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EXECUTIVE SUMMARY

The NRF Executive commissioned this evaluation as a first effort towards demonstrating the value of the socioeconomic impacts resulting from NRF support to the South African higher education sector. The effort is well in line with the current international engagement with better understanding and assessing value for money (VfM) for development, research and other kinds of “difficult to measure” public sector investments. The evaluation team resisted the temptation - seen in many of these types of studies abroad - to conduct the work in order for it to be used for marketing or advocacy efforts. Instead, the NRF wished it to be treated as an exploration to help the organisation to engage more fully with a useful definition and classification of socioeconomic impact; to better understand the pathways to impact resulting from their support mechanisms, and to integrate a systematic focus on impact into grants portfolio management processes.

The evaluation proposes a generic classification framework for changes or outcomes towards impact, based on the measure of control grant-holders have over the production and take-up of their work. A first effort was made to map emerging and achieved impacts per funding instrument; many more types of mapping are possible. It shows two main streams of socioeconomic impact to which the NRF contributes – one generated through capacity strengthening of emerging and next generation highly educated scientists, engineers and entrepreneurs, and the other through the take-up of research results.

The chance of socioeconomic impact through both streams is enhanced when eight interconnected factors work in synergy. They are more fully described in the main report, but can be grouped into two sets of factors that reflect (i) leadership in science and innovation that has very specific attributes and approaches, and (ii) the character and quality of the context for science and innovation in the country – that is, the enabling environment shaped by the NRF and other influential funders, by a policy environment cognisant of economic, environmental and sociocultural trends, and by the interface between the producers and users of the capacities and knowledge the NRF grants and scholarships helped to develop. This has been most effectively demonstrated by the Centres of Excellence funding instrument, but is equally applicable in most of the others. This means that if the NRF takes the strategic decision to enhance its impact through any particular funding instrument, it should focus on searching for or enabling these eight factors.

Exploration of the benefits and impacts resulting from the five funding instruments highlights three broad categories of value added through NRF support: (i) strategic value, (ii) direct and indirect economic value, and (iii) wider social or societal value. It is thus essential to recognise that the value created through NRF funding is not only that which can be calculated in financial terms. The strategic benefits and many of the societal impacts are not readily monetisable, but are important contributions of the funding instruments - as long as the benefits and impacts are real. In other words, there should be ample evidence of actual achievements that have led to such benefits or impacts. Just engaging in research or capacity development is not reason enough to confirm strategic benefits.

The evaluation showed cases with very significant economic or financial benefits that flowed from research results taken up by users in government and business. In one or two cases analyses were done based on an estimation of potential. The economic valuations could not do justice to what is possible within the limited resources available for the evaluation; full-fledged “social return on investment” (SROI) studies were not possible. Much more time than expected was spent on cleaning and organising available data to be useful, on collecting very significant amounts of qualitative information and doing analyses to help structure matters at grant portfolio level. More can be done with the selected cases to sharpen arguments and calculations.

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From conventional perspectives the wider changes in society to which the NRF grants and scholarships contribute - through the work of the people delivered and the application of the knowledge generated - are most usually regarded as the actual “socioeconomic impact”. Many of these impacts can in principle be traced and monetary value calculated. However, this usually means dealing with small contributions to potentially major changes, and lengthy and unpredictable change trajectories that require frequently controversial assumptions when models for valuing are established. This can be done using special types of evaluation methodologies that tend to be time-consuming and expensive, and yield specific findings that cannot always be transferred to other contexts.

This evaluation therefore proposes that the full value proposition of each funding instrument is understood and described when doing “value for money” type studies, and that valuing efforts in future make use of classification and stratification within and across funding instrument portfolios in order to get better insight into the different types of value supported through the funding instruments.

The NRF contributions to the benefits and impacts through the support of research and capacity strengthening were found to be significant. It was noted, with clear examples, by a large majority of sampled Centres of Excellence and SA Research Chairs Initiative grant-holders as transformative and/or catalytic rather than incremental. A number of different mechanisms were identified through which the DST-NRF grants, branding and management approaches enable progress towards socioeconomic impact. Of course, these are not equally reflected across all funding instruments, and it will be worth ensuring that these enabling factors are strengthened, or at least not diluted, when funding instruments are designed and implemented.

Some negative consequences followed from some grant and scholarship allocations. These are mostly related to pressures of time, expectations and relationships. None are as yet serious enough for concern, but they provide signals for adaptive management – in other words, to include them in ongoing monitoring and learning efforts in order to make adjustments during the implementation and management of a funding instrument.

Several recommendations emphasise the need to be realistic and strategic in the approach to value for money studies. They will contribute to strategic directions in NRF only if they can better reflect the organisation’s value proposition at programme portfolio level, and much still needs to be done in this regard. In particular, funding instrument portfolios, data sets and information should be managed with a stronger sense of what is meant by impact, and which strategies increase the chance of impact – including the lessons learned about the factors influencing the pathways to impact. This will include finding more effective and precise ways to recognise, measure and promote boundary-spanning leadership, building on the assumption that this is essential for creating and sustaining national value in the national science and innovation system.

Furthermore, if a focus on socioeconomic impact is to take hold in the higher education system in particular, supported by the NRF - it will be essential for the NRF and universities to use the realities of South Africa to determine exactly what can be expected in terms of encouraging socioeconomic impact; to continue to implement coherent national and institutional policies that stimulate the whole system in this direction; and to have effective strategies in place, for example aligning promotion criteria, incentives and monitoring and evaluation systems with this purpose. This means working in smarter ways to encourage current leaders in science and innovation to cultivate the next generations of leaders with the appropriate mind-set and skills set, and to produce and facilitate the uptake of useful research findings.

NRF will likely have to concentrate in future on value for money type studies as a result of political and other imperatives. To ensure concrete action after this evaluation, it would be useful to give a cadre of thoughtful staff members, grant-holders and policy-makers the responsibility to study the findings and devise effective follow-up strategies. In the long term, concerted action can establish South Africa as a leader in this important and growing field of work.
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1. INTRODUCTION

1.1. STRUCTURE OF THE REPORT

The report is divided into four parts that can be read together or separately, although they cross-reference one another.

They provide different levels of detail and can be used for different planning and assessment purposes.

Part 1 of 4: This is the Summary Report. It describes the evaluation purpose and context, the approach and methodology followed, the main strategic findings and insights, and the resulting recommendations. It summarises the different value propositions of NRF supported research and research capacity strengthening efforts, the role that the NRF has played, and other factors that influence road to impact in each of the funding instruments.

Part 2 of 4: Understanding Impact in five NRF Funding Instrument Portfolios. This part of the report discusses the type and scope of the benefits, outcomes and impacts found as a result of the support of each of the five funding instruments. It highlights the factors influencing efforts to achieve impact, and how the NRF has contributed. It also describes the valuing and effort at monetisation done for the HCD Scholarships and Fellowships Funding Instrument. The frameworks and methodologies that were used for this part of the study are described in Part 1 of the report. For easy reference the list of findings in this part of the report is also provided in the list of annexes in Part 4.

Part 3 of 4: Valuing Research and Research Capacities - the Case Studies. This part of the report focuses on the economic valuing and efforts at monetisation that were done for the CoEs, SARChI and NEP/NEPP funding instruments. It gives a description of the eight case studies used for this purpose, the valuing methods and calculations. The level of detail in the case study descriptions also gives an opportunity to illustrate the role that the NRF has played on the road to impact.

Part 4 of 4: The Annexes provide details relevant to the evaluation questions that had to be answered; the documents read persons interviewed; the acronyms used, the findings that followed from the analyses in Part 2 of the report, and the biographies of the evaluation team members. The survey instruments are not provided due to the complex routings that were followed on-line, while the interviews, although semi-structured, were significantly adapted per stakeholder and purpose. These instruments are available from the evaluation team.

