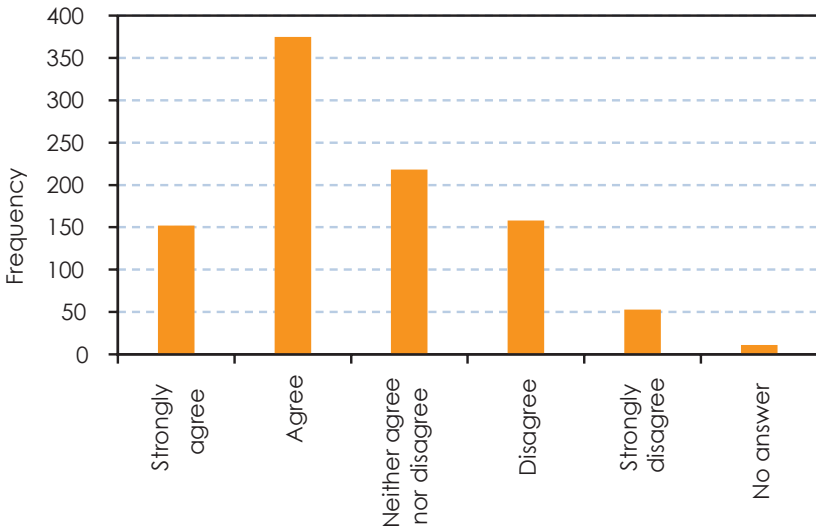
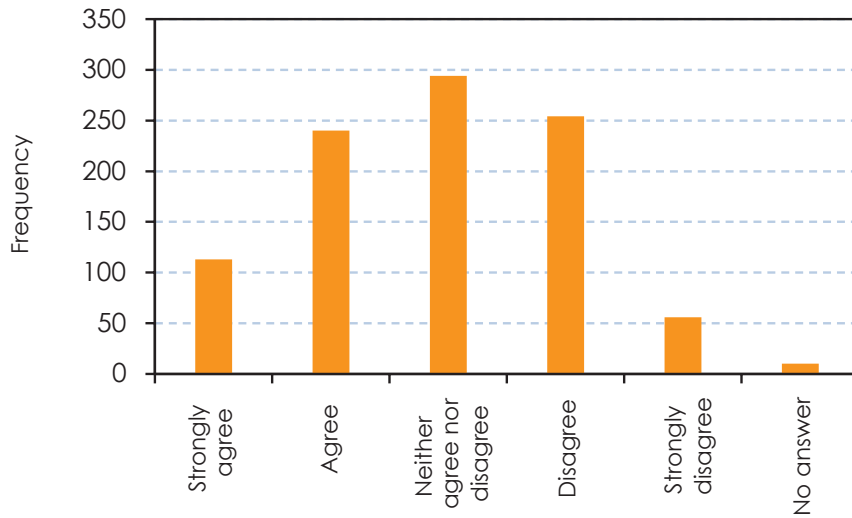
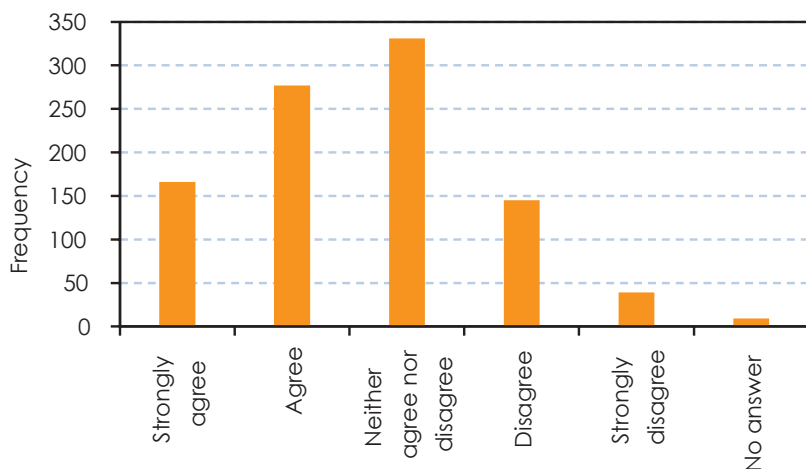


Figure 19. Response to the question on 'barrier to co-publishing'



However, this feedback is contradicted by the responses to the two subsequent questions which asked for input on the two key statements of 'proportional reward prevents researchers from co-publishing' and 'proportional reward unfair to large co-authorships', both of which scored similarly on the Likert scale (average responses 3.1 and 3.4 respectively). In other words, although the respondents consider the present system to be fair and equitable, they recognise or acknowledge that it acts as a barrier to co-publishing and it is unfair to large co-authorships.

Figure 20. Response to the question on impact on 'large collaborations'



In order to resolve this contradiction, a limited amount of cross-tabulation has also been attempted. For instance, it is possible to ask the question of 'if the respondent considers the present system to be fair and equitable', is the same respondent more likely to disagree with the statement that the system acts as a barrier to collaboration and co-authorship. Although there are some trends, these are not clear and consistent. This contradiction is evident even at a segregated level of analysis. For instance, 29% of those who strongly agree or agree with the fairness of the present system (the latter being 55% of the total respondents) also agree with the statement that it prevents authors from co-publishing; similarly, only 64% of those who strongly disagree or disagree with the fairness of the present system (the latter being 22% of total respondents) agree that it is unfair to large collaborations.

These results do suggest, however, that there may be support at the researcher level for changes to the system which could address the barriers to large collaborations. This initial conclusion from the survey could form the basis for the third round of the ASSAf project, covering the semi-structured interviews with DVCs on the main topic of incentives for large collaborations and co-authorships.

3.2.3 Disaggregation by Research Field

In the next part of this analysis, an attempt has been made to understand the contradictory nature of the responses, as outlined in the introduction. The contradiction is apparent, namely that a system which is fair and equitable (answer to Q1) cannot simultaneously not prevent co-authorship (Q2) and be unfair to large collaborations (Q3). Since the initial analysis was completed on the aggregated data, it is possible that the responses are consistent at a disaggregated level; as a consequence, the analysis was repeated based on research field.

The results to the three survey questions are shown in Figure 21, Figure 22 and Figure 23. It is concluded from the figures that there is no confirmation that researchers in the field of 'Mathematical, IT and Physical Sciences' are the most likely to consider the system to be unfair and disadvantageous to multiple co-authorships. Indeed, it is the respondents from the category of 'Health Sciences' who are the most disaffected with the present system, particularly in respect of its fairness to large collaborations (see Figure 24).

Figure 24 is probably the most insightful representation of the data within this phase of the analysis. The analysis was compiled by agglomerating the responses within the Likert categories 'Agree' and 'Strongly Agree' into a single category of 'Agree' and similarly the categories 'Disagree' and 'Strongly Disagree' into 'Disagree'. The figure shows that there is at least some consistency in the responses by research field. For instance, respondents from the Health Sciences have the highest level of dissatisfaction with the present system and agreed most strongly that it was unfair to large collaborations. Similarly, researchers in the category 'Agricultural, Earth and Marine Sciences' have a comparatively high level of disaffection with the fairness of the present system and consider that it prevents co-publication or is unfair to large collaborations.

Figure 21. Responses to 'fair and equitable' by research field (Q1)

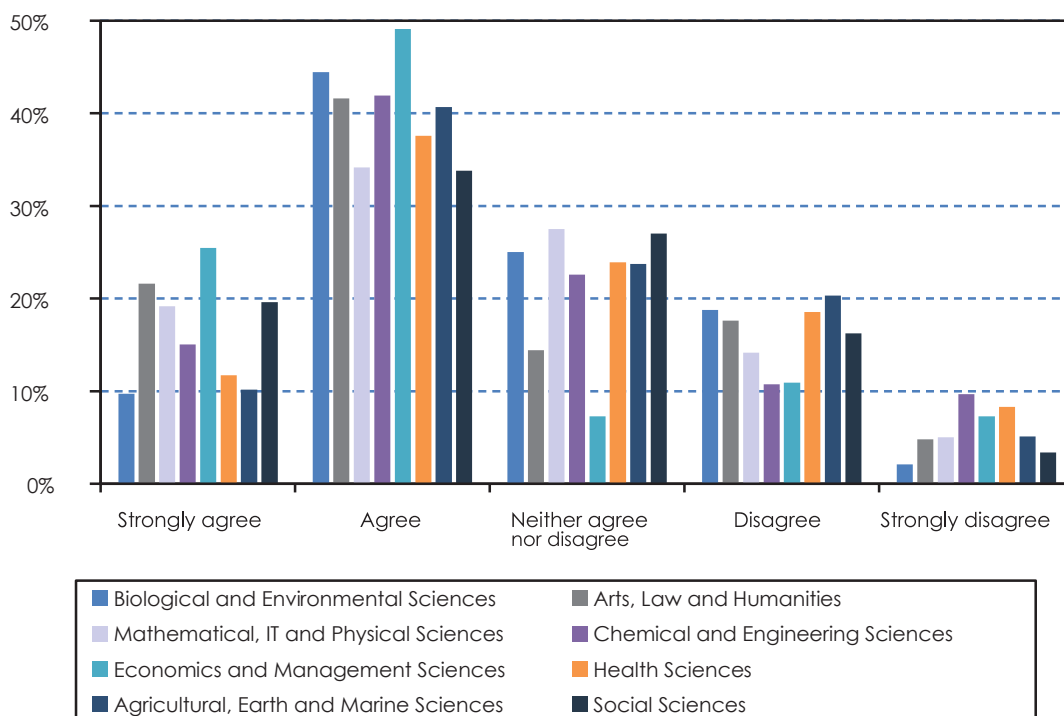


Figure 22. Responses to 'prevents co-publication' by research field (Q2)

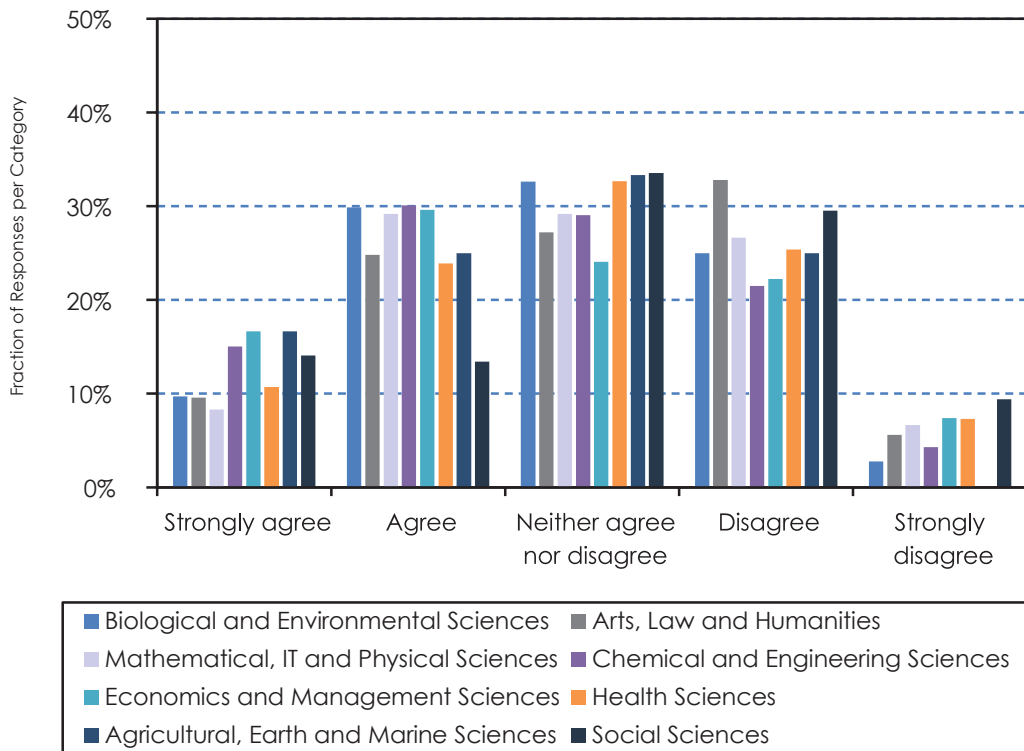


Figure 23. Responses to 'unfair to large collaborations' by research field (Q3)