1.2. RATIONALE FOR THE STUDY

The National Research Foundation (NRF) is a critical actor in the South African National System of Innovation (NSI). It is responsible for providing strategic leadership on, advocating for, and funding efforts in the higher education sector to develop new knowledge, strengthen research infrastructure and build human capacities in and through research.

As national contexts and policies have changed over the last three decades, the strategic imperatives for NRF research have evolved, shaping its interventions. This is apparent from its current strategic plan, Vision 2015, which has a sharper focus on research and innovation in priority areas for national development than earlier strategies. These priorities are established under leadership of the Department of Science and Technology (DST), the line department responsible for the coordination of the NSI within the larger national context. For example, its Ten Year Innovation Plan (TYIP) spells out five “Grand Challenges” for national development – areas regarded as of critical strategic importance and requiring research and innovation driven by scientists across the NSI, including those who work in, and emerge from the higher education sector.
Performance reviews regularly inform NRF planning and accountability measures. These include two reviews of the NSI\(^8\), several five-year reviews of NRF performance, and occasional reviews of individual funding instruments. Yet to date there has been almost no systematic effort to determine and understand the *impact* of its work.

Understanding what impacts (which can be positive or negative) are generated through the support of a certain funding instrument, and how, for whom, under what circumstances and at what cost, can illuminate past funding efforts and help structure future conceptual and implementation strategies. Such ‘impact evaluations’ reinforce accountability and inform on-going as well as new strategies and operations, and therefore have to be commissioned and used as part of organisational learning processes.

Impact evaluations can thus improve the effectiveness of NRF funding instruments and help shape new initiatives. Positive results can highlight the role of the NRF in, and its key contributions to the NSI and to the socioeconomic development of the country.

Socioeconomic impact evaluation is a specific type of evaluation that focuses in large part on calculating the ‘social return on investment’ (SROI) of interventions – in this case, of research contributions to development – using a variety of economic valuation methodologies.

The higher education sector, not only in South Africa but across the world, is increasingly subjected to competition for scarce resources, calls for accountability for performance, and acknowledgment of the importance of timely and on-going learning from the past in order to improve and enrich future work. An external evaluation of the socioeconomic impact of funding provided by the NRF to the higher education sector has thus recently emerged as a key priority for the NRF Board, its leadership and management. With this priority came the challenge of ensuring credible methods for credible findings.

**1.3. PURPOSE OF THE EVALUATION**

This evaluation has been conceptualised as an exploratory evaluation, specifically of the socioeconomic impacts of NRF, focusing on five funding instruments at different stages of the Human Capacity Excellence Development Pipeline that represents the NRF investment strategy (Figure 1)\(^9\).

*Figure 1: The selected funding instruments & the NRF Human Capacity Excellence Development Pipeline*

Three of these funding instruments (CoEs, SARChI and NEP) are strategic investments in support of the needs of some of the best and most experienced scientists in the South African academic sector. The other two focus on the needs of emerging and next generation scientists (Thuthuka and the HCD Scholarships and Fellowships). The evaluation had funding sufficient for 150 days’ work only – that is, 30 days per funding instrument for evaluators and researchers at three different levels of experience.

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It was therefore structured as an exploratory evaluation – i.e. it was experimental and illustrative. It was not intended to be a full-fledged impact evaluation, or to produce a comprehensive economic valuation of all types of socioeconomic benefits brought about by NRF funding. In other words, this evaluation was not aimed at evaluating a whole funding instrument or its impacts, or determining its total socioeconomic value. It was also not to be used to judge the funding instruments against each other.

Instead, the NRF commissioned the evaluation in order to gain a better understanding of the actual and potential contributions to society of some of its key investments, to determine what can be valued in economic or financial terms (i.e. ‘monetised’), and to use this knowledge to inform its strategies towards achieving more or better impact, enhance its accountability to multiple stakeholders, and develop credible and reliable methodologies for conducting such evaluations in future.

The evaluation was thus intended to be illustrative, practical and forward-looking – highlighting examples, lessons and approaches that can direct future evaluations of this kind.

Although examples of evaluations and valuations of socioeconomic impacts exist, they are frequently very controversial as a result of disputes about the assumptions underlying the quantification or monetisation of the impacts. They are also not common in a research context. The impact of research is multi-faceted and methodologically challenging to assess in a credible and useful manner.

This report has therefore been prepared with the objective of highlighting for the NRF and other interested stakeholders: (i) some of the key evaluation literature available that can inform further work on the topic; (ii) the intricacies of a comprehensive and nuanced understanding of “research impact”; (iii) some of the main issues that need to be considered when developing evaluation frameworks and methodologies in this arena; and (iv) some approaches that can be fruitfully used, with suggestions for follow-up studies.

The evaluation team would like to see this exploratory evaluation used to stimulate discourses and develop evaluation solutions in this field that can support the important work of the NRF, and of the South African National System of Innovation (NSI) as a whole.

1.4. GUIDING PRINCIPLES FOR THE EVALUATION

The following principles helped to direct the evaluation:

1. Independence of the evaluation team
2. Transparency in developing the evaluation process and content
3. Utility of the evaluation findings for multiple stakeholders
4. Respect for stakeholders’ perspectives
5. Awareness of the state of the art in evaluation
6. Realism about what was possible in the given context
7. Frugality in the use of resources.

1.5. QUALITY ASSURANCE

A quality assurance strategy was implemented to help ensure that the evaluation would meet professional standards. The key components of the strategy included:

SELECTED FUNDING INSTRUMENTS
1. Centres of Excellence (CoEs)
2. South African Research Chairs Initiative (SARChI)
3. National Equipment Programme (NEP/NNEP)
4. Thuthuka
5. HCD Scholarships and Fellowships
1. Within the constraints posed by the evaluation, the use of the *African Evaluation Guidelines (AEG)*\(^{10}\), based on the International Evaluation Standards.

2. Appropriate methodologies with, to the extent feasible, systematic triangulation between (i) sources of information, (ii) methods and (iii) analysts.

3. A verification strategy which includes cross-checking information with grant-holders, case study informants and NRF staff, comment on the draft report, and an opportunity for a formal management response.

4. Distance from the NRF. The commissioners of the evaluation, the NRF Executive represented by Dr Gansen Pillay, were adamant that the evaluation team should operate at a distance from the organisation in order to preserve their independence. An NRF Resource Group consisting of relevant members of the executive and management teams was established as link with the organisation for information provision.

5. The engagement of both a technical and stakeholder reference group with a variety of members who can view the evaluation from different technical and political viewpoints. Such reference groups are a very useful and often-used mechanism in major evaluations. Although individual members were consulted on specific technical issues, their expertise was not well utilised throughout the evaluation process. Future evaluations of this kind will benefit from a systematic process of engagement with a reference group in order to enhance and assure the quality of the evaluation.

### 1.6. EVALUATION TEAM VALUES

The evaluation team members

- believe that those who evaluate research performance and impact need to avoid superficial interpretations that follow insufficient collection and integration of qualitative and quantitative data and information, and that fail to recognise the complexity of what constitutes performance in different contexts;

- have respect for the fact that research impact evolve through systemic interrelatedness and co-causality, and that impact trajectories tend to be non-linear and context-dependent – impacts thus cannot be predicted and expected to emerge within a pre-determined period;

- recognise the importance of encouraging and measuring quality outputs when determining research performance, but do not promote the notion that the benefits from research should be quantifiable, monetisable and easy to measure or value, especially when determining ‘value for money’;

- recognise the long-term, strategic value of a strong, flexible and diversified research base that covers the spectrum from basic to applied research, especially in emerging knowledge economies such as South Africa, yet support the notion that funding and incentives, carefully applied, can and should direct science in order to help achieve national objectives;

- draw from appropriate state of the art evaluation literature, and use with equal respect and rigor the range of appropriate designs, methodologies and methods available to evaluators;

- are transparent about the challenges in this evaluation in order to help advance discourses on, and experimentation with issues that will move the field of research monitoring and evaluation forward;

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\(^{10}\) In practice the application of the African Evaluation Guidelines is challenging, and the constraints posed by the exploratory nature of the evaluation meant that the evaluation team could not adhere to all expectations.
2. CONTEXT FOR THE EVALUATION

2.1. NATIONAL POLICIES AND PRIORITIES

The NRF (and its predecessor, the Foundation for Research Development or FRD) plays a pivotal role in the South African National System of Innovation (NSI). This has been very well illuminated in its various annual reports as well as in a recent Ministerial Review of the NSI. Without aiming to be comprehensive, Figure 2 highlights some of the key elements of the national policy context within which the NRF has been operating and within which NRF strategies and funding priorities have evolved.

Figure 2: Elements of the policy arena within which the NRF has been operating.

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The five funding instruments have to encourage the delivery of highly qualified market-attractive people for the NSI\textsuperscript{12}. It was therefore important to determine whether the portfolios of the five funding instruments reflected national strategic priorities, as determined by defining national policies or strategies such as the National R&D Strategy (NRDS) implemented in 2002, the DST Ten-Year Innovation Plan (TYIP) in 2008, the National Biotechnology Strategy implemented between 2001 and 2008 – and would continue to be relevant given the priorities in the National Development Plan (NDP) (refer to Annex).

2.2. USING BIBLIOMETRICS TO EVALUATE RESEARCH PERFORMANCE

Every scientist works within her own unique research ecosystem – defined by her own and her research teams’ values, her evolving capacities, and attributes such as gender, ethnicity, educational level and experience. It is also influenced by the personal and professional interactions, relationships and processes in which she participates over time, by the changing contexts within which she operates, and by the potential and actual users of her output.

This whole ecosystem influences the scientist’s professional development path, and her performance in her chosen field of science. In turn, the impact of her work ripples out across her whole ecosystem and beyond.

Concerns include the “gaming” of the system by the pursuit of a larger number at the cost of quality publications; disputed methodologies to normalise citations across disciplines; use of incomplete repositories of articles from all disciplines (including the Science Citation Index and Web of Science); uneven citation practices and data availability across disciplines; insufficient data points when using citation counts for multi-, inter- or trans-disciplinary research; self-citations and citation cartels; the inability to track creative works and software; the undue prominence of “research fads”; lower citation rates in practice-based disciplines where impact is achieved in terms of changed practices rather than citations; the critique of journal impact factors applied to individual articles or researchers; weakening of the relationship between the citation rate of an article and where it is published, given increasing on-line, open-source and grey literature publishing; and flaws in the peer review of unconventional work, with as prominent examples the failure to identify the breakthrough work on graphene and the ulcerc-causing \textit{Hellobacter pylori}, both instances where the researchers eventually won Nobel prizes yet whose publications were initially declined by prestigious journals (Marco Fahmi, PhD thesis in process).

Research performance and impact have until recently been measured and valued almost exclusively in terms of the difference made in the scholarly environment, as indicated by peer reviewed publications, citations, journal impact factors, the h- (and other letters) index, and more. Yet the veracity and utility of these measures for research performance and impact, and the accompanying incentives systems are increasingly being questioned.

Efforts such as the Source Normalised Impact per Paper (SNIP) and the ScImago Journal Rank bring refinements, but the limitations continue due to the very nature of such metrics. Substitutes are not yet readily available. Social media have succeeded in enhancing the profile of ‘open’ publication and grey literature, and this has also accelerated interest in cybermetrics, webometrics and other forms of altmetrics, leading to a series of new measures\textsuperscript{13} and related services\textsuperscript{14}.

\textsuperscript{12} There is also in this report reference to the national science and innovation system, in order to reinforce the connection between science and innovation.

\textsuperscript{13} such as the Twitter-related twimpact (tw) factor and twindex

\textsuperscript{14} e.g. Impact Story, Altmetric, PLOS Article-level Metrics, ORCID, Klout!, PeerIndex, Kred, STAR Metrics
As a result, several formal efforts are on-going to review the role and utility of conventional metrics and to improve assessment systems. At the same time pressure on public funds is causing a major shift towards assessing wider impacts beyond the academic sector, and determining their ‘value for money’ (VfM). Methodological constraints continue to hamper progress; impacts outside the scholarly environment are even harder to identify, measure and value. They take long to emerge, if at all, and the pathways or trajectories towards impact are seldom linear or predictable.

Yet the world is increasingly divided between those who have superb access to data and information, who know how to generate and effectively use new knowledge, and those who do not. Understanding and being able to measure the impact of new knowledge is therefore increasingly seen as critical for national development strategies – even as the value of research in national development is being contested. The influence of scientists and the research they produce are today more than ever rippling out across research ecosystems. It has become imperative for organisations and countries to understand, better plan for, and value these under-explored impacts.

In this process the limitations of focusing on impact in the scholarly environment (only), the diversity and interconnectedness of outcomes and impacts within research ecosystems, and the inadequacy of linear ‘cause and effect’ thinking need to be considered. The evaluation of research requires a holistic approach, and related methodological challenges have to be resolved with a sense of urgency.

### 2.3. EVALUATING SOCIOECONOMIC IMPACT

Over the past six decades evaluation has evolved worldwide as a full-fledged profession with its own specialised body of literature, standards and guidelines, and practitioner communities – and in Africa and other ‘developing’ regions, only over the past 15-20 years. That it has been gaining momentum is highlighted among others by the UN declaration of 2015 as the “Year of Evaluation”, and by the recent explosion in the number of national, regional and global professional evaluation associations to nearly 150 today. It has been very prominent in international development cooperation, and increasingly also in business and government, including in South Africa.

As in many other professions, evaluation evolves through waves of activity in specific areas for certain periods. Over the past decade these ‘waves’ or phases included managing and evaluating for results; reductionist approaches to measuring impact using randomised control trials, countered by efforts to integrate into evaluation systems approaches and complexity thinking; using ‘theories of change’ and ‘theories of action’ to guide planning, monitoring and evaluation; using impact evaluations to influence policy and practice; learning through experimentation supported by integrated monitoring and evaluation; and evaluating ‘value for money’ (VfM). These phases were accompanied by on-going confusion about what exactly constitutes ‘impact’, with a proliferation of terminology that tried to distinguish between various interpretations and definitions of ‘outputs’, ‘outcomes’ and ‘impacts’.

Although those who devise research evaluation frameworks and practices are frequently not part of professional evaluation communities, these waves have also affected evaluation in this domain – including the focus on ‘measuring impact’ and understanding ‘value for money’. Over the past few years, social return on investment (SROI) and related approaches have garnered significant attention and controversy in efforts to determine the socioeconomic impact of research. At the same time they have expanded possibilities for innovation and improved practice in evaluation, as they have to address both the challenges of defining and identifying research impact and, to the extent possible, the quantification and monetisation of socioeconomic and environmental benefits following these impacts.

The recent rise in interest in SROI has been driven in part by its framing of evaluation in the language of value for money. This has made it an attractive framework to organisations for whom economic returns are not the primary goal and are experiencing greater scrutiny by their funders for the impact they create. In short, it is a methodology closely related to social cost benefit analysis, though with a greater willingness to consider those outcomes others might consider immaterial to valuation, such as externalities or well-being outcomes. While it is rightly viewed as

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15 See for example the San Francisco Declaration on Research Assessment (DORA), and the Higher Education Funding Council for Education review requested by the Minister for Universities and Science in the UK.
attempting to illustrate a more complete impact picture, that more holistic approach to understanding often necessitates greater resource intensity.

2.4. WHAT IS SCIENCE REALLY WORTH?

As noted in earlier in this report, leading Cambridge-based economist Ha-Joon Chang observed that a country can be called ‘developed’ only if its high income is based on superior knowledge embodied in technologies and institutions. He contends that sustained development requires effective, efficient institutions and productive enterprises, supported by the collective accumulation and use of knowledge, and the expansion of those social and technological capabilities that are “both the causes and the consequences of such transformation”.