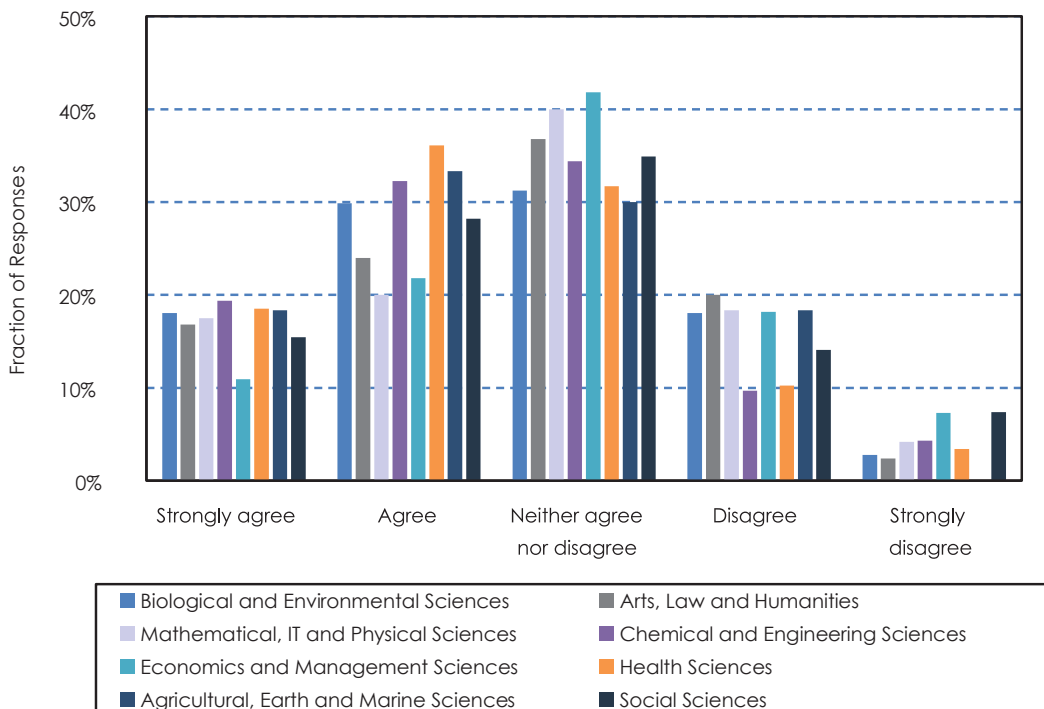
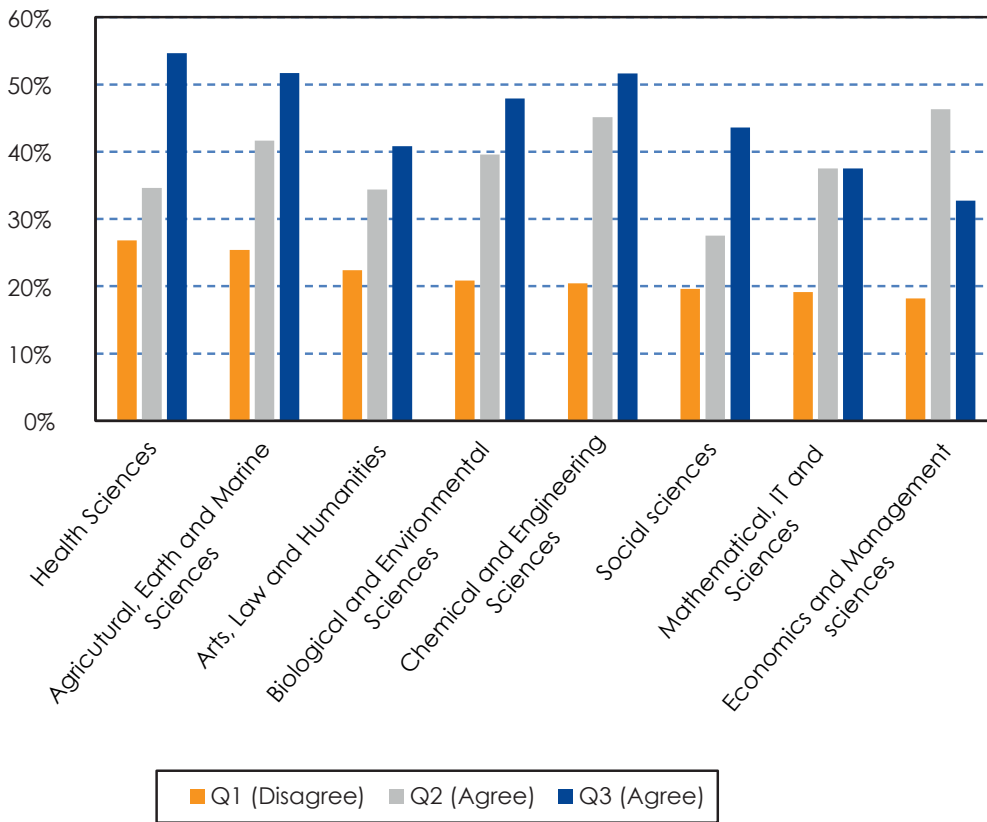


Figure 24. Agglomerated responses to Q1, 2 and 3 by research field

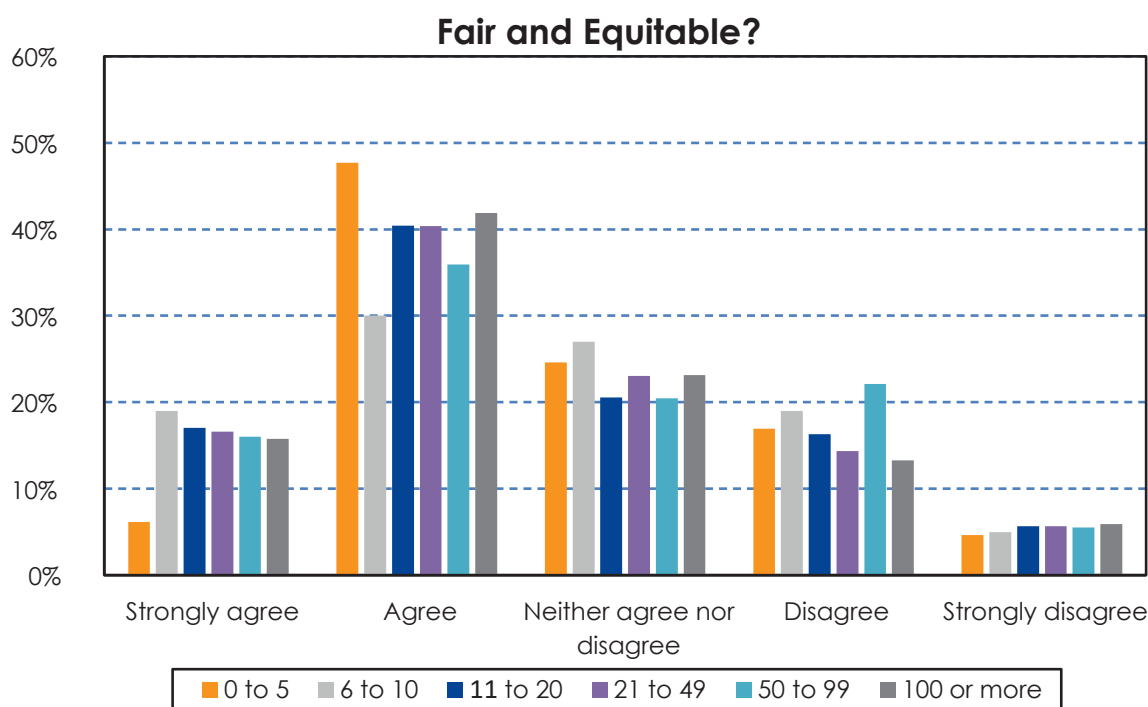


The anomalies in this trend are certainly the categories of 'Mathematical, IT and Physical Sciences' and 'Economics and Management Sciences', where fewer respondents disagree with the statement that the system is fair and do not on the whole agree that it is unfair towards large collaborations. Perceptions about overall system fairness and specific ways in which it acts to disincentivise large collaborations or co-publication are clearly more complex than has been assumed in this survey. Further qualitative work is required to explore these aspects of the system.

3.2.4 Disaggregation by Number of Publications

In the final part of this analysis, the responses were disaggregated according to the number of publications of the respondent. As shown in Figure 24, there is little variation between the different categories, suggesting that level of experience with the system does not determine the perceptions of the respondent in terms of fairness and equity. Similar patterns were noted for the other two key questions of the survey (Q2 and Q3).

Figure 25. Responses to Q1 disaggregated by number of publications



3.3 QUALITATIVE RESPONSES

The survey also provided the opportunity for respondents to comment on the survey and how the system could be changed to address its shortcomings. A sample of these suggestions now follows:

3.3.1 Comments on the Overall System

“The proportional award concept lends itself to cutting out authors that may have contributed to papers, just so that the proportion allocation increases in favour of those authors who have been credited. Other contributors are then relegated to the acknowledgments section.”

“In my practice, all participants add his/her knowledge and work to the project, which is usually interdisciplinary (organic chemist, radiochemist, analytical chemist, veterinarian, PET imager, nuclear physicist), it means everybody must be counted as full member, without any of them the publication cannot be realised. However, it is true that ‘we are publishing in small group, with 6-7 authors as maximum’.”

“Yes. The University runs on this reward and funds research through infrastructure. That is

why I support it. I DO NOT support linking it to the high-end journals because it means fewer publications. I strive to get PhD and MSc to learn how to do research that benefits SOUTH AFRICA so don't like them publishing in European Union (EU) and USA journals that are too expensive for our libraries and academics. The 'high end journals' are only for top end academics who want to get famous, not for those of us who want to do local research to meet the needs of local students and communities and our own country."

"My experience is that the way the DHET subsidy is apportioned has little effect on authorship decisions. I found that individual career building played a more significant role."

"This system affects different disciplines and research groups differently. I have on several occasions been pressured by collaborators to REMOVE STUDENT AUTHORS from the papers in order to increase their personal take. This system incentivises the disenfranchisement of student and postdoctoral researchers who have not yet achieved the professional leverage to fight for their rights!"

"The proportional allocation is not well understood, at least in my University research division. I publish regularly, with a student/s and with overseas collaborators. We only receive an amount according to our proportion of all authors, even though the other authors could be all from foreign institutions."

"I think the whole idea undermines the values that are necessary to maintain scientific integrity and healthy collaborations."

"The proportional system gives the bully academics a licence to continue being bullies. Make them justify their contribution and account for it."

"I know it is a difficult issue, but I still think that it hinders collaboration. Maybe the amount of money per publication can be increased when multiple authors are involved and then proportionally divided. Fact of the matter is, from an incentive point of view, it is better to publish solo, while collaborative research is actually the better way to go from a purely academic viewpoint. On the other hand, collaborative research can lead to more publications, thereby negating the negative effects of smaller incentives."

"Is the present system of proportional reward fair and equitable? This depends on the actual contribution of each author's contribution (concept vs. data collection vs. writing of the article, vs. editing. vs. etc.) to the publication, which is not easy to quantify. Thus, the present system is fair and easy to implement."

“There will never be a system that is completely fair. The current system is simple, transparent and a good incentive to promote research despite it having certain drawbacks. We should be happy that we have such a system.”

“These questions and their answers are not clear cut. 1. A proportional system is fair to an extent – although the primary author (by definition) in many cases will have done a greater proportion of the work. 2. Proportional rewards may prevent co-authoring. However, authorship should not be defined based on monetary reward – monetary reward (as is the case currently) may lead to certain co-authors being added who do not meet the criteria for having contributed. On the other hand, where proportional rewarding results in reduced co-authoring, there may be some contributors who are unfairly excluded from authorship. Ultimately, the authors should all be deserving of authorship, and no contributors who are deserving of authorship should be excluded. This should be the case regardless of financial incentive. 3. In the case of > 50 authors, many (if not most) of these authors have probably not contributed sufficiently to the paper in the first place, to warrant authorship. Therefore, proportional financial reward is the sacrifice that they must make for having a paper with > 50 authors. Ultimately, one manuscript is likely to have the same amount of impact, regardless of the number of authors (if all else e.g. impact factor of the journal, remains equal). Therefore, there is absolutely no reason why there should not be a fixed amount for a paper (e.g. at a set impact factor), regardless of the number of authors.”

“We are encouraged to collaborate with other universities but punished at the same time.”

“Does anyone really deserve an incentive if you are one of 50 co-authors? What on earth could each one have contributed? I am strongly against an author's list that looks like a telephone directory. Otherwise I am happy with proportional reward. It does however influence one in choosing co-authors.”

3.3.2 Comments on Alternative Approaches

“The contributors' effort should be weighed by the contributors and rewards should be given in suitable proportion. This must be agreed on by the authors after the article is published.”

“I think the number of authors does not matter ... what matters is the impact factor.”

“The last question is a bit silly. NO article (ever) should have that many authors. If that is the case then the authors need to have a look at the author guidelines, whichever ones they use. Or perhaps obtain some guidelines, since that many authors could not possibly have contributed equally.”

“Proportional reward should be based on the number of authors and also their contributions”

“As I understand this model is actually part of the funding-model to channel money to universities for training students, one of the reasons it is not extended to science councils. I can see that it can cause pressure as well as substantial acrimony and has vast potential for being unfairly implemented. The only way I see around it would be to stop it entirely and change the funding of Universities.”

“Researchers need to first of all think about the interest of their research before thinking about the monetary rewards. It’s about research, its goals and objectives rather than the rewards.”

“First authors should receive a higher proportion than co-authors.”

“I think researchers should NOT be motivated by incentives. Instead they should be motivated by quality of their research as judged by the impact factor of the journal in which they publish and also acceptability of their work by others (as measured by number of citations). If a large number of authors is necessary to make authors a publication of high impact, with high quality data, then that is fine. Reduced incentive gains per author should not de-motivate the many authors in a single publication.”

“Finally, if the incentive funding value is related to impact factor of the journal, this would likely encourage better papers, that are of a collaborative nature to ensure that they are acceptable in higher impact factor journals. This should also prevent or reduce the incidence of ‘salami slicing’.”

“It does seem as if researchers get penalised for collaborating. I feel there is scope for abuse here, especially in terms of academics removing postgraduates as authors where their data is used. We should be encouraging collaboration, and getting as many young scientists to publish their work as possible. Ironically, changing the system to one where each author is rewarded equally, irrespective of number of authors, will lead to alternative problems, where co-authors are added merely to raise more funds within a research group.”

“I would prefer the incentive system to take quality as well as quantity into account. Use of a sliding scale of rewards, based on journal impact factors (or some similar metric), would seem to be beneficial.”

3.4 CONCLUSION

It has been established using a population-wide survey that although the present system of proportional counting is considered on average to be fair and equitable, it prevents multiple co-authorships and acts as a barrier to large co-authorship.

The analysis has revealed firstly that responses were obtained from a wide range of research fields, indicating that the survey is widely represented across the different disciplines within the universities and public research institutions (national facilities and science councils). Secondly a large proportion (>75%) of the respondents are experienced researchers within the system, having more than 20 publications and being over the age of 40.

Disaggregation of the responses to the three core questions of the study (Q1 – 'Is the system fair and equitable?', Q2 – 'Does proportional reward prevent researchers from co-publishing?' and Q3 – 'Is proportional reward unfair to large collaborations?') indicates that the highest level of disaffection with the present system lies in the Health Sciences, with respondents in this category also agreeing to some extent with Q2 and Q3. In other words, there is a level of internal consistency within this research field.

However, the results for the category 'Mathematical, IT and Physical Sciences' are surprising, with fewer respondents disagreeing with the statement that the system is fair and mostly not considering that it is unfair towards large collaborations. Perceptions about overall system fairness and specific ways in which it acts to disincentivise large collaborations or co-publication are clearly more complex than has been assumed in this survey. Further qualitative work is required to explore these aspects of the system.

Most of the more quantitative results from the survey, as presented in this document, are supported by the qualitative comments which were collected as part of the survey. Some of the respondents have indicated that the present system is simple and fair, whereas others question its integrity and beneficial influence on research outcomes. Alternative suggestions include the incorporation of quality factors on the publication incentive and the weighting of proportional counting based on the individual author's actual contribution. However, it is also clear that the system is inconsistently implemented and that there are varying degrees of understanding in terms of its actual operation. Both issues could be beneficially addressed at institutional level given a willingness to support the research system and the way in which co-authorship patterns are changing.

CHAPTER 4. QUALITATIVE SURVEY ON THE USE OF PROPORTIONAL PUBLICATION COUNTS IN PUBLIC RESEARCH AND HEIS AS A RESEARCH INCENTIVE

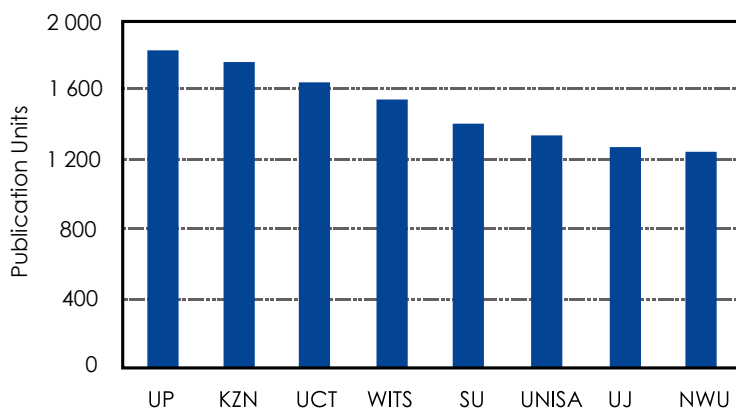
4.1 METHODOLOGY OF THE ASSIGNMENT

4.1.1 Population and Sample

The population for this study is all the South African PRHEIs (universities and research-performing science councils). Since it was impractical for the task team to adopt a comprehensive sampling strategy and interview all the senior research executives in the population, a partly purposive and partly convenience strategy was adopted as follows:

- The HEIs were ranked according to their 2015 publication units (see Figure 26).
- Five of the top eight HEIs were selected for the sample (University of Cape Town (UCT), University of Witwatersrand (Wits), Stellenbosch University (SU), UP, and University of Johannesburg (UJ)).
- Two science councils (the CSIR and the Medical Research Council) and two further HEIs (University of Western Cape (UWC) and Durban University of Technology (DUT)) were added to the list in order to obtain a broader perspective on the core issue of proportional publication counts as a performance or reward measure.

Figure 26. Publication units for South African HEIs (2015)



Source: CHET, 2018

Of this sample, one HEI declined to be interviewed and the interview with UWC was repeated with two different respondents as a consequence of changes at the Executive level. All other interviews were completed as per the schedule.

4.1.2 Data Collection and Analysis

Five of the nine interviews were recorded and transcribed; the remainder were reported in the form of written replies to the questions, in each case completed by the interviewer. Although

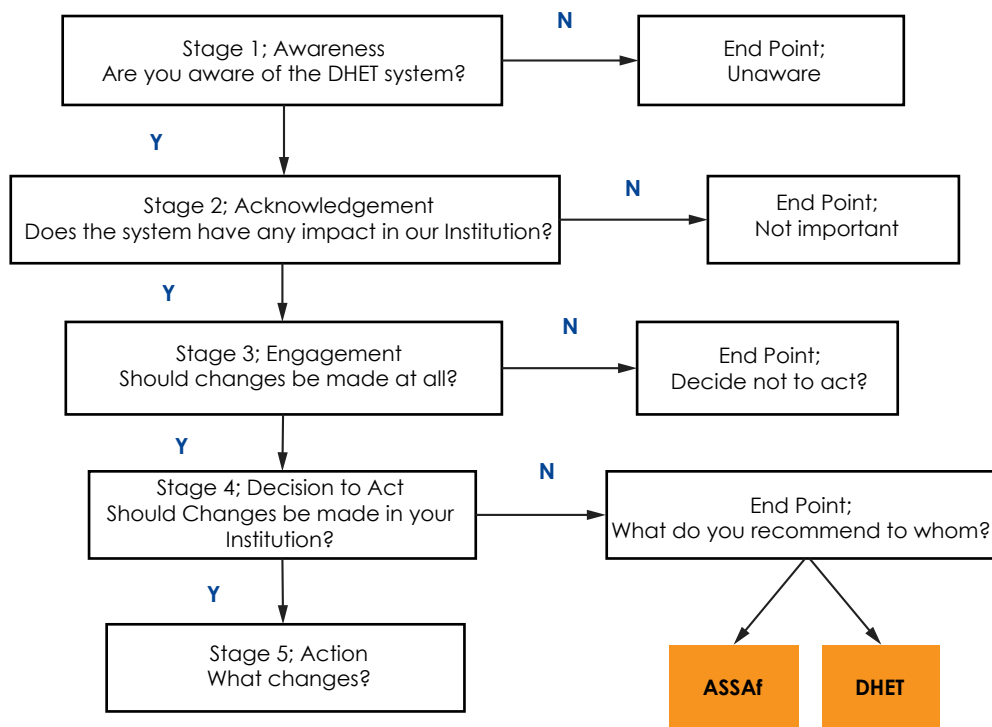
the names and institutional associations of the interviewees were recorded, such details have not been disclosed here and all quotes/discussions of the material have been reported on an anonymous basis, as is standard practice for surveys of this kind.

Once the interviews had been completed, and the transcriptions or written replies had been received, the documents were coded using ATLAS.ti (Friese, 2014), with the codes and the coding structure being pre-specified according to the overall analytical framework for the study, as described in the following section.

4.1.3 Analytical Framework

The analytical framework for this study was informed by two separate perspectives. In the first instance, the study used a modified version of the Precaution Adoption Process Model which was originally developed as a cognitive behavioural model to describe the process from awareness to action (Weinstein et al., 2008). The modified version, as developed for this study, defines five distinct stages as shown in Figure 27, and refers specifically to the question of whether and how institutions should respond to the impact of the DHET system, and particularly its use of proportional counting, on the recognition of researchers who publish their work within articles with large numbers of co-authors.

Figure 27. Stages of the Precaution Adoption Model

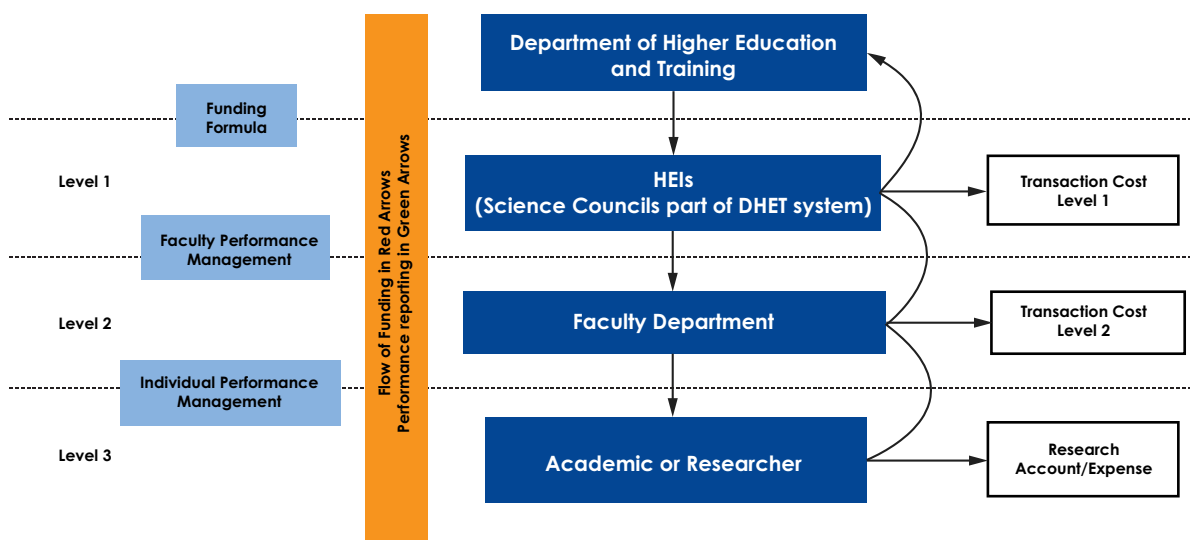


Source: Adapted from Weinstein et al, 2008

Secondly, the framework separated the analysis of performance management, and its associated impact on funding, into two distinct levels, namely the institutional and the individual levels (see Figure 28). This separation was critical as a means of understanding the reason that the institutional-level framework is applied at the level of the individual and the extent or depth of this application.

The use of publication counts as a metric of both institutional and individual performance measurement, and particular proportional counting, also referred to as publication equivalents, starts with the DHET but cascades to all levels within the HEIs. It is applied as a means of calculating the annual DHET transfers to individual universities through its funding formula (Level 1 in Figure 28); it is adopted in some cases as a means of assessing faculty performance (Level 2 in Figure 28); and it is widely applied as a metric for the performance measurement and management of individual academics/researchers (Level 3 in Figure 28).

Figure 28. Institutional and individual performance management/funding system for HEIs



Although it may be relevant, it is noted that in this study there has been little focus on the practices of Level 2; all of the discussion in the document relates to Levels 1 and 3 only. The aggregation of Levels 1 and 2 from the perspective of the researcher means that some information in terms of the diversity of performance management within PRHEIs has been lost. However, this decision has been necessary in order to allow the study to focus on its main objective, namely how the present system of proportional counting may disincentivise collaboration and co-authorship in large teams.

The relationship between the analytical frameworks, the questions and the coding structure

is shown in Table 4. The questions and the codes were grouped according to the stages of the precaution adoption model (Weinstein et al., 2008) and the transcripts were then coded according to the code descriptors as indicated in this table. Although the approach seems somewhat contrived, the structure has been useful in consolidating all the responses within their relevant sections within what is essentially a complex network of performance management/ incentive instruments and employee hierarchies within institutions. The results of the analysis are presented in the next section.

Table 4. Structure of coding with examples of questions

Code Group	Code Descriptor as Applied	Level of Application	Directly Relevant to Co-Authorship	Example of Question (ex-Questionnaire)
Awareness and Implementation	Distribution	1, 2 and 3	N	Is the monetary award attached to publication counts, as received by your institution as part of the DHET funding, retained at a central level, or devolved to faculties, departments, individual research accounts and researchers?
	Examples of Utilisation of Central Funds	1, 2 and 3	N	
	Diversity	2	N	Do different faculties within your university adopt different practices in terms of the monetary award? If so, please give two examples of the approaches.
	Performance Management	3	N	Is the system of publication counts, as defined by the DHET framework, used as a means of performance management within your university, either at a faculty level, or department level, or the level of the individual academic?
	Strategic Goals	1	N	
	Operational Management	1	N	Is the metric irrelevant to the operational management within your university, other than as a means of calculating the DHET grant?
	Examples of Implementation	2	N	

Code Group	Code Descriptor as Applied	Level of Application	Directly Relevant to Co-Authorship	Example of Question (ex-Questionnaire)
Acknowledgement and General Perception	Overall Support of System	1	N	
	General Perception on DHET System	1		Open code
	Impact on Output	2 and 3	N	In your opinion, does the system of publication counts and hence proportional counting enhance the research output of the university?
	Misappropriation	3	N	Are you aware of misappropriation by individual academics, as claimed recently by Muller (2017)? If so, how common is this practice.
	Fair and Equitable	2 and 3	Y	What do you think of the approach of proportional counting?
	Treatment of Proportionality	3	Y	
	Proportionality and Promotion	3	Y	Is proportionality considered as important in selection and promotion
Acknowledge and Collaboration – Specific Perception	Barrier to Collaboration	1, 2 and 3	Y	What are your perceptions of the DHET system as it is applied to universities, with specific reference to the case of large collaborations and co-authorship (>50 authors)?
	Barrier Justifiable	1, 2 and 3	Y	
	Large Collaboration Other Benefits	1, 2 and 3	Y	Open code
	Barrier @ Level 3	3	Y	If the DHET approach of proportional counting is applied at the level of individual performance management within your university or institution, do you consider it to be disadvantageous to such collaborations?
	Barrier @ Level 4	3	Y	
	Need to System Response	1	Y	If so, do you think this is a problem of sufficient importance that it needs a system-level response?

Code Group	Code Descriptor as Applied	Level of Application	Directly Relevant to Co-Authorship	Example of Question (ex-Questionnaire)
Engagement and Action	Can it be Changed?	0	Y	Could the system of proportional accounting be changed to provide greater recognition to large collaborations?
	Recommendation DHET	0	Y	What recommendations should be made to the DHET?
	Recommendation ASSAf	0	Y	What do you recommend to ASSAf in terms of the study's objectives?
	Changes Being Considered?	1	Y	Is the university considering any changes to the way in which the system has been implemented?
	Example of Changes Being Considered	1	N	If so, how will it be changed?

4.2 RESPONSES TO THE QUESTIONNAIRE

4.2.1 Awareness and Implementation

Based on their replies in the interview, all the respondents were aware of the two important issues being discussed, namely the use of proportional counting as a means of increasing research outputs, and its specific application to large co-authorships. Furthermore, their current practices with respect to these two issues reflect broad implementation of the DHET funding formula.