If he is correct, as many believe, how can a value or price possibly be placed on the type of committed research and capacity strengthening action that will be needed to enable and sustain this concept of national development – and in which the NRF patently plays a critical role?

Debates have been raging about the extent to which spending on science in an academic environment, and hence the development of new knowledge and related capacities, is justified by its contributions to economic growth. Much of what is done to prove this connection can be seen as advocacy, and appropriate methodologies – although increasingly available – are burdensome to apply in a credible and rigorous manner. This issue is far from resolved, and evidence for the various arguments – for or against – is both limited and contested. A much debated literature review (albeit focused primarily on low income countries) by the UK Department for International Development (DFID) and UKAid published in July 2014 concludes that research makes important and significant contributions to socioeconomic development, but that some commonly held assumptions about how research leads to changes are not backed up by evidence.

Having said that, there are numerous studies that reach the conclusion that in both the developing and developed world, greater investment in higher levels of education (secondary and tertiary) boosts economic growth. Overall, stating that higher education has an overall positive impact on growth is non-controversial – with cautionary footnotes. Indeed some research considers higher education as “a necessary but not sufficient condition” for growth, given other types of constraints – most prominently institutional development and political environments. There are, however, some lessons that cannot be derived from quantitative studies of the value of educational investment beyond private returns, the most relevant to this work being: (i) it is not possible to derive “mechanical” conclusions regarding the links between higher education and development – given that there are numerous other forms of constraints which can impede segregating the social benefits of higher education; and (ii) one cannot determine with confidence an arbitrage between different forms of higher education investment.

Most approaches are hampered by their inability to clearly distribute the full value between stakeholder groups or provide aggregated impacts. For example licensing and simulation modelling are incapable of aggregation of impacts across the spread of impacts typical of NRF funding. Econometric approaches used to measure the value of an input e.g. research investment often suffer from omitting explanatory variables. This then leads to incomplete understanding of change drivers and adoption of perceived returns by different sectors.

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21 DFID (2014).
As pointed out by Geoff Mulgan in the Stanford Social Innovation Review\(^{22}\), there are several complexities that bedevil the measurement of social value. The social field does not have the predictability of the laws that operate in the natural sciences. Stakeholders do not just argue about social value, but about social values – societies’ morals, ethics and priorities vary, and “societies are made up of competing and conflicting systems of valuation and justification”. It is hard to predict how long it will take for benefits of research to accrue. As many authors have pointed out,\(^{23}\) the pathways to policy and other impacts can be long and convoluted, and the ‘good’ flowing from research might be far into the future.

It has become clear that conventional metrics are insufficient to determine the social value and thus the worth of science. Metrics used for social valuation are inherently problematic, even in the case of SROI, where the assumptions can be highly contested and value estimates quite arbitrary. Furthermore, most metrics assume that value is objective and therefore discoverable through analysis; instead, value depends on multiple factors, many of which can hardly be called objective. They are also limited in what they can measure. It is particularly challenging to determine the costs and benefits of research in a comprehensive manner that accounts for, say, the additional expense of caring for the very sick who are kept alive by new treatments. It is also difficult yet necessary to account for undesirable impacts following from what might even be breakthrough technologies, such as nuclear clean-up or the toxic effects on health resulting from the careless use of agricultural pesticides\(^{24}\).

The point is that it is important for the sake of national strategy to try to determine the value of research, including in monetary terms. But considering only the financial or economic benefits, or even giving them undue prominence in evaluation and planning efforts, can lead to severely limiting policies and priorities. Alternative ways of looking at the value of research have to be considered. We return to this issue in Chapter 4.

2.5. **IN SUMMARY**

The five funding instruments used as pilots were purposefully selected to span the Human Capacity Excellence Development Pipeline that represents the NRF investment strategy. The analysis of each presented particular technical and practical challenges given the chosen evaluation approach, the limited resources available, the lack of existing systematic data and information on either impacts or the pathways to impact, and the difficulties inherent in calculating (social) return on investment in areas such as human capacity strengthening and research.

The aspects studied were (i) the types of impacts observed per grants portfolio; (ii) the role and contributions of NRF to the impacts and pathways to impact; and (iii) examples of ‘light touch’ economic valuation as illustration of what can be done. The fact that the first two aspects were studied to varying degrees of depth for each funding instrument during the first phase of data collection and analysis absorbed significant resources and limited the number of actual economic valuation analyses that could be done during the second phase.

The valuations were therefore by no means an attempt to be comprehensive or to express a judgment on the total value created by a particular funding instrument. Instead, analysis and synthesis within and across the funding instruments highlighted approaches to, and examples of the strategic, indirect and direct financial value created - or with significant potential to be created - by the research endeavour, *i.e.* by the intertwined processes of producing research results and high level human capital that are available to the national science and innovation system in South Africa and beyond.

This means that the evaluation has to be seen as (i) a pilot or exploratory effort to enhance stakeholders’ understanding of the impacts the NRF has been influencing, how, for whom and under what circumstances; (ii) highlighting key issues in how to manage grant portfolios for greater impact; and (iii) as demonstration of how to think about the types of value creation through research and how these can be credibly measured in future.

\(^{22}\) Summer 2010 edition

\(^{23}\) Refer to the list of documents consulted in the Annex in Part 4 of this report.

\(^{24}\) Macilwain, C (2010)
3. APPROACH, DESIGN AND METHODOLOGY

“The art of evaluating medical research and science is to adopt approaches that are true to the thing you are trying to evaluate ……. Research evaluators are used to drawing on a range of proxy measures that are relatively easy to capture – research publication metrics, intellectual property data, number of Doctorates of Philosophy attained – and which tell us something about research progression.

But, in our quest to discover impact, what we must avoid is the temptation to measure what we can count rather than measure what counts. To counter some of this quantification of impact, funding agencies are increasingly using qualitative approaches such as research narratives and case studies which allow us to recognise the multitude of actors involved in research and the timeframe to impact.”

Liz Allen in The art of evaluating the impact of medical science, WHO Bulletin, 2010

3.1. DEFINING ‘IMPACT’

This evaluation was commissioned to focus on the socioeconomic value of NRF investments. This means that the evaluation team has had to emphasise, to the extent that practicalities allowed, those changes outside the scholarly environment to which grant funding or scholarship support provided by the NRF has contributed.

**DEFINITION OF IMPACT FOR THIS EVALUATION**

Any significant changes – positive or negative, expected or unexpected, within and beyond the scholarly environment – to which NRF support contributed and that exhibit socioeconomic benefits.

3.2. DETERMINANTS OF THE EVALUATION DESIGN

In line with convention, the evaluation design was steered by (i) the purpose and envisaged use of the evaluation, (ii) the notion of ‘impact’ as defined for NRF purposes, (iii) the evaluation questions posed by the NRF and later elaborated by the evaluation team (Annex), (iv) limitations imposed by budget constraints and (v) other practical

**KEY EVALUATION QUESTIONS**

1. To what extent has NRF planned and executed for socioeconomic impact in the funding instruments?
2. To what extent have desired impacts with socioeconomic value been achieved?
3. What is the nature of these impacts, and their distribution? Have there been any unexpected positive or negative consequences or impacts?
4. What is the socioeconomic value of the (selected) impacts?
5. How were the impacts achieved? Has the NRF role met expectations? What were (other) significant influencing factors?
6. Seen on balance, are these impacts sustainable and contributing to national development and resilience in line with the critical role of the NRF in the national science and innovation system?

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25 The definition used in this evaluation simplifies the notion of “impact” so that the research community is not caught up in on-going debates about what constitutes ‘(intermediate) outcomes’, ‘(long-term) impacts’, etc. There are many different definitions of impact. One of the common is that used by the OECD DAC, viz “Positive and negative, primary and secondary long-term effects produced by a development intervention, directly or indirectly, intended or unintended”. DPME uses a results-based pyramid that indicates the need to consider the relationship between inputs, activities, outputs, outcomes and impacts, and state that an impact evaluation studies both outcomes and impacts. ‘Benefits’ are usually precursors to impact. In this evaluation both outcomes and impacts are included under ‘impact’.
considerations, primarily related to secondary data availability.