In further assessing the institution-specific variants for publication incentive, the study considered the aspects of distribution (the extent to which DHET funding for publication units is retained centrally or distributed to faculty or individuals); diversity (differences in the way in which faculties manage the proportion allocated to them); whether proportional publication counts were used for performance management; and finally, whether this metric was used in strategic/operational management.

The responses to these questions are now reported.

4.2.2 Distribution

All HEIs in the sample retain at least a portion of the DHET funding centrally whilst distributing the remainder to faculties and individual researchers. Practices in terms of the quantum or proportion of funding retained centrally and the proportion distributed to faculty and individuals vary widely across institutions. In the extreme, one institution retains as much as 90% of the funding received centrally, whereas at the other extreme up to 50% is distributed to faculties and individual researchers.

With one exception, funding distributed to individual researchers is paid to their research accounts. In the exceptional case, some of the funding allocated to individual academics can be earned as taxable income with the aim of incentivising progress towards the institution's strategic goals to "increase the number of NRF-rated researchers and research publication outputs, with particular reference to those published in high impact international journals, those produced in collaboration with distinguished international researchers, and research publications that are generated via Masters and Doctoral studies". In this case the proportion that can be earned as taxable income rises in proportion to the standing of the researcher (in terms of their NRF rating) and the standing of the journal in which an article was published.

Where funding is allocated to individual academics, the proportionality inherent in the DHET system cascades to the individual academics. Academics are therefore allocated a portion of the funding received equal to the funding divided by the number of authors in accordance with the DHET system. One respondent indicated that where students are co-authors their component would be allocated to the supervisor's research account. This aspect was not specifically surveyed but presumably similar arrangements exist at other institutions.

Science councils do not receive funding from DHET for publication counts and hence there is no distribution of funding in the sense that this is done at HEIs. However, in one of the two science councils surveyed, the DHET publication count system is used at several levels in the organisation and for several purposes as part of the operational management of the institution. In this case the system has an impact on the parliamentary grant allocation to units within the science council and is a factor in the promotion and remuneration of individual researchers. The effect of proportionality within these measures is mixed, with some measures such as career ladders being counted proportionally and others being independent of the number of authors.

4.2.3 Use of Proportional Count in Performance Management

It appears that the proportional counts are widely used as a means of incentivising scholarly publications. In six of the institutions, this metric explicitly forms part of the reward structure for individual academics. In the remaining cases the institutions either do not have an explicit performance management system, or the institution's emphasis is on 'performance development' rather than performance management, or a publication count of some form is used but not exactly according to the DHET formula.

In terms of the more nuanced aspects of implementation, several respondents indicated the importance of quality, as measured by impact, over quantity in academic publishing.

"The emphasis is much more on the quality of the product than the number. So, none of our promotion criteria for example in the academic space, none of that is based on the number of units or the number of the publications."

And:

"We do count publications but, as mentioned already, we focus on impact and not simply on the number of publications."

The respondents emphasised that their institutions avoided allowing the publication count to drive quantity over quality and employed various mechanisms to guard against this possibility including peer review of quality and the use of impact factors such as the h-Index. One of the respondents sounded a warning of the potential unintended consequences of implementing publication count as a major incentive in a mechanistic manner:

"I mean if we had to like 50% going into the pocket of someone, that would change the behaviour of people and I think negatively because they start to cut their papers up slice them, put them into any kind of journal, etc."

4.2.4 Strategic and Operational Management

In contrast to the view that funding flowing to individuals was too small to significantly alter publishing behaviour, the total magnitude of funding received by the institution through the DHET system can be substantial. Its impact on strategic and operational management of the institution

can therefore be significant and it is seen as crucial to the financial viability of HEIs. The funding that is retained centrally is utilised in varied and unique ways and it has become an important funding source as indicated by the following responses:

“They understand that that money that’s in the main budget contributes to our first and second stream income which eventually then pays their salaries and balances the books of the university. There is this one way in which the university actually gets their money.”

“It is important for the following: If we have, say for argument sake, a certain percentage of our staff that never publishes, it’s a problem, because every academic actually has, in very hard terms, has an economic value. Now they have to earn twice their own salary in a year. The only way they can do that, is to publish papers, to graduate Masters and PhD students, and to lecture at an undergraduate level. It would very difficult if you look at the (funding formula) to earn your salary just purely based on undergraduate teaching.”

Consistent with the earlier discussion on proportional count in performance management, funding retained centrally is used to promote research output and quality:

“Some percentage of the money goes to what we call the incentive fund, which is divided into the international conferences where you as a researcher can apply every second year to attend an international conference and we pay for your flight and registration.”

And:

“We have a research incentive system.”

Centrally retained DHET funding is applied to support the publication process:

“Then we also have a category where we allocate page fees, some of the money goes to, so that we pay for page fees in these journals that cost lots of dollars these days, so we cover that in terms of the authors.”

And to support emerging researchers:

“We have what we are calling start-up funds for researchers where they can apply for the R30,000 to be able to start their research.”

4.3 GENERAL PERCEPTIONS

In addition to reviewing implementation practices, the general perception of the DHET publication count was surveyed. In terms of overall support of the system only a minority of respondents expressed a negative perception of the system overall.

4.3.1 *Impact on Research Output*

The respondents' view on whether the system impacted positively or negatively on research output was mixed. One respondent stated that:

“It does enhance the system in South Africa. I think it has played an important role in lifting science in South Africa, and specifically scientific output as measured by peer review papers. There is no doubt, all the figures show that. So that's a good thing.”

And:

“When the system was introduced it had its value in terms of making sure that at least all institutions were getting some portion of this pie.”

On the other hand, some respondents felt that the magnitude of the funding to individual researchers had become so small that it was less likely to be a significant factor in driving publishing behaviour.

“And ... the academics A-rated, B-rated scientists and so on, don't even care about that 10%, nothing. What they want to do is they want to build their CV. ... And the way to build that reputation is do it with good quality publications, simple as that. What I do think should happen to... you know at the DHET level, would be to reduce the list of the journals that they actually subsidise.”

The majority were, however, of the view that the system had a positive impact on research output.

4.3.2 *Misappropriation*

Misappropriation does not appear to be a major concern amongst the respondents. Although most respondents indicated awareness of the issue, the checks on this are best illustrated by the

following response which indicates that the system is self-correcting: “Well they will... that fine, because the only thing that will happen is, they will damage their own reputation. ...the system sorts itself out. They will realise that they will not get promoted, they will realise that those papers don't get cited and in the long run, they are actually undermining their own careers.”

4.3.3 Fairness and Equitability

The majority of respondents had some concerns about the fairness and equitability of the current systems. Concerns regarding this aspect were not consistent across respondents with different respondents emphasising different issues.

For instance, respondents pointed out that:

“It is not a fair system which is why we largely do not use it.”

And:

“It is not fair and equitable where senior staff are included in the list of authors where they have made minimal contributions, especially in comparison with young staff.”

Whereas another emphasised that:

“You would have noticed as the publication outputs of the Higher Education Sectors increase, the money per unit has dropped. Because the financial pool has not increased, a number of units has increased, so the numerator has remained, remained the same, the denominator increased, so the fraction has dropped.”

And:

“See it from the perspective of the researchers. ... here I am doing this work all on my own, within the South African environment and I produce this piece of work and half of this work has been done by somebody else in another part of the world, it is not a South African, not working within the challenging environment in which you are working. Yet you are rewarding him (for) his collaboration, this component is unfair to me.”

4.3.4 Treatment of Proportionality vis-a-vis Promotion

Proportionality has negative consequences for researchers in terms of disbursement of DHET as “the bigger the amount of authors the less credit you get”. It appears that the HEIs accept this consequence in terms of funding to academics but are more sanguine or cautious when it is used for promotion. In this case, the respondents consistently indicated that proportionality would not disadvantage researchers who published a high number of publications annually but accrued low or zero publication units due to the high number of co-authors.

One respondent stated that:

“Such an academic would not be frowned upon or ignored, especially if involved in international collaborations.”

Institutions took a broader view when evaluating the research component of an academic's performance for promotion purposes:

“The number of collaborations and the journal impact factors of publications would be used: for example, a 1000 author paper in Science cannot be ignored. Individuals are asked to convey these cases in their Performance Evaluations.”

Impact was raised as an important consideration:

“We would be impressed by his or her h-index. We would not be bothered if the scientist got very little credit, but we would be impressed if the journal had a high impact factor and the scientist was first or last author.”

4.4 PERCEPTION OF THE IMPACT OF PROPORTIONAL COUNTING ON COLLABORATION

The impact of proportional counting on collaboration was assessed in terms of its consequences at the individual level as well as at the institutional level. On balance, proportional counting is seen as a barrier to participation in large collaborations as seen from these responses:

“It is counterproductive because if you use that [indistinct] by just dividing by the number they see it is, you know, if we work in this group of 10 you will get less.”

“Some may ask why they should work so hard to prove their contribution [**and this may be regarded as a barrier].”

However, a more nuanced view provided by some of the respondents indicates that in practice the apparent barrier to collaboration resulting from the reduced direct financial incentive is tempered by other considerations:

"...even though the proportion counting is kind of countering the collaborative effect, on the other hand it still brings in money into the institution that allows for, in our case, our context, broader use of the money, if you hear what I am saying. Because that R120 000 or whatever proportion that comes in, even though you are not publishing per se, or you do publish, you get your R12 000 but me, I can still apply."

"It would seem so. If our scientists didn't collaborate because of the funding implications, that would be a negative. The science has to be more important than the money".

An interesting institutional response to the disincentive to participation in large collaborations is provided by the following response:

"So what we did we collected them and we made sure that we knew who those authors, who the authors were and we internally publicised them and we say well done and we have a research recognition day and we make sure that we recognise those authors and we gave them certificates and what not. So, we wanted to make it clear that it was not, it did not count for DHET, so we forgot about it and we still made sure that they are very important because that collaboration, that Atlas collaboration is brilliant. I mean we have got a group of physicists that are really making a difference. They, you know they were part of the Higgs boson discovery and they are part of the Medela discovery that is about, they are about to announce shortly and what not. So, it has brought huge kudos and it has attracted people from around the world.

You know, so it has attracted people from around the world and it has enhanced our students' capabilities because they have been exposed to these international people and the DHET has done nothing to support them. So, you know that is a shame in itself."

In summary it appears that despite the lack of DHET incentive for participation in large collaboration, researchers are increasingly taking part in such collaborations for other reasons. Institutions are responding to the problem by ensuring that participants in large collaborations are not disadvantaged in terms of their career development and at least in some cases their effort is celebrated in different ways.

4.5 NEED AND RECOMMENDATIONS FOR CHANGES

There was a mixed response on the need for change, with some respondents indicating that changes were imminent and others stating that “we do not use DHET system, so no big changes needed”. With specific reference to the large co-authorship issue, it was noted that “they are few and far between those papers” and as a result, there was no need to develop a specific set of guidelines.

There was also some concern about the possible impact of any changes on the present beneficiaries with one respondent noting that “if the system were to be changed and money would be taken away from people, there would need to be a focus on why that is being done”.

For those respondents for whom changes were considered necessary, their recommendations were addressed at the two levels of own-institution and the DHET. With respect to own-institution, minimal changes are being considered which leads to the conclusion that generally the leadership of the PRHEs consider that although the problem statement may be valid, it is not of sufficient impact to induce the need for their action.

However, a number of recommendations were made in terms of how the DHET system itself could be changed. Many of the interviewees were disparaging of the proxy nature of proportional publication counts as a means of measuring research outputs, as already noted in Section 4.2.1 (“the DHET should adopt a system that is more nuanced; the current system is a blunt instrument that does not reward talent”), but acknowledged that metrics are generally a compromise between ease of application and accuracy. The declining value of the DHET funding per publication unit, as a result of static budgets and rising publication outputs, was also considered a drawback, since it was restricting the ability of HEIs to fund the incentive scheme.

In view of these difficulties, the interviewees made a number of suggestions for improvements to the system as follows:

- There should be more funding for publications in high-impact journals, rather than treating all publications as equal.
- Alternatively, there should be a smaller and more refined list of DHET-approved journals, which would lead to publications in high impact journals only being recognised. This change would introduce an element of quality control in the DHET grant and could help to reduce publications in predatory journals. It will also reduce the total number of publication units which are claimed by all the HEIs, hence maintaining some consistency in the monetary value of the DHET grant per publication unit, and by implication, the value of the disbursed publication incentive.

- The publication unit should be weighted according to author-agreed levels of contribution to the research and hence the final publication.
- The monetary value attached to a publication unit should be kept above a minimum value, either by reducing the number of qualifying units or by increasing the total DHET grant. One respondent noted that “the one other thing that the DHET should consider doing is to go to (National) Treasury and ask for more money”.
- The calculation of proportionality for the DHET publication unit should be based on the number of South African authors only, not authors from international or non-qualifying institutions.
- The proposed funding allocations under the university capacity development grant should include a significant allocation for direct incentives to encourage collaboration with local HEIs (this recommendation is discussed in more detail in Section 4.6.1).
- Institutions should consider other means of rewarding the work and contribution of a large research team, such as issuing special publications and media statements as may be warranted at the time of their discoveries.

Table 5. Institutional guidelines for payment of publication incentive

	UCT	UJ	DUT	UWC	SU	WITS	Explanation
Single author from RSA university		See Note 3			10% of DHET amount per PU	R10,000 or R20,000 (see Note 2)	
Multiple authors from same institution	Divide by Nx	Divide by Nx		Divide by Nx	Divide by Nx	Divide by Nx	Nx Authors from University X
Multiple authors from different eligible institutions					Divide by N where $N = (N_x + N_y)$	Divide by N where $N = (N_x + N_y)$	Nx Authors from University X, Ny from University Y
Multiple authors including authors from ineligible institutions (such as science council or international)					Divide by N where $N = (N_x + N_y + N_{sc} + N_f)$	Divide by N where $N = (N_x + N_y)$	Nx Author from X, Nsc from SC and Nf from overseas
Multiple authors from same institution where some are students or postdocs		See Note 1			?	All authors treated equally	N Authors affiliated to X but Ns are students

1. Supervisor receives 50% of the payment due to the student or postdoctoral fellow.
2. Amount depends on whether the journal is WoS and/or IBSS listed (R20K) or not (R10K).
3. UJ is the only institution of this cohort in which individuals are able to receive part of the incentive as taxable income.

4.6 DISCUSSION

The main objective of this study has been to review South Africa's systems for recognising individual contributions to publications with more than 50 co-authors, and hence provide a basis for an evidence-based approach to such recognition. As part of the study, it has been necessary to review the overall systems for incentivising collaboration and academic publications, since these frameworks form the basis on which large co-authorships are recognised. In the following sections, the results of the study in respect of the publication incentive and the impact on large collaborations, are discussed.

4.6.1 Overall System for Incentivising Scholarly Publications

Although there is some diversity of approaches within the PRHEIs, the dominant approach to publication incentives is the use of proportional publication counts as defined by the DHET Research Outputs policy (DHET, 2015). The approach adopts a number of common principles, as follows:

- i. It recognises that the research output component of the DHET block grant is a significant and important income stream for the HEIs; for this reason alone, but also for other reasons such as the international ranking of universities, it is in the interests of HEIs to incentivise scholarly publications.
- ii. It also recognises that although publication output is a ubiquitous measure of academic output, whether at the level of the individual (such as professor, lecturer, researcher or head of department) or the institution (PHREI), it is a weak and inadequate measure of academic excellence and should be used with caution as a means of performance management or assessing prospects for promotion. In particular, it lacks the appropriate consideration of quality.
- iii. The common international publication metric, which is often used for institutional benchmarking, is the average number of publications per FTE employee, the value for which varies considerably (from 0.2 to 3) (Bunting et al., 2017). However, within the population of this study (South African PRHEIs), the standard approach is the DHET metric of publication units, which includes various types of publication (such as books, book chapters and journal articles) and is adjusted for the number of authors; the latter adjustment is referred to as proportional counting (DHET, 2015).
- iv. In order to incentivise scholarly publication, authors of articles in peer-reviewed journals and other DHET-approved publication types receive into their research accounts a publication incentive or reward in proportion to the number of authors and the institution's agreed value per single unit, where the latter ranges from R10,000 to R20,000 per unit (see Table 5).

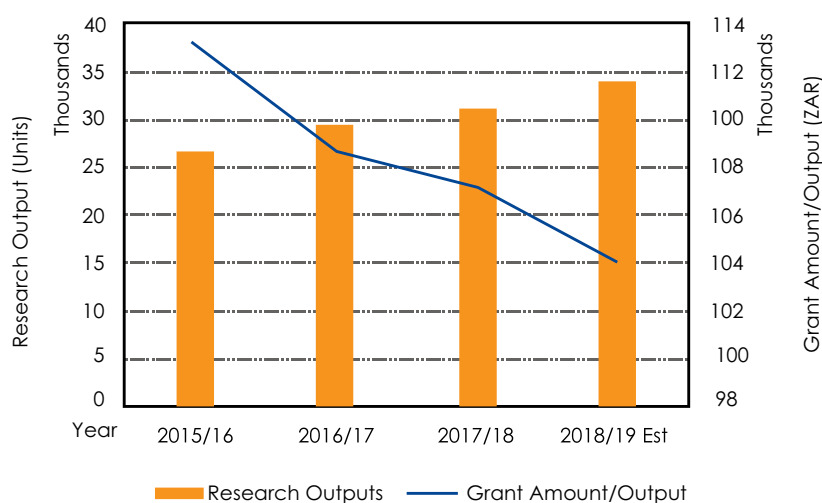
- v. As a general rule, the incentive is not paid directly to the author(s) as taxable income (only one out of all the PRHEIs surveyed in this study allowed such payment and it is reported that the DHET does not support such disbursements due to the consequent abuse of its system (Mouton, 2017; Tomaselli, 2017).

This study has not specifically looked at the question of whether the system of publication incentives achieves its intended outcome, namely, to increase the quantity, and perhaps the quality, of scholarly publications. Its continued existence and operation suggests, however, that it is effective and is at least partly responsible for the growth in publication outputs over the last two decades (Mouton, 2017).

Despite this positive impact, it is clear that there are two emerging and persistent difficulties for the incentives, namely that the available funding pool is decreasing and that it fails to adequately recognise quality.

In terms of the overall funding pool, it is noted that payments to the HEIs from DHET for research outputs, which are used as the basis for the publication incentive, have declined as shown in Figure 29. Furthermore, on average only about 10% of these funds are paid into the research accounts, with the result that the publication incentive is considered by the respondents to have a relatively small impact on behaviour and is a minor contributor to the overall research costs, being limited to partial payment only for an item such as the attendance of an overseas conference. As a result, its ongoing basis as an incentive, already minimal, is further declining.

Figure 29. Research outputs and grant value per output (2015/16 to 2017/18)



Source: Minister of Higher Education and Training (2016)

The quality issue, clearly important, remains unresolved although a number of recommendations are given in Section 4.5. These HEI Executives are favouring the approach whereby they tolerate the existing system, including the issue of proportionality, when disbursing funds to authors. They appear however to feel it is not fair that the funding to the institutions and the individual authors is reduced through authors that are not eligible for DHET funding (international collaborators or authors at science councils etc.) and made some proposals on how this should be handled, as discussed in Section 4.5.

The institutions also ensure that academics are not disadvantaged by proportionality when evaluating them for promotion. They do this by taking a broader view considering factors such as the standing of the journal in which the publication appeared, the prestige associated with working in these large collaborations and the impact of the publications produced in this manner.

Finally, it is noted that the respondents did not consider that misappropriation of the incentive through the present systems was a problem and required system-wide response.

4.6.2 Impact on Large Collaborations

Based on the responses in the study, this group of DVCs considered that a decision by an individual researcher to collaborate comes before a decision on co-authorship, given that the publication incentive is a small amount relative to the benefits of large collaborations, where the latter includes large-scale funding for research projects, international prestige and access to broader resources.

In other words, this group considered that drivers for collaboration overwhelm the negative impact of the dilution of any publication incentive. Such drivers include building the national or international reputation of the university and the researcher, securing research funding, especially funding, which is designed to develop partnerships, accessing expensive research equipment and diversifying the skills of research teams.

4.7 CONCLUSION

The central problem statement of this study, namely the limited recognition of collaborative work for individual researchers within the framework of the DHET system of proportional counting, has been difficult to resolve in this study. There is no general agreement within either cohort, as surveyed in this chapter and in Chapter 3, on its solution, or indeed whether one is even necessary. It is possible, however, to make a number of general comments and recommendations based on the survey results as follows (all of which reflect the views of the sample only):

Comments

- Based on the views of the respondents and acknowledging that this may not be a general or widespread perspective, it is maintained that the present DHET system, and its institutional equivalents, has little impact on collaboration; the latter has a separate set of drivers which overwhelm any negative impact of the publication incentive (such as funding and prestige).
- The respondents in the study believe that there is minimal misappropriation of the institutional-level systems.

Recommendations (from the respondents)

- Performance management should not use publication counts unless these are mediated by other indicators that include the quality aspects of academic outputs.
- In order not to dilute the positive impact of the DHET system on publication outputs, the value of the research output grant per unit should be kept above a minimum level.

CHAPTER 5. RESULTS OF SIMULATION STUDIES ON ALTERNATIVE ALGORITHMS FOR THE CALCULATION OF PUBLICATION UNITS

5.1 BACKGROUND

HEIs in South Africa receive grant funding from the DHET based on a formula which includes the number of publication units. The present formula scales the total number of academic publications in proportion to the number of authors per publication, resulting in the total publication unit being about 60% to 80% of the total number of actual publications (see Chapter 2). The relevant figures, including the level of funding, are shown in Table 6. The funding amounts have been estimated based on the reported values for funding per publication unit (Pather, 2014) and the reported publication units (CHET, 2018).

Table 6. Summary of existing funding of selected HEIs for research publications (2016)

Institution	Existing Funding (ZAR)	Total Publications	Total Publication Units
Total System	1,593,259,650	18,875	15,060
University A	183,820,073	3,256	1,737
University B	141,330,963	2,134	1,336
University C	6,777,352	75	64

Source: This study and Pather (2014) for funding, CHET for publication units, CREST for total publications

This DHET approach, referred to as proportional counting, has a number of weaknesses including two concerns of the panel, namely that the system discourages collaboration and fails to recognise the contribution of individuals within large research teams (>100 authors). As a result, six alternative models were proposed by the panel. The algorithms for each model are now discussed, preceded by a brief summary of the existing DHET system, and followed by the results of a simulation in which the impact of each model on the DHET funding for 'typical institutions' was determined. The latter analysis is then concluded with a discussion of the broader consequences should the respective models be adopted by the DHET.

5.1.1 Present DHET System

The present DHET system (DHET, 2015, para 5.7) requires that a research article published in an approved journal is subsidised as a single unit. In the case where authors are affiliated with two or more institutions, the subsidy is shared between the claiming institutions. Institutions submit audited subsidy claims for research outputs appearing in the approved journals.

The guidelines also state that “fractions of units must be expressed in decimal form and must be rounded off to the second decimal place, for example 12.45” (DHET, 2015 para 5.21(e)). Although the practices of each institution may differ, it appears that this rule has been interpreted as truncating the units for each publication before computing the total number of units. In other words, the system is based on proportional counting up to 100 authors and then defaults to zero. The mathematical formulation is:

$$\text{For all } X \leq 100 \quad PU = \sum_{i=1}^N \frac{P_i}{X}$$

$$\text{For } X > 100 \quad PU = 0$$

where:

PU = publication units (per author or institution)

X = number of authors

P_i = publication unit for publication i (usually 0.5, 1 or 5 depending on the type of publication)

The linear scaling is apparent from the formula. The simulation work has attempted to calculate the total publication units, both at an aggregated level (all the HEIs) and at the level of individual institutions, using the data obtained from CREST but has been unsuccessful in obtaining a close match. Problems with the level of detail required for this exercise, and the detail which has been made available, are discussed in Section 5.

5.1.2 Proposal 1: Modified Korean Model

The Korean model, as previously listed in Chapter 2 has been modified in order to provide a more realistic alternative. The revised formulation is as follows:

$$\text{For } X = 1 \quad PU = \sum_{i=1}^N P_i$$

$$\text{For } X \leq 10 \quad PU = \sum_{i=1}^N \frac{P_i}{X} * (1 + E) * (1 - e^{-X})$$

$$\text{For } X \geq 10 \quad PU = \sum_{i=1}^N \frac{P_i}{X_i} * (1 + E)$$

where:

E = assumed level of enhancement (40% to 80%)

5.1.3 Proposal 2: Mesnard Model

The Mesnard model was designed to allow for greater recognition of collaboration and is an enhanced system of non-proportional counting. The mathematical formulation of the model is shown in the equation below; further details are in Chapter 2 and the ASSAf briefing document (ASSAf, 2016).

$$PU = \sum_{i=1}^N P_i \frac{(X + 2)}{3X}$$

5.1.4 Proposal 3: Modified DHET

Proposal 3 follows the standard DHET algorithm with the exception that publications with the number of co-authors greater than 100 are divided by the total number of South African authors (authors affiliated to South African institution) and not the total number of authors.

The relevant equation is as follows:

$$\text{For } X \leq 100 \quad PU = \sum_{i=1}^N \frac{P_i}{X}$$

$$\text{For } X > 100 \quad PU = \sum_{i=1}^N \frac{P_i}{Y}$$

where:

Y = number of authors affiliated to South African institutions

5.1.5 Proposal 4: Minimum Units with Upper Bound

Proposal 4 covers the concept of a single (article) publication earning at least 0.01 publication units with an upper bound for the total number of publication units per author. It has been motivated on the basis that it would ensure that authors on large publications are seen by their peers as contributing to the scientific effort of the collaboration adequately but are not 'over-rewarded'.

The mathematical formulation of the model is as follows (for all X):

$$\text{For an individual author: } PU = \text{Min} \left(UB_i, \sum_{i=1}^N \text{Max} \left(0.01, \frac{P_i}{X} \right) \right)$$

where:

UB_i = upper bound for publication units per author on publications with more than 100 authors

The effect of various UB_i values on the calculation of publication units is minimal, as discussed in Section 5.4. The base case value is taken as 2 publication units per author.

5.1.6 Proposal 5: Modified Arithmetic Sequence

Proposal 5 is the simplest of the ASSAf alternatives. The scheme proposes that the system should be changed by removing the limit of 100 authors, and then converting to the nearest integer after adding all the publication units at the institutional level. In mathematical terms this would mean:

$$\text{For all X } PU = \sum_{i=1}^N \frac{P_i}{X}$$

5.1.7 Proposal 6: Contribution Matrix

The approach of the contribution matrix has been outlined in Section 2.6.2; this method was considered in the case of articles with more than 100 co-authors. The panel concluded that although such a matrix could be appropriate for small numbers of co-authors, it would be impractical for large numbers and was therefore not recommended for further modelling or implementation.

5.2 METHODOLOGY OF THE SIMULATION

The consequences of the adoption of the alternative models has been assessed by developing institutional-level frequency data for the years 1996 and 2016. The choice of the two years was based on firstly the selection of the year for which the most recent and complete dataset was available (2016), and secondly the year a decade earlier (1996). The idea of two years was to get an idea of the trend in the consequences and enable a forward prediction, although as it turns out, this was not very useful.

Since the frequency data had to be manually generated, it was not possible to include all HEIs; the selected institutions, together with the reasons for the selection, are shown in Table 7.