A major consideration was that a thorough investigation of the secondary data quality and availability, as well as the type and scope of possible impacts, could not be conducted before commencing evaluation. This had to be built into the design. The relatively limited budget was also a significant constraint\(^{26}\), allowing only for 30 days’ evaluator level engagement for each of the funding instruments, with the budget divided more or less equally between phases 1 and 2. It made it impossible to experiment widely or conduct comprehensive assessments of all those aspects covered by the evaluation questions. It was therefore agreed to focus on examples and case studies, and to have a phased and flexible approach during implementation.

### 3.3. FRAMEWORK FOR CHANGES TOWARDS IMPACT

This project focuses on socioeconomic impacts, and therefore on identifying, understanding and illustratively valuing changes in the social, cultural, economic and environmental wellbeing of a group, a country, or society at large. The impacts were considered using a simple classification framework to help illuminate and distinguish between different types of outputs, outcomes and impacts (Figure 3)\(^{27}\).

\(^{26}\) DPME highlights the international rule of thumb that evaluation expenses for an intervention should be between 0.1% and 5.0% of its budget, although many factors can affect the eventual amount (DPME Evaluation Guideline No 2.2.13: Guideline on Impact Evaluation).

\(^{27}\) Several useful frameworks for research impact exist, and can be found in some of the reference documents in the Annexes in Part 4 of this report.
The classification of outputs, outcomes and impacts entails the following:\textsuperscript{28}

- **In the ‘sphere of control’:** Largely under the control of the scholarship holder or grant-holder together with his/her research team and partners. This relates to the changes brought about directly as a result of changes in output – thus aspects such as changes in the attributes of research outputs such as relevance, quality, availability or types (or other attributes, e.g. gender-responsiveness); changes in the attributes of researchers, research teams or students, such as productivity and visibility; new technologies, innovations or proposed solutions (ideally with application potential); the formation of effective strategic collaborations, networks or consortia; or strengthened knowledge infrastructure, i.e. the funding, facilities, opportunities and in-kind-resources mobilised.

- **In the ‘sphere of influence’:** Influenced by the work of the grant-holder together with his/her team and partners, but not under their control. This relates most closely to terminology and concepts such as “intermediate outcomes”. This relates to the take-up and application of their work – their research findings and their capacity strengthening initiatives – by others both within and outside the scholarly environment, most often in the private sector, in policy-making and implementation, and in institutional or programmatic decision-making. The uptake of research findings reflected for example in the number of citations or media attention therefore also fall in this category, as well as benefits to their own and partner institutions, and international recognition of national contributions to global knowledge. The outcomes/impacts may be positive or negative, and may emerge at any time.

- **In the ‘sphere of interest’:** Of interest to the grant-holder and his/her team and partners as the ‘ultimate’ benefits flowing from their research, but far beyond what they can influence except perhaps in the most indirect way (in the ‘sphere of interest’; usually regarded as the impact). This relates to the result of the application of their work by others in policy, technology or practice in order to effect socioeconomic impact, reflected for example in national or global progress, lives saved, quality of life improved, customs and habits of life changed, greater societal cohesiveness, cultural heritage protected, or environmental destruction prevented. It also refers for example to the result of the recognition of national contributions to global knowledge. The impacts may be positive or negative. They emerge usually, but not exclusively, in the long-term.

Knowledge-based outputs and the results of their almost immediate uptake within the academic sector are most frequently the focus of assessment of research performance using metrics. They focus on the effect of the outputs on the researchers and the research itself, on the scientific production and behaviour of the researchers, their career structure or research environments, etc.

The combined effect of the quality and quantity of knowledge outputs and the people producing them, the effectiveness with which they are communicated, and their actual take-up and use within and outside the scholarly environment, will indicate whether the competitiveness of the South African knowledge sector has increased through contributions by NRF grant-holders and/or bursary holders.

In the sphere of influence, potential users take up and apply the research results, or the results (outputs) help to develop their capacities, ideas and insights, primarily but not only outside the scholarly environment.\textsuperscript{29} Such application of new knowledge may lead to changes in mindset, relationships or behaviour among the users of the research, in turn leading to changes in institutions, a sector or a system. The potential users are typically policymakers, entrepreneurs, industry or business representatives, development practitioners, etc., operating at local, national, regional or global levels. They are usually located outside the scholarly environment, although this might not always be the case; the outputs might also be taken up by other academic researchers into secondary or tertiary knowledge products that eventually lead to impact outside the academic sector.


\textsuperscript{29} In other definitions, changes in the sphere of influence are often termed ‘outcomes’, ‘intermediate outcomes’ or ‘intermediate impacts’.
The uptake and application of the research thus imply changes in policy, strategy, practices, technology, user capacities, and more.

In the sphere of influence the Chair and his/her team (or the bursary holder) might exert some influence and thus enhance the chance that impact might be achieved. For example, they can engage policymakers, industry representatives or smallholder farmers early on in the research effort to determine their needs and get their input as the research evolves. However, they cannot determine or control whether the research results will be taken up and used, and are often just contributors to a change taking place.

Impacts in the sphere of interest refer to the wider socio-cultural, economic or environmental changes in society and in societal wellbeing that come about as a result of the uptake and application of the original research in policy, technology or practice. The research will almost always be a contributing factor rather than the sole reason for the changes, leading to significant technical challenges during causal analysis.

The Payback Framework (Figure 4) is the best known of existing research frameworks that focus on impact beyond the scholarly environment. Already in use for more than a decade, it shows a linear progression from outputs to final outcomes or impacts through a number of stages. It relates to the framework used in this evaluation. The “sphere of control” can roughly be equated to stages 2 and 3, the “sphere of influence” to stages 4 and 5, and the “sphere of influence to stage 6.

It is critical to keep in mind the timeframes and trajectories of impact in order not to draw false negative conclusions. Some research efforts can expect to yield significant impacts at an early stage. Others may take far longer to show impact, not because they are ineffective, but because the changes they are targeting are inherently long-term in nature. For example, recent analysis estimated that, for a selection of cardiovascular-related medical interventions, the time lag between original, key research and tangible impact on health was at least 17 years. For this reason sampling strategies for the evaluation in four of the funding instruments focused primarily on those grant-holders who have been beneficiaries of NRF funding over a significant period – and even this is unlikely to be sufficient.

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20 In other definitions, these societal changes are often regarded as the actual ‘impact’, or as the ‘ultimate’ or ‘long-term impact’.
21 Recent explanation of the framework by Claire Donovan and Stephen Hanney in Research Evaluation, 20(3), September 2011, pages 181–183
22 Allen L., Bulletin of the World Health Organisation 2010; 88:4-4
3.4. THE EVALUATION DESIGN

Consideration of the factors determining the evaluation design led to a theory-based, case-based design using mixed methods, followed by economic valuation. The latter comprised two streams of work.

- The use of ‘rates of return to education’\(^{33}\) (private and social) approach to represent the impact of NRF funding from a VfM perspective. This analysis was performed on the largest single financing instrument aimed solely at capacity development, the HCD free-standing grants.

- A valuation of the key net\(^{34}\) social / economic / environmental impacts of a number of case studies drawn from across the financing instruments.

Of the two approaches, the latter could more easily be further developed into a full SROI analysis, an approach that is resource intensive (due in part to the wide range of data and estimations required) and beyond the resources of this pilot. Thus, in the case studies, a wider range of potential value is identified than is quantified. The sheer variety of impacts the NRF funding is expected to create makes the development of a valuation analysis akin to SROI an unworkable exercise at the level of financing instrument. A case study approach was thus used to inform the economic valuation, focusing on analysing successful demonstrations of impact, although time did not allow sufficient comparative analysis of successful and unsuccessful cases; this can be very useful in future.

This pilot evaluation made little systematic use of bibliometrics. The approach paper from the outset confirmed the focus on impacts that have socioeconomic impact, hence those primarily outside the scholarly environment in the ‘sphere of influence’ and ‘sphere of interest’, complementing bibliometric studies. These impacts are not well understood, with little systematic analysis of available information in the five selected funding instruments to shed light on their frequency and scope. Furthermore, given the long-standing contested nature of conventional bibliometrics, the growing emphasis on altmetrics, and recent controversies around peer review and citations, as noted earlier, conventional metrics of ‘impact’ have to be handled with care and nuance to avoid simplistic findings. There is excellent bibliometric and scientometric expertise in South Africa - CREST at the University of Stellenbosch\(^{35}\) is a prime example - that can in future generate rich metrics to support full-fledged impact evaluations, and complement or verify some of the findings in this study.

The methodology was thus structured to shed light on

1. the kinds and scope of impacts expected per funding instrument portfolio, and the logic underlying the design of the portfolio
2. the different kinds and scope of positive impacts actually obtained in the portfolio (or in a subset of the portfolio), and to which the NRF contributed
3. negative consequences or impacts to which NRF support might have contributed, and which might have had a negative or neutralising effect on positive achievements
4. any patterns illuminating how, why, for whom and under what conditions they were obtained (thus highlighting main causal pathways), and the main influencing factors
5. the role that specific circumstances (‘context’) may play in achieving impact
6. the ‘value creating vectors’ that highlight the strategic, social and economic value proposition of the NRF to the NSI and to wider society through the work of the grant-holders (and bursary holders) supported by NRF funding in each of the five funding instruments, and
7. the ‘monetisable’ value-creating vectors, aiming principally to highlight the direct and indirect (multiplier) economic value of NRF contributions, but also where material and feasible, the social and environmental value using use value or intrinsic value measurement techniques.

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\(^{33}\) Originally formulated by Psacharopoulos et al (1986) and subsequently proved by Psacharopoulos and Patrinos (2002).

\(^{34}\) Net of the counterfactual and attribution (where appropriate)

\(^{35}\) Now a DST-NRF Centre of Excellence
Engaging with the underlying logic of the funding instrument (their ‘results frameworks’ and/or ‘theories of change’), the impacts within the funding instrument portfolio, and analysis of the nature of and reasons for the impacts, were conceived as ‘Phase 1’ of the evaluation.

‘Phase 2’ consisted of the economic evaluation using relevant value creating vectors, including through illustrative case studies. There was some overlap between the phases; for practical reasons we could not separate them completely as was initially intended.

The reference documents, key informants and case studies are listed in the annex. Inductive and deductive analyses were done by integrating quantitative data and qualitative information from both primary and secondary sources. Perceptual and factual data and information were both taken as acceptable evidence, as long as triangulation, systematic coding, interpretation and logical reasoning, and appropriate pattern analyses could confirm their credibility. Quantitative and qualitative methods, and the data and information following from their application, were thus treated as of equal importance, informing each other and providing information to help confirm the change logic and economic valuation to the required depth.

Understanding ‘cause-and-effect’ towards impact was based on counterfactual reasoning, thus using a generative approach to causal inference. In each case the counterfactual was based on the simple question: What would have been the situation if NRF did not exist? Has it been in a position to make a unique contribution?

Control or comparison groups were not used. In other words, a statistical counterfactual was not applied. Experimental designs with control groups were for obvious reasons out of the question. With several caveats, in a comprehensive impact evaluation quasi-experimental comparison group designs might be useful for some funding instruments; in others, this would make little sense and may yield misleading results. In such instances, theory-based, case-based, before-after or time-series designs were regarded as more useful.

In this evaluation, where the illustrative case studies focused on specific research interventions where impact pathways could be readily traced, and on socioeconomic impacts primarily outside the academic sector, counterfactual reasoning was relatively simple.

In the cases of Thuthuka and the HCD Scholarships the design would have benefitted from having credible comparison groups of sufficient size – an impossible undertaking within the limited funding and time available in the evaluation. The evaluation team therefore focused on understanding as well as possible the difference made by the NRF, by testing the change logic (theory of change) for each to the extent possible, using both factual data and perceptual information. The absence of a comparison groups was not regarded as a significant weakness, as the team could focus on major value creating vectors that were not dependent on differences between the grant-holder/bursary holders and a comparison group (e.g., delivery of highly qualified people in the NSI). Rich information was obtained that can assist future more comprehensive evaluations of this kind.

In terms of attribution, the evaluation team focused a significant amount of effort on triangulation to determine the role of the NRF support within the larger set-up, what difference it had made exactly towards the scientific achievements and subsequent impact, and whether it contributed in a unique way. Subjective questions were

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26 A Theory of Change (ToC) is a model that explains how an intervention – in this case a specific NRF funding instrument and/or a selected research effort of its grant-holders - is expected to lead to intended or observed impacts. A full-fledged theory of change makes explicit, in text or diagrammatic format, any feedback loops as well as the series of assumptions and linkages underpinning the presumed causal relationships between inputs, outputs and outcomes or impacts at various levels. Contrary to the norm, which often only shows the impacts in a ‘results framework’, a range of aspects is part of a comprehensive ToC, including the main assumptions underlying the logic, explicit intermediate states between core steps in the model, and rival explanations. The ToC is also frequently accompanied by the ‘Theory of Action’ (ToA) that clarifies the mechanism according to which the ToC is supposed to be made to work.

27 The purpose of using a counterfactual in an evaluation is to address the question “What would have been the situation if the intervention had not taken place?” It is seen by most as an essential component of an ‘impact evaluation’. Conventional approaches to impact evaluations normally assume a randomised control trial or quasi-experimental design with matched control or comparison groups, implementing a statistical counterfactual. Alternative ways to conceptualise a counterfactual have been gaining ground in view of the complexity of most interventions in the real world, the inter-relatedness of variables, and the need for sufficient statistical power for credible results.


29 This is most often used in impact evaluations.
employed to understand the value of the investment relative to other investment sources. The specific evaluation designs are described in greater detail in part 2 of the report for each of the funding instruments.

3.5. CLASSIFYING THE TYPE OF RESEARCH

This evaluation provided an opportunity to do a rudimentary mapping of the types of research practiced by many of the best scientists in South Africa. It was far beyond the scope of this study to work through the research of each scientist for this purpose; instead, the question was posed to the CoE and SARChI grant-holders to determine how they would classify their own unit’s research based on the allocation of both financial and human resources. In future such categorisation can be extended to specific cases to develop a better understanding of the different contributions – if any - following from different research philosophies.

In 1997 Donald Stokes proposed a way to map different types of research in a manner that recasts tension in science between understanding and use. At the core of his argument were the fundamental yet use-inspired studies of Louis Pasteur that laid the foundations for the discipline of microbiology. Known as Pasteur’s Quadrant (Figure 5), it defines three categories of research based on two binary dimensions: (i) a quest for fundamental understanding, and (ii) considerations of use.

The first category is exemplified by the work of theoretical physicist Niels Bohr. Researchers search for fundamental knowledge with little concern for application. Thomas Edison’s focus on practical inventions characterises the work of scientists whose interest is problem solution. They draw from whatever basic and practical knowledge is available. They may conduct fundamental research when necessary, but their professional choices are driven by the goal of solving the problem at hand as quickly and efficiently as possible. The research of Louis Pasteur defines the work of scientists who search for fundamental knowledge, but select their questions and methods based on potential relevance to real world problems.

Figure 5: Pasteur’s Quadrant, a typology of research proposed by Stokes (1997)

In other words, Stokes suggested that researchers who engage in research primarily in a quest for fundamental understanding could be represented by Niels Bohr; those who do so primarily with the consideration of use, by Thomas Edison; and those who consider both use and contributions to fundamental knowledge, by Louis Pasteur. It is of course clear that the boundaries or distinctions between them are often blurred, especially where basic research and technology tend to overlap, for example in biotechnology or nanotechnology.

The national science and innovation system needs an appropriate balance between all three types of research. Opinions differ on what the balance should be, especially in the academic sector. Many see Pasteur’s quadrant as the ideal in the modern world, one that requires scholarship that is sensitive to, and interested in, contributing to both the quest for new knowledge and market or societal needs. Others argue that universities should focus on pursuing new ideas irrespective of wider considerations such as strategic value or potential for application.

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The results of the classification by grant-holders are noted in the relevant chapters of this report. The evaluation team used the results to determine whether there was a connection with the type of reported impacts; for example, whether researchers focusing on applied research could show more applications. The results may also help inform debates about the principles and strategies that should underpin and catalyse the evolution of the South African National System of Innovation.

### 3.6. IMPLEMENTATION OF THE EVALUATION

The implementation of the evaluation, and the key considerations and challenges captured in the process, are set out in Figure 6.

*Figure 6: Steps in the evaluation process, with key considerations and challenges*

**INCEPTION PHASE: Set-up & Planning**
- Preliminary document study
- Approach paper
- Reference / Resource groups
- Preliminary interviews
- Comprehensive document study
- Analysis of NRF data systems
- Evaluation plan per FI

**PHASE 1: Portfolio Analysis**
- Change logic (ToC) of FIs
- Secondary data analysis
- Primary data collection – semi-structured interviews
- Primary data collection – off / on-line surveys
- Integration & Inductive / deductive analysis of impacts in FI portfolios

**PHASE 2: Economic Valuation**
- Identification of value creating vectors & case studies
- Case studies
- Economic valuation / monetisation
- Verification & synthesis

**CONSIDERATIONS & CHALLENGES**
- Case studies selected based on a set of criteria aimed at demonstrating different types of cases; interventions through NRF funding and valuation calculations – not necessarily most economically valuable cases.
- Two FIs, CHD Scholarships and TutuKhula, serve as case studies as a result of the type of allocations – thus requiring significant primary data collection.
- Limit of 30 evaluator days on average per FI ensures focus on proposals for future, rather than allowing exemplary execution in pilot.

- As noted in Approach Paper, rudimentary change logic per FI was constructed without a participatory process in line with good practice – the result of budget constraints.
- More intensive primary data collection and analysis of NRF secondary data than expected.
- Systematic coding and analysis of qualitative information, but Dedoose analysis software not used due to systems crash in Cloud storage.

- Case studies selected based on a set of criteria aimed at demonstrating different types of cases; interventions through NRF funding and valuation calculations – not necessarily most economically valuable cases.
- Two FIs, CHD Scholarships and TutuKhula, serve as case studies as a result of the type of allocations – thus requiring significant primary data collection.
- Limit of 30 evaluator days on average per FI ensures focus on proposals for future, rather than allowing exemplary execution in pilot.
4. DETERMINING ‘VALUE’

4.1. DEFINING THE VALUE PROPOSITION OF NRF INVESTMENTS

Each case study refers to a specific object to which a specific NRF grant or funding instrument has been proven to have contributed in some or other way – for example a research programme or suite of programmes of a Centre of Excellence; the educational project of a SARChI Research Chair; or the instrumentation acquired through a NEP/NEPP grant.

The value proposition of that object refers to the value that it has delivered, or promises to deliver, in order to satisfy (in this case) national interests. Determining the ‘value (to be) delivered’ requires an assessment of the balance between the benefits and the costs or risk involved. It is inappropriate, in a scientific or research context (in particular in universities where basic research is encouraged), to propose that such value can and has to be measured only in terms of financial or economic benefit.

The so-called ‘value for money’ studies therefore need to consider firstly and where appropriate, the direct financial value of the object – i.e., value that with a good measure of confidence can be translated into ‘monetisable’ or financial terms.

Secondly, they have to consider the strategic value or benefit resulting from the object. This is frequently (but not always) intangible, and are usually difficult, if not impossible, to quantify or monetise, yet of significant importance to national interests. They are often precursors or preconditions for impact.

Thirdly, they have to consider the wider societal, economic and environmental value or benefit that has resulted, or has the potential to result, from the object under consideration due to decision-making that has led to wider benefits (typically long-term impacts, emerging in the ‘sphere of interest’). This type of value is often quantifiable and monetisable, but seldom supported by sufficient evidence. For this, extensive (and appropriate) monitoring and/or evaluations are required, which are frequently beyond the scope of institutions or even national programmes. This type of value therefore frequently has to be assessed for potential rather than realised impact.

**TYPOLOGY FOR THE VALUE CREATED BY NRF GRANT-HOLDERS**

**Strategic value:** Brought about by (i) benefits or impacts that enhance institutional, sector, national or international decision-making and practices in line with national priorities; and/or (ii) the delivery of appropriately qualified high level human capital in line with national priorities.

**Direct financial value:** Brought about by direct and quantifiable (including monetisable) benefits or impacts following from the grant activities that measurably contribute to improving the efficiency, effectiveness or competitiveness of key stakeholders in the national interest, or for regional or global advancement.

**Wider societal value:** Brought about by improved policies, technologies or practices that have contributed to delivering positive, often quantifiable (including monetisable) benefits or impacts to the wider society, whether at national, regional, international or global levels. The impacts are frequently difficult to identify as a result of lengthy and convoluted trajectories, and the influence of many other factors and contributions.

It is crucial that valuing such benefits or impacts is based on strong, credible and relevant evidence, both of the benefit or impact and of the role of the NRF funding instrument in the achievement. Not all scientists who dabble in research will deliver good “value for money”. Some may suffer from a lack of originality, or conduct work of dubious quality. Collaborations might be in name only. Not all researchers who supervise students can deliver well qualified and appropriately educated human capital who can function well in the national science and innovation system. Not all outreach or advocacy initiatives can be regarded as providing value. They might implement many activities, but waste all the resources on ineffective communication or irrelevant messages that make no difference to the audience.
Furthermore, the type and extent of the NRF contribution should be carefully traced; many actors may contribute to impact, and none should be put in a position where credit is taken where it is not due. Cases also suffered from limitations; the volume of work required to conduct even just one full-fledged valuation can be extensive when sufficient triangulation and investigation are included. Even then, assumptions can be contested; they are coloured by the context and experiences of stakeholders and observers.

The evaluation team used part of the change logic of each of the five selected funding instruments, available data and feedback of those surveyed and interviewed, to identify and verify those impacts influenced by the NRF support for each portfolio. They then illuminated the potential pathways perceived to create value as a result of NRF funding, branding and administrative support.

### 4.2. APPROACH TO VALUING HIGHER EDUCATION

A ‘rates of return to education’ approach was employed to calculate the economic value of the HCD scholarships. The ‘rates of return’ approach is the narrowest approach to capturing the value that education produces. It estimates the private returns (higher income levels) plus societal returns (additional taxation) relative to the private costs (foregone income) and societal costs (state provided funding for education). While narrow, this approach is a widely recognised approach to valuation and used to guide funding allocation through quantifiable evidence. It is the approach that was deemed most suitable to create credible results for this pilot evaluation, given the available resources.

Approaches designed to capture the wider value associated with investment in education include those that analyse the macro-economic dimension. In short, these approaches estimate the value to the macro economy in terms of education’s impact on economic growth rates. These approaches employ one of two approaches. The first uses regression analysis to determine whether higher education enrolment rates and investment have an impact on economic growth. The second stream focuses on researching the impacts of higher education on total factor productivity (TFP) by using frontier production functions. The latter approach invites investigation into whether higher education increases the speed at which new technologies are adopted, thus increasing TFP and growth potential. Bloom et al (2006)\(^{41}\) employ this approach to analyse productivity gaps in a number of Sub-Saharan African countries. One of their key findings is that only tertiary education can induce a technological catch-up.

These approaches could provide a broader picture of the value of higher education expenditure on the wider economy of South Africa. However, the ability of such a methodology to distinguish the contribution of one particular form of graduate and post-graduate level assistance over another, or one focus of funding e.g. science versus humanities, is likely to be highly limited.

Another approach to capture wider economic value associated with investment in education is to measure the total (direct, indirect and enabled local and regional) economic impacts. This value is understood through capturing: (i) The direct impacts of their expenditures on local, regional and national economies; (ii) the indirect impacts of their supply chain expenditures on local, regional and national economies; (iii) the direct employment of personnel; and (iv) the employment indirectly generated via their supply chain expenditures. This too could provide a broader understanding of the wider impacts of higher education spending on the South African economy. Detailed spending surveys, such as the annual student spending report produced by Student Village\(^{42}\) would be required to then distribute the direct impact across different economic sectors and for that value to be transposed (via input-output tables) into multiplier impacts on the local, regional and national economy.

The additional approaches illustrated that are available to undertake valuation analyses for returns to education indicate that the holistic economic (not to mention social) returns to education are likely to exceed the returns generated in the ‘rates of return’ approach employed in this valuation. The data requirements required to execute these additional approaches were beyond the scope of this pilot evaluation. It has been suggested\(^{43}\) that upwards of

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\(^{41}\) Bloom, D, David Canning, and Kevin Chan (2006); Higher Education and Economic Development in Africa. Report Commissioned by the World Bank


75% of total value of research comes in the form of spill over benefits, value that would not be captured in the model employed here. Thus any value captured by the ‘rates of return’ approach may only constitute around one quarter of the total value generated.

The rate of return to education model captures human capital development through a narrow lens only. It was decided, therefore, that running the model multiple times for each financing instrument would add little additional value. Instead, the HCD Scholarships and Fellowships funding instrument was selected to illustrate the value of human capital development supported by NRF student scholarship funding specifically. This funding instrument was selected for the following reasons:

- It represents nearly 60% of the total students on NRF funded free-standing scholarships during the valuation analysis period (2008-2012).
- The survey of HCD scholarship and fellowship holders provided:
  - the greatest disaggregation of demographic data (race/gender/socioeconomic status) on the recipient population of any NRF student scholarship scheme, and
  - data detailing counterfactual and attribution considerations, crucial to the calculations.

### 4.3. APPROACH TO VALUING RESEARCH CONTRIBUTIONS

Details of the approach to valuing research contributions are given in the Part 3 of this report, *i.e.* under *Valuing Research and Research Capacities: The Case Studies*, where seven case studies across three of the five funding instruments are presented and valued.
5. SUMMARY OF FINDINGS: MONETISATION OF SOCIOECONOMIC IMPACT

5.1. ABOUT THE FINDINGS IN THIS REPORT

The findings related to each of the funding instruments are captured in detail in Parts 2 and 3 of this report. Each chapter in Part 2 of the report includes a summary of the main findings for that specific funding instrument. These are not repeated here. Although this evaluation was not an evaluation of the funding instruments themselves, a number of the findings in Part 2 can be considered for improvement of the particular funding instrument. For easy reference, findings focusing on better understanding the impacts and the pathways to impact for each of the funding instruments were collated from Part 2 of this report and listed in an Annex in Part 4.

The following sections capture those key findings related to the monetisation of socioeconomic impact. Detailed analyses can be found in the Chapter on the HCD Scholarships and Fellowships in Part 2 of the report, and in the case study analyses in Part 3.

5.2. WORKING TOWARDS IMPACT

More than almost any other initiative, the CoE and SARChI Funding Instruments have the potential to influence a large group of leading scientists in South Africa, and they have done so. The vast majority of grant-holders in both these funding instruments have noted the influence of the NRF grants as “transformative” or “catalytic”, rather than “incremental”.

It is therefore significant that this study confirmed several important pathways to socioeconomic impact\(^\text{44}\) - largely verifying the change logic described in the NRF documents - based on how the majority of grant-holders in these two funding instruments organise and conduct their work in their ‘sphere of control’:

i. Where the field allows, most grant-holders focus on use-inspired research, defined as scholarship that is sensitive to, and interested in, contributing to both the quest for new knowledge and market or societal needs.

ii. Most work in areas identified over the past decade as national priorities.

iii. Many have implemented special initiatives to engage, support and further develop the expertise of a larger and more diverse cohort of students and postdoctoral fellows, through mentoring, community formation, collaboration and special exposure opportunities (many international).

iv. Most have increasingly demonstrated boundary spanning leadership, the critical attribute of being willing and able to communicate and work effectively across vertical (levels of hierarchy), horizontal (across functions and disciplinary expertise), stakeholder (with external partners from different sectors), demographic (across diverse groups, e.g. gender, ethnicity, nationality) and geographic (across regions and locality) boundaries\(^\text{45}\).

These ways of doing have manifested to the greatest degree in the sampled CoE supported initiatives, in large part a result of the way in which the funding instrument has been designed and managed (its specific objectives, SLAs and different stages of growth for which grant-holders have to show evidence). A good number of examples of change as a result of relevant research findings and effective engagement with stakeholders have been found in their sphere of influence, i.e. as intermediate outcomes or impacts. Following from these, the CoEs and some SARChI Research Chairs

\(^{44}\) Refer to the chapter on each funding instrument in Part 2

offer a few significant examples of (potential, emerging and actual) socioeconomic impacts in the sphere of interest, in one or two cases used in the case studies.

It is unlikely that any grant-holder is able to track all benefits and impacts of his/her contributions outside the scholarly environment; there are likely more than have been observed to date.

The NEP/NNEP Funding Instrument was not studied in depth as a result of a lack of time and information on impact. It is nevertheless clear from other relevant studies from South African and abroad, and from the two case studies (recorded in Part 3 of this report), that in an increasingly more technology-driven world it is essential for a knowledge-based economy to have sophisticated state-of-the-art equipment supporting both research breakthroughs and the development of high level human capital. They are often a critical success factor in research impact, and therefore of strategic as well as, in many cases, direct economic value. Before any appropriate valuation can be done, the type and magnitude of their contribution to developing unique skills or in any research breakthroughs have to be determined. This presents a significant challenge, as their contributions are usually several degrees removed from the eventual impact, and will vary significantly from case to case.

One instrument, such as the high resolution NMR spectrometer used in one of the cases in this study, played a small yet essential role in enabling fast progress towards what might be a major breakthrough; in another, several instruments together are at the core of advances in a cutting edge area of work. They provide only two examples of the many different important contributions that equipment makes to the scientific arena in South Africa.

Thuthuka and HCD Scholarships and Fellowships are primarily focused on human capacity development. The latter is also a cross-cutting issue in the other three funding instruments. Delivering high level, market-attractive and/or entrepreneurial expertise into the science system has significant value from a national perspective, especially when such scientists show that they are capable of contributing further towards the competitiveness of the South African knowledge sector and economy, and can address pertinent development challenges. Their socioeconomic impact is further reflected in the work that they produce in turn, and in the attention and investments they garner directly or indirectly from international actors, including as a result of the increasingly high profile of the South African knowledge-based economy to which they are contributing. In the case of Thuthuka, the good initial results and leveraging of resources by many of the emerging researchers as a result of the additional NRF funding will increase their chance of success as the leading scientists of the future.

The delivery of the existing and new cohorts of scientists into the science system therefore serves only as a somewhat distant proxy for their eventual socioeconomic impact. There are some accepted models that connect higher education research and postgraduate output to national development, but their underlying assumptions can be controversial. Developing useful models for the South African context would be important, but will require more resources than this evaluation offered.

Detailed findings related to the impacts for each of these funding instruments can be found in Parts 2 of this report. The valuing aspects are discussed below.

5.3. VALUE OF THE HUMAN RESOURCE CONTRIBUTIONS

The HCD Scholarships and Fellowships, and Thuthuka Funding Instruments are first and foremost vehicles