Table 7. HEIs selected for inclusion in the modelling study

Institution	No. of Publications (2016)	Proportion of Total Publications > 100 Co-Authors (2016)	Reason for Selection
University A	3,256	5%	Large number of annual publications; higher than average proportion of the total publications with > 100 co-authors
University B	2,134	1%	Large number of annual publications; small proportion of the total publications with > 100 co-authors
University C	75	0%	Small number of annual publications; small proportion of the total publications with > 100 co-authors
Total HEI Publications	18,875	3%	

The simulation proceeded as follows:

- re-layered and reorganised the CREST data so as to allow institutional-level analysis;
- developed histograms showing number of publication units for bands of number of authors (say 0 to 5, 5 to 20, 20 to 50, etc.) for up to ten institutions;
- calculated the impact of the changes as per the five models.

The main difficulty with the analysis has been to separate affiliation from authorship, since some authors have multiple affiliations. In general, this distinction has been ignored but it has led to some issues with the data and inaccuracies in the final result. Other problems have been:

- The CREST data for institutions covers research articles and not all the publications such as books, conference proceedings and reviews.
- The CREST data does not distinguish between conference publications, books and book chapters, all of which are assigned different weightings within the DHET system.
- The CREST data for total publications does not include data for HEIs only.
- The data has not allowed calculation of the numbers of authors per publication, separate from the calculation of the number of institutions. In other words, the CREST data could not be used to calculate the number of authors per local institution. As a result, a set of average numbers, as shown in Table 8, was applied.

Table 8. Assumed average number of authors per South African institution as a function of X

Number of Authors/ Paper (X)	Assumed Number of SA Affiliated Authors/Paper	Assumed Average Number of SA Affiliated Authors/SA Institution
1	1	1
2	2	1
5	3	1
10	6	2
20	8	3
50	10	4
100	15	5
500	20	5
1,000	25	5

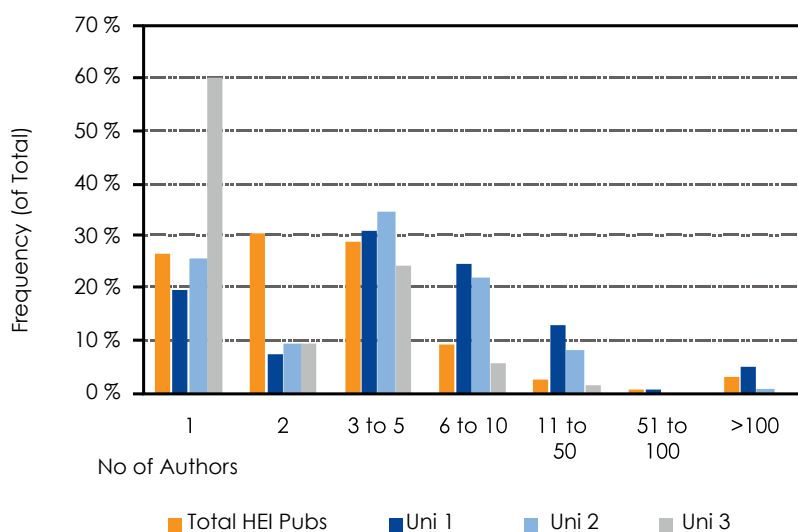
5.3 DATA SOURCES

5.3.1 Institutional Data

Data for the institutional-level histograms were obtained from the CREST database (Mouton, 2017). The downloaded dataset covered the headings publication year, article number, number of authors, flag for multi-institution affiliation (true or false) and listing of affiliated institutions (South African institutions only).

The data was processed as previously outlined and used to generate the histograms for University A, University B and University C, as shown in Figure 30. Surprisingly, the average level of collaboration is high across the whole system, with the result that the average number of authors per paper did not differ as widely as was expected between the total system and the individual HEIs, with the exception of CUT for which the prevalence of single-author papers was indeed much higher.

Figure 30. Institutional-level histograms (co-authorship frequency vs. number of authors)



5.3.2 Baseline System Data

Baseline data, covering funding, performance and outputs of the present system including total publications and publication unit numbers for the assessment period, were extracted from an updated version of the CREST data, as used in the initial phase of this project, from the Centre for Higher Education Transformation (CHET) database (CHET, 2018) and for the value of a publication unit from the published data of Pather (2014). The actual values are listed in Table 9.

Table 9. Annual outputs and funding of publication units

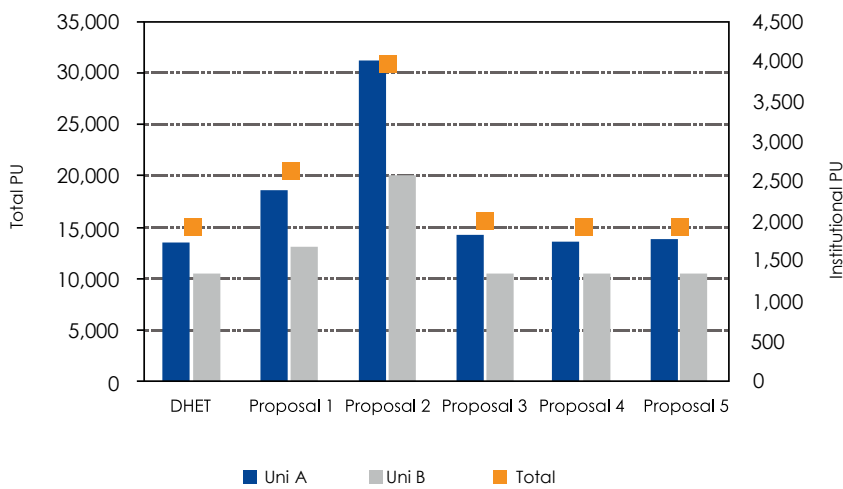
Publication Year	Total Articles	Estimated HEI Publications	HEI Publication Units	Grant Amount (ZAR/PU)
2006	11,401	8,390	8,086	
2007	13,016	9,578	7,751	
2008	14,604	10,747	8,352	
2009	16,247	11,956	9,109	
2010	18,228	13,414	9,748	
2011	20,728	15,254	11,191	127,638
2012	21,974	16,171	12,364	115,052
2013	24,203	17,811	14,009	114,545
2014	26,343	19,386	15,542	113,975
2015	25,492	18,759	15,040 ^e	113,183
2016	26,092	19,201	15,394 ^e	108,691
2017				107,221
2018 (est)				103,979

Source: Pather, 2014, CREST and CHET

5.4 RESULTS OF THE SIMULATION

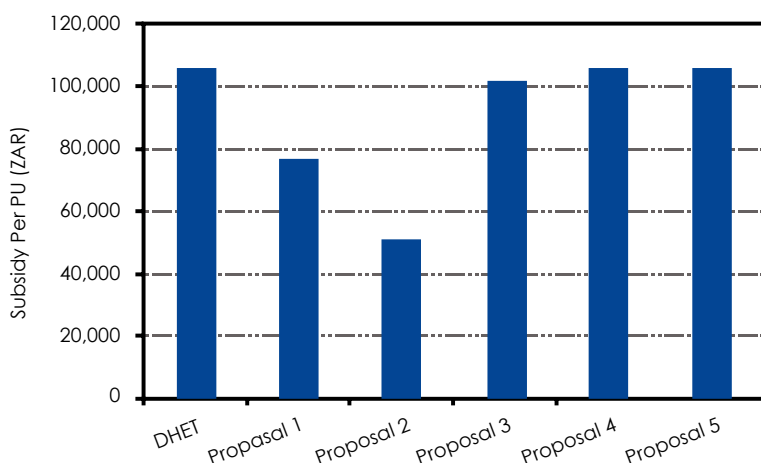
The models result in changes to the total (system) publication units, and as a consequence, adjustments to the value of each publication unit, as shown in Figure 31. The baseline value per publication unit, based on the DHET algorithm, was calculated at R105,797 per unit; this value was then adjusted for each alternative model, and the revised value used to calculate changes to the institutional funding. Fractional changes (equivalent to the actual change in proportion to the original DHET allocation) were then calculated and are shown in Figure 33.

Figure 31. Impact of different models on total and HEI publication units



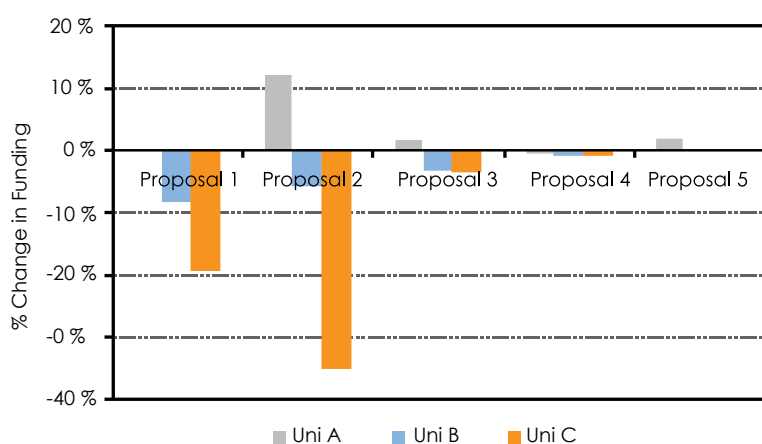
The total publication unit count is only very slightly increased for Proposals 3, 4 and 5 (< 0.5%), with the increase being due to the inclusion of publications in the unit counting where the number of authors exceed 100. Heavier weightings for collaborative publications, as used for Proposal 1 (Modified Korean Model) and Proposal 2 (Mesnard Model), significantly increase the total publication unit count (by 36% and 104% respectively), and hence decrease the value of each publication unit, as shown in Figure 32.

Figure 32. Value of a single publication unit for each scheme (ZAR/unit)



The implication of these changes on the overall level of funding for the HEIs within the DHET funding category which supports publication outputs depends similarly on the calculated publication units per institution. As expected, Proposal 5 (inclusion of publication units for all articles regardless of number of authors) makes little difference to the funding allocations, as shown in Figure 33 and Table 10. Of the test institutions, only the University A would receive increased funding (2%), since, as noted in Table 7, this institution has an above-average frequency of co-authored publications where the number of authors exceeds 100.

Figure 33. Fractional (%) changes to funding allocations to HEIs arising from publication outputs



Similarly, Proposal 3 (where publication units for articles with number of co-authors greater than 100 are calculated by dividing the number of publications by the number of South African authors only) and 4 (where all articles would receive at least 0.01 of a publication unit subject to an upper bound of 2 units per author), make little difference to the overall funding levels, with the exception of University A where the amount is slightly increased in the case of Proposal 3. The effect of varying levels in the upper bound was tested and shown to have little overall impact, which is not unsurprising that the number of publications with more than 100 authors is still small (<3%) compared to the total number of publications.

Table 10. Results of simulation on total publication units and funding levels

Institution	Alternative Proposal				
	Proposal 1	Proposal 2	Proposal 3	Proposal 4	Proposal 5
University A	1%	13%	2%	-0.44%	2%
University B	-6%	-4%	-3%	-0.85%	0%
University C	-1%	-1%	-3%	-0.89%	0%

In contrast to the other proposals, the algorithms of the Modified Korean (Proposal 1) and the Mesnard Model (Proposal 2), both of which use a non-proportional approach designed to reward collaboration and not discount large co-authorships, provide interesting results. In both cases, the University A, which has an above-average level of co-authorship, would receive higher levels of funding, whereas Universities B and C would be penalised (in the case of University B by the amounts of -6% and -4% respectively for the two models). This result is consistent with the publication profile of each institution. University B has a lower than average level of co-authorship, and hence would receive a lower proportion of the DHET subsidy for publication outputs.

5.5 CONCLUSION

In this study, the consequence of five alternative algorithms for the calculation of numbers of publication units per institution have been assessed. Using frequency data for number of publications per year within five predetermined categories of number of authors per publication (1; 2; 2 to 5; 6 to 10; 11 to 50; 51 to 100; and >100), it has been shown that variants on proportional counting which include articles for which the number of authors exceeds 100, has little impact on the level of funding for individual HEIs, with the predicted changes being less than $\pm 2\%$, even for the most prolific institutions.

The result is not surprising given that the proportion of articles in the highest category (>100 authors) is less than 3% of the total HEI output. As a result, the difference in the total publication units between the two approaches (inclusion or exclusion of the highest category) is less than 0.02%. The impact on individual scores could be more important, since single researchers with a high output (>50) of multi-author publications could move from a publication unit count of zero to 0.5.

The consequences of the two systems for non-proportional counting (Modified Korean and Mesnard) are more significant. In the case of the Korean model, where the algorithm is adjusted to reward co-authorship through two measures, firstly an enhancement factor for all co-authored publications and secondly an exponential factor for the calculation of publication units which does not decay to zero but is instead constant for publications with greater than 10 authors, the benefit to highly collaborative organisations is small (1 to 2%). On the other hand, the penalty to non-collaborative organisations, as measured by a low proportion of multi-authored articles is large (10% to 20%). For instance, University A, as an example of a highly collaborative HEI, would receive 1% more income whereas funding for University C would drop by 19%.

The consequences of the Mesnard system would be similar in direction but more pronounced since the funding for co-authored articles is more generous than the Modified Korean approach. For instance, under this system, the figures for University A and University C are +13% and -35% respectively.

CHAPTER 6. FINAL CONCLUSIONS AND RECOMMENDATIONS

The object of this consensus report was to investigate how the contributions of individuals engaged in large scale (>100) collaborative research projects are currently recognised and whether this should be revised. This was undertaken with specific reference to the research output funding mechanism in place in the South African HEIs. Recognition of research output by individuals is often measured using the number of research publications or publication units. The last decade has seen an increase in the number of authors on individual publications, both in terms of the total number per publication as well as the average number of authors. This is true internationally, as well as in South Africa. However, the increase in the number of co-authors has a disadvantageous effect on the number of publication units that is assigned to an individual author or academic.

In South Africa, the DHET allocates research funding to tertiary educational institutions based on a formula which includes proportional co-authorship as one input variable. Thus, universities have been incentivised to increase their publication output. Unfortunately, this proportional publication unit calculation has also been used by some HEIs to incentivise faculties and departments to increase the publication output of their staff. The consequence of this approach is that in some cases this has also encouraged individual authors to increase the publication units that they produce, by sometimes publishing greater numbers of less substantial articles, or submitting to journals that are perceived to be less rigorous in their peer-review processes.

Performance management in the HEI environment is fraught with challenges. There is the contested terrain of management approaches developed in the private sector that are considered to be inappropriate for the career development of knowledge workers whose time horizons span extended periods of time. Academics are career professionals who are independently motivated and self-driven. Moreover, their outputs are not usually measurable in linear terms and the nature of outputs from different disciplines vary dramatically. However, universities are funded largely from public funding and need to account, and be accountable, for this support. Additionally, the availability of objective measures of performance to help managers evaluate whether academics are succeeding in their current roles, and which can be used as promotion criteria is desirable as part of a formal performance management system.

One of the easier outputs to measure when evaluating academic performance is the number of publications that an academic has published. As is the case with any metric, merely counting the number of publications is simplistic; this number is dependent both on the nature of the discipline and on the form of the output. Other aspects, can be contentious such as the specific contribution of the author to the publication where there is multiple authorship. The use of the proportional publication unit approach, which is applied by the DHET, is a simple mechanism for distributing funding among institutions, but has deficiencies when it is used in performance appraisal systems of individuals.

The occurrence of hyperauthorship is challenging the use of existing performance appraisal systems and requires the revision of such systems in the interests of what could be described as 'performance justice', which can be loosely defined as the principle that two academics who achieve equally, but work in different disciplines, should be equally rewarded or acknowledged. The impact of the widely-used DHET- 'publication units'-based approach to performance appraisal is well illustrated by a comparison of the publication outputs from two academics, the one working in the engineering field, and the other in particle physics. The 'average' professor could be expected to generate five to ten publications per year, equivalent to 2 to 5 publication units. However, a physicist working within several large research teams might (co-) author 50 to 100 publications per year, which will be measured as zero publication units (publications with more than 100 co-authors are rounded to zero). It is apparent, in these circumstances that the proportional counting metric is misleading.

The study included an initial literature review, followed by two surveys, covering firstly the attitudes of some researchers to the publication incentive and secondly the views of university executives. In the first survey, the opinions were mixed, with some respondents indicating that the present system is simple and fair, and others questioning its integrity and beneficial influence on research outcomes. Alternative suggestions include the incorporation of quality factors on the publication incentive and the weighting of proportional counting based on the individual author's actual contribution. However, it is also clear that the system is inconsistently implemented and that there are varying degrees of understanding in terms of its actual operation. Both issues could be beneficially addressed at institutional level given a willingness to support the research system and the way in which co-authorship patterns are changing.

In the second survey, the respondents (senior university management) considered that the present DHET system, and its institutional equivalents, have little impact on collaboration; the latter has a separate set of drivers which overrides any negative impact of the publication incentive (such as funding and prestige). The respondents also suggest that there is minimal misappropriation of the institutional-level systems.

Recommendations (from the respondents) suggested that performance management should not use publication counts unless these are mediated by other indicators that include the quality aspects of academic outputs. In order not to dilute the positive impact of the DHET system on publication outputs, the value of the research output grant per unit should also be kept above a minimum level.

The conclusions of these two chapters, while self-explanatory, need further comment. It is clear that there is a system of proportional counting in relation to multiple authorship that determines publication units for an HEI in South Africa. It is also clear that there is an incentive linked to these outputs that encourages institutions to increase their outputs, but that the way in which individual institutions cascade or devolve this system to individual academics varies across the country. Although there are cases in which publication units are used for performance management, the executives confirmed the criteria used for promotion were not only based on publication units. Indeed, the DHET Research Outputs Policy of 2015 advises institutions to be cautious of directly incentivising individual authors⁹.

Overall, researchers in South Africa understand that the system is not ideal, but clear proposals for an alternative approach did not emerge in this study. The present situation is that authors who publish with many co-authors are allocated either no publication units or small fractions of a publication unit at best. Thus, the system appears to discourage collaboration and co-authorship. A number of recommendations for alternatives were suggested by various respondents during the study. The authors of this report decided to provide some simulations of these alternatives using South African data, since well-intentioned suggestions may fail if they are implemented with no testing. In this way, the impact of using a different system could be explored in order to determine its impact on the funding to different types of institutions. We note that these are not the only possible alternatives that could be used. The intention was not to be exhaustive, but to illustrate the impact that some of the suggestions might have, and to encourage simulation and pilot testing should alternatives be considered. The recommended approach results in recognition of multi-author publications that are not currently included in institutional or individual publication unit counts. Authors are then able to list these publications as earning publication units. However, these publications do not significantly disturb the current stability or predictability of the system, both of which are traits valued by the representatives of senior management interviewed.

RECOMMENDATIONS

A. Recommendations to HEIs on their Treatment of Individuals

1. There needs to be a greater awareness within HEIs of the 'bimodal distribution' in the numbers of co-authors (Fig. 7, p 24), particularly in the case of disciplines such as physics, genomics, medicine and statistics, where large numbers of co-authors are becoming more prevalent.
2. In the disciplines identified in 1, the appraisal of an individual's performance must take cognisance of these developments.
3. The DHET publication unit system should not be used as a metric to measure the publication output of individuals for the reasons articulated in the San Francisco DORA (see appendix D).

⁹Research Outputs Policy 2015, Government Gazette, Republic of South Africa, Vol. 597, Number 38552, 11 March 2015, paragraph 3.1

4. The use of the publication unit system is a poor proxy for the assessment of research productivity and should not be used in the selection and promotion of academics.

B. Recommendations to the DHET on its Funding and Performance Management Relationship with Institutions

1. The DHET formula for allocation of units should be modified to include publications with in excess of 100 co-authors. The funding formula is suggested in Proposal 5, p 79.
2. The funding per publication unit should be increased. Its real value has fallen as a result of inflation and as a function of the doubling of the number of recognised units produced (see Fig. 3, p 20). The incentive has been effective in achieving its intended outcome, but a larger allocation of funds is required in order to maintain a constant real value per publication unit to continue the successful trend.

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APPENDICES

A. TERMS OF REFERENCE FOR THE EXPERT PANEL

COLLABORATIVE RESEARCH IN SOUTH AFRICA: how to evaluate and recognise contributions of individuals

Aim

The aim of this proposed study is to provide a guiding framework for a multidisciplinary investigation of ways in which collaborative research can be appropriately recognised and rewarded in South Africa.

Introduction

Usage of term

This document primarily addresses multiple authorship of research papers. The general term 'collaboration', in research, can refer to the work done towards a common aim by a group of individuals, or by a number of research groups or institutions, or work performed across disciplines or between countries, or any combination of these. While illustrations of some of these are given below and the term 'collaboration' is used to describe them, the central problem in this document is concerned with papers with more than one author and particularly with those with more than ten or a hundred authors.

The term 'collaboration' is also used in a specific sense to mean 'a set of authors of a paper', both in this document and in general scientific usage. As an example, the 'ATLAS Collaboration' appears in the author list of papers on the ATLAS experiment at CERN. The number of author names is 2932 on an example; the number of institutions of affiliation listed on this paper is 178.

International changes

A change in the nature of collaboration is taking place in the environment of intellectual endeavour and may be observed at present in the natural sciences, information sciences, social and health sciences. The problems now being tackled are so complex that they often require the contributions of individuals from a range of disciplines and skills in order to make progress. International funding and research networks (NIH, EU, CERN, HGP) have recognised the need to bring people together and combine resources since many of the research projects undertaken at present are just too big for one country to finance.

Notwithstanding the role of small groups or single authors and researcher-driven publication, the nature of big collaboration has changed dramatically over the last decade and the nature of the

way in which participation in these projects is recognised needs to be considered. International funding mechanisms encourage collaboration, and, in many cases, are explicitly designed to ensure that it takes place.

South African response

This international change has been recognised in South Africa, and both the government Departments of Higher Education and Training, and Science and Technology in conjunction with the research community are responding to it. Collaborative projects are becoming more significant and we need to consider how best to advise funding agencies, researchers, research institutions, and decision-makers on the way in which these projects and their participants should be evaluated and rewarded.

This project aims to review the mechanisms used internationally to evaluate the output of collaborative research, and then make recommendations on how to evaluate the output of collaborative research and propose a guiding framework for an evaluation scheme in the SA context.

Evaluation is a concern

There are growing indications that new thinking on evaluation is required in several fields in South Africa. These include physics, where, for example, formal recognition of South African participants in the discovery of the Higgs boson was difficult or absent, and a sound foundation for collaborative authorship of research outputs from SKA is needed; the biomedical sciences, where recognising the role of data scientists, statisticians, and downstream data analysis is difficult in huge consortia despite the provisions made by journals for statements on contributory roles; and fields where there is at present an absence of recognition for the critical roles of supporting scientists, engineers, and technicians.

Given the role of collaboration as a catalyst for innovation, it is important to review our systems for recognising individual contributions to high quality collaborative research, and more important, to provide a basis for informed decision-making in the future, keeping in mind possible unintended consequences.

Problem Statement

The scientific community has identified some key challenges associated with participation in large projects.

Evaluation for career advancement

The need for individual evaluation is increasing rather than decreasing. Many universities are now using the DHET Publication Unit metric when considering promotions, grading of research performance of staff, hiring of new staff and the shaping of internal policy regarding research directions. The DHET metric does not recognise papers with more than 100 authors. The impact of policy decisions based on this metric is of urgent concern and one of the consequences is that staff involved in hyperauthorships may choose to leave and work elsewhere.

The adoption of the DHET metric for University purposes is, of course, a matter internal to the institutions concerned. However, it is inescapable that the current incentive scheme devalues the contributions made to collaborative projects. The consequences include a lack of recognition for scientific contributions, with a direct impact on promotion and career advancement, and on career decisions on participation in large projects where recognition of contributions is problematic. To give a specific example from astronomy, in the ten large Meerkat survey projects which have of the order of 100 scientists participating at a time, the current DHET Incentive Scheme would not recognise individual, or institutional, contributions. However, these contributions to the knowledge outcomes of the projects would need to be assessed.

Conflicting drivers

There is significant variation in the way in which universities make decisions regarding the importance and impact of the research outputs from, and the role of employees in, collaborative research. This can be accentuated in the context of limited resources at the research office level and may be further influenced by simultaneously striving to increase the quality and quantity of research output. The tension between encouragement to collaborate through megaprojects, and discouragement through institutional policy, needs resolution.

An understanding of the way in which individuals participating in collaborative projects can be rewarded may assist with providing recommendations that help institutions to address these dilemmas.

Incentive funding

In environments where incentive funding per se is important, resources are not provided to those who participate in projects with numerous authors. This concern is reduced or negligible in well-funded groups but may inhibit individuals from being able to establish independent careers.

The major questions

In terms of evaluation of individuals, the underlying problem of finding fair, transparent, viable mechanisms for recognising individual contributions to complex collaborations in South Africa should be addressed.

One aspect to be considered is an observed shift from fundamental science pursued in discrete disciplines (Mode 1) towards the convening of multidisciplinary teams to solve applied problems (Mode 2). A basic tenet of the study should be that aspects of current evaluations and incentive schemes that do currently work successfully for large scale collaborative projects should not be discarded; excellent science is being accomplished by individuals or in teams smaller than the big collaborations that are the source of concern; and this shift does not affect all fields of scholarship or all disciplines equally. A second major aspect is the discrepancy between disciplines in terms of bibliometrics, and this should be considered in the study as well; for example, publishing practices and indices are very different in engineering from those in the biosciences. Therefore, the help of sociologists of science may be needed. A requirement for the study is that it should be informed by similar studies in South Africa, notably the ongoing CREST study. The recommendations of the study should be aimed at creating a workable consensus in a contentious field.

This study as a foundation for the future

A study of this nature is timely given the number of big projects and global consortia that South Africa is participating in or coordinating. The Academy is well placed to review the way in which participants in large collaborative projects are recognised and rewarded. Based on an analysis of this information the study would make recommendations regarding the way that these matters should be treated in the future.

The local academic community needs to develop appropriate methodologies and metrics to recognise individuals within collaborative research projects. The study that is proposed here will result in a set of recommendations that could be generally applicable to large-scale collaborative projects.

Target groups

The study is intended to primarily benefit researchers, policymakers, research funders, research institutions, higher education institutions and the research system. The outcomes of the study will provide policymakers and funders with recommendations and guidelines for implementing policies that will promote, support and encourage excellence in research particularly excellence in collaborative research while at the same time providing appropriate recognition for the participating individuals. Researchers and research institutions will benefit from the opportunities and acknowledgement of the importance of collaborations.

Possible key questions for investigation:

- What defines a collaboration, and what roles are played in such a collaborative research project?
- Identify other, or similar studies currently being conducted in South Africa i.e. CREST, and how it could provide evidence for this project?
- Identify the extent of collaborations nationally and internationally and their impact?
- Investigate the role of an individual's research contribution to a collaborative project to national funding decisions versus international practices?
- Establish nature of incentives, type of research funded, policies underpinning incentivised funding, and recipients of such funding?
- Establish effectiveness of the incentive schemes used?
 - » Has incentivisation increased quantity and quality of output?
 - » Has incentivisation strengthened the importance of collaborative research?
- Investigate any unintended consequences of the incentive schemes used.
- Propose solutions to the problems identified.

Methodology

The Study panel guided by its Chairperson will be able to select appropriate methodologies to address the brief provided by the ASSAf Council, as described in the relevant Guidelines. These will include:

- i. Hiring researchers to address sub-topics and help provide draft sections of the Report;
- ii. Interviewing key individuals and stakeholders with oral and/or written input;
- iii. Holding public workshops with invited speakers and/or panel discussions;
- iv. Holding Panel workshops to debate and resolve particular questions and issues
- v. Delegating initial analysis of topics of the Study to individual members or sub-groups of the Panel; and
- vi. Any other ways of working towards a proper understanding of the evidence and information that can help to complete the Study.

Deliverables

The main output of the proposed study is an authoritative, peer reviewed, evidence-based ASSAf Report published in the public domain and presented to all stakeholders.

The Academy will also assist in disseminating the outcomes of the report to all stakeholders to promote the uptake of the recommendations, through a formal launch of the report, face-to-face meetings with key stakeholders and using of media and Internet platforms.

B. APPENDIX FOR CHAPTER 2: DETAILS OF THE SCISTIP SURVEY

Overview

An investigation of researcher's experiences of academic and scientific authorship in South Africa

Disputes on authorship are common across fields and may concern not only who is to be named (e.g. issues related to ghost authorship and honorary authorship), but also the sequence in which the authors should be listed. The goal of this study is to investigate South African researchers' understanding and experiences of authorship ethics and the impact of research incentives on publication behaviour and authorship ethics. There are three phases to addressing this goal. The first phase focuses on direct and indirect research incentives and rewards to researchers in South Africa and its possible impact on authorship practices. The second phase investigates researchers' understanding of issues related to academic and scientific authorship, including their perceived ability to implement authorship principles in an academic work environment, and possible challenges encountered with, and perspectives on, publication incentives. The third phase sets out to unpack researchers' perceptions of publication incentives, authorship principles, and related politics of capacity building in academia, including issues of redress.

The knowledge generated from the data may help us to better understand how researchers think about academic and scientific authorship; their perceived ability to implement recognised guidelines for authorship within a context that promotes research integrity and responsible conduct; and the nature, or impact on publication behaviour and authorship practices, of incentive schemes in universities and research institutions. We are interested not only in normative views on this issue, but also in experiences of disputes and difficulties in making decisions about authorship, and responses to publication incentives. The question of authorship is an important ethical one, and affects people's careers, as a publication list is one of the most significant measures of academic and scientific performance.

Covering Letter

Dear Prof/Dr/Mr/Ms

You are hereby invited to take part in a survey of how researchers experience academic and scientific authorship practices, and the incentives and rewards linked to authorship. This study is conducted by the Academy of Science of South Africa (ASSAf) and the DST/NRF Centre of

Excellence in Scientometrics and Science, Technology and Innovation Policy (SciSTIP). For more information about the project, click [here](#).

We are sending this request to all scientists and scholars in South Africa who have published peer-reviewed scholarly articles, books, book chapters and/or conference proceedings since 2005.

We are quite aware of the demands made on people – and especially academics and scientists – to complete surveys of this nature. Given the importance of the study and the fact that it should not take you no more than 20 minutes to complete the survey, we sincerely hope that you will take the time to do this. In our preparatory work for this project, we have been made aware of considerable debate and strong feelings about authorship practices and incentives in South Africa; this will be the first study examining these issues nationally and represents an opportunity for you to state your opinion.

Participation in this online survey is voluntary and there are no known or anticipated risks. This study has received ethical clearance from Stellenbosch University. You may decline to answer any of the questions and exit the survey at any time. All data collected will be treated as confidential and your anonymity will be protected in any reports or publications produced from the survey.

You have received this invitation because you have authored or co-authored at least one scientific publication accredited by the Department of Higher Education and Training (DHET) for subsidy purposes.

Please reply and indicate whether you agree to participate in the survey. We will then send you the link to the electronic survey to complete.

Looking forward to hearing from you,

Cordially yours

Prof Johann Mouton
Director SciSTIP
Stellenbosch University

Prof. Roseanne Diab
Chief Executive Officer,
Academy of Science of South Africa (ASSAf)

Research team: Prof Jan Botha (SU), Dr Lyn Horn (UCT), Prof Leslie Swartz (SU), Prof David Walwyn (UP), Ms Elsie Breed (SU)

(See also http://www0.sun.ac.za/scistip/?page_id=4118)

C. APPENDIX FOR CHAPTER 3: DETAILS OF THE QUESTIONNAIRE

Overview

The Academy of Science of South Africa (ASSAf) has initiated a study of how collaborative research can be appropriately recognised and rewarded in South Africa (ASSAf, 2016).

The Academy recognises that the participation of individual researchers in large national and international collaborations has become an increasingly common phenomenon of the research landscape. Notwithstanding the input of these researchers to the team effort, such a contribution is generally under-recognised, especially in large teams (>50 participants and hence authors). Given the role of collaboration as a catalyst for innovation, ASSAf has agreed to review South Africa's systems for recognising individual contributions to high quality collaborative research, and hence to provide a basis for informed decision-making on the appropriate recognition for such individuals in the future. This study is being undertaken by an ASSAf expert panel.

A comprehensive review of the literature and high-level assessment of the existing systems within South Africa's research institutions have already been completed. In the final phase of this project, the panel has undertaken to interview the Deputy Vice Chancellors (DVCs) of all public research universities in South Africa on the institutional response to, and impact of, the present system. In broad terms, this phase will seek to clarify the perspective of the university executive (research) on the present system of proportional reward, the general impact of publication counts, the ASSAf-defined understanding of the problem statement and possible recommendations for alternative systems.

The survey will take place through semi-structured interviews; an outline of the type of questions to be covered follows.

Questions

1. *Respondent's Background and Challenges as DVC Research*

Briefly describe the background to the study and why the DVCs are being interviewed, as described in the introduction. At this point, although the material will not be used, it may be useful to ask about the respondent's background and a couple of general questions on what the DVC considers to be the major challenges in his/her job (as research manager for a public research

university). The latter will be useful, but not critical in determining whether the proportional reward system, as introduced by the DHET, is considered to have any priority at all within the DVC's diary.

2. *Implementation of the DHET System for Publication Counts*

The implementation of the DHET system, as a means of incentivising department- and researcher-level publication practice, varies widely within the public research universities and science councils/national facilities. In this section, the intention is to develop a good summary of whether publication counts are important as performance indicators within the organisation.

- Initial General Question: Is the system of publication counts, as defined by the DHET framework, used as a means of performance management within your university, either at a faculty level, or department level, or the level of the individual academic?

This question should be followed by more specific questions covering the way in which publication counts may be used within the university. Here are some suggestions:

- Is the monetary award attached to publication counts, as received by your institution as part of the DHET funding, retained at a central level, or devolved to faculties, departments, individual research accounts and researchers?
- Do different faculties within your university adopt different practices in terms of the monetary award? If so, please give two examples of the approaches.
- If there is re-allocation to other levels, are you able to give figures of the proportions that reside in each level? What are these proportions?
- Is the metric of publication count linked to performance management of university or science council departments/units?
- Is the metric of publication count linked to performance management of individual academics?
- (Is this metric used in any other way, apart from the abovementioned examples?)
- (Is the metric irrelevant to the operational management within your university, other than as a means of calculating the DHET grant?)

3. *Perception of the System in General*

This section covers the DVC's view or perception of the DHET system. It will be a good idea to read the Muller article before the interview. Perverse behaviour by academics in response to the incentive has also been reported in a study undertaken by CREST, supported by ASSAf. If you are aware of this study, and have access to the initial reports, it will also be useful background material.

- What do you think of the approach of proportional counting?
- In your opinion, does the system of publication counts and hence proportional counting enhance the research output of the university?
- Is the system effective in improving faculty, departmental and individual performance?
- Are you aware of misappropriation by individual academics, as claimed recently by Muller (2017)? If so, how common is this practice.
- Is it fair and equitable? If not, please give examples of cases where it is unfair or inequitable.
- How would your institution evaluate the research component of job performance of an academic who published a high number of publications annually but accrued zero publication units due to the high number of co-authors?
- Would your institution encourage a researcher, who published a high number of publications annually but accrued zero publication units due to the high number of co-authors, to seek to accrue publication units?
- Could an academic faculty member of your institution who published a high number of publications annually but accrued zero publication units due to the high number of co-authors, be considered eligible for promotion (assuming that they were eligible in all other aspects)?

4. *Perception of the System as Applied to Large Collaborations*

This section gets to the core of our study (the panel). It is important that all the questions are asked and that clear answers are obtained. The previous reports of this study (Walwyn, 2017) are important background documents for the questions. As a member of the panel, you may need to remind yourself of the material.

- What are your perceptions of the DHET system as it is applied to universities, with specific reference to the case of large collaborations and co-authorship (>50 authors)?
- Is it a barrier to such collaboration?
- If so, is this barrier justifiable?
- If the DHET approach of proportional counting is applied at the level of individual performance management within your university or institution, do you consider it to be disadvantageous to such collaborations?
- If so, do you think this is a problem of sufficient importance that it needs a system-level response?

5. *Suggestions or Recommendations for Improvements*

In this section, it is important to gather suggestions for improvements to the present arrangements, particularly in terms of Section 5. The difference between these questions, and those in Section 7,

lies only in terms of the extent of ownership of the problems with the present system (if any have been identified) and hence whether the respondent may consider introducing any changes.

- Could the system of proportional accounting be changed to provide greater recognition to large collaborations?
- What recommendations should be made to the DHET?
- What do you recommend to ASSAf in terms of the study's objectives?

Examples of Alternatives:

- a. In South Korea, the universities have adopted a partial discount or non-proportional system for co-authored papers. For example, the author of a double authored paper may receive 80% of the credit of a single-authored paper, or more recently, the first or corresponding author of a double-authored paper receives same full credit as the author of a single-authored paper.
- b. In South Africa, the National Research Foundation uses an incentive instrument known as the 'Research and Innovation Reward Programme'. Each publication unit is allocated an amount of R60,000 (adjusted every few years), and the National Facility is then granted funding, additional to its core funding, in proportion to the number of publication units where the latter are calculated using the DHET subsidy formula. However, the NRF calculation differs from the DHET formula in that the calculation of the publication units is proportional to the number of authors only up to the level of 4 authors or 25% of the incentive. For publications by 5 authors and more, it is assumed that only 4 authors are involved. In other words, the value of the grant does not reduce below 25% of the initial grant of R60,000 per publication unit.

6. *Future Plans within the University on the Management of the System*

The intention of this section is to establish whether the DVC considers the present arrangements to be inadequate or imperfect, with the result that changes at an organisational level are being planned. In the question below, 'system' refers to the use of proportional counting as a means of rewarding publication behaviour, as covered in the previous questions, but especially Question 5.

- Is the university considering any changes to the way in which the system has been implemented?
- If so, how will it be changed?

D. APPENDIX FOR CHAPTER 4: THE SAN FRANCISCO DECLARATION ON RESEARCH ASSESSMENT (DORA)

The need to improve the evaluation of research outputs prompted a statement from the American Society for Cell Biology (ASCB) in 2012 (ASCB, 2012). The statement, known as the San Francisco Declaration on Research Assessment (DORA) relies on key themes, the two most relevant being:

- the need to eliminate the use of journal-based metrics, such as Journal Impact Factors, in funding, appointment, and promotion considerations;
- the need to assess research on its own merits rather than on the basis of the journal in which the research is published.

The statement declares that a Journal Impact Factor should never be used as a proxy for the quality of individual papers, individual research contributions, or for hiring, promotion or funding decisions. Selected recommendations are shown below. An evaluation of the effects of DORA, its endorsement by institutions and individuals, was published in 2017 (Schmid, 2017). It is stated that the Journal Impact Factor was designed for use by librarians; as a surrogate for publication quality it is field-specific, is vulnerable to manipulation, and may lead to unnecessary delays in promotion of young scientists.

Selected Relevant Recommendations from DORA

General Recommendation

1. Do not use journal-based metrics, such as Journal Impact Factors, as a surrogate measure of the quality of individual research articles, to assess an individual scientist's contributions, or in hiring, promotion, or funding decisions.

For Funding Agencies

4. Be explicit about the criteria used in evaluating the scientific productivity of grant applicants and clearly highlight, especially for early-stage investigators, that the scientific content of a paper is much more important than publication metrics or the identity of the journal in which it was published.

For Researchers

15. When involved in committees making decisions about funding, hiring, tenure, or promotion, make assessments based on scientific content rather than publication metrics.

17. Use a range of article metrics and indicators on personal/supporting statements, as evidence of the impact of individual published articles and other research outputs.
18. Challenge research assessment practices that rely inappropriately on Journal Impact Factors and promote and teach best practice that focuses on the value and influence of specific research outputs.

SAIP and the PU

The increasingly broad use of the DHET Incentive Scheme PU was raised as a concern by the physicists at the Annual General Meeting of the South African Institute of Physics (SAIP) in July 2014. The Annual General Meeting appointed a SAIP Task Team to develop a Position Paper, which could be submitted to Government to alert them of its concerns and to propose alternatives. The Task Team issued a statement, in draft form by October 2014. In this statement, the Task Team noted, among many other items, that:

- “many Universities are now using this PU metric when considering promotions, the hiring of new staff and the shaping of policy regarding the research directions of Departments and Faculties”;
- “the Scheme is used for evaluation of individuals in some universities”; and
- [an] “implementation issue concerns the adoption of the Scheme within Universities for purposes of individual assessment, for Performance Targets and Evaluation and Promotion.”

The Task Team met in 2014 with representatives of the DHET Research Coordination Monitoring and Evaluation Directorate, who noted that:

“the subsidy formula is a simple mechanism to distribute the subsidy among institutions as a block grant, and is not intended to be applied to individuals, for example for research evaluation. Each institution is free to spend its subsidy as it wishes, to support research as it sees fit, and therefore may support research from large collaborations if it is valued. Therefore, this issue is best resolved at institutional level.”



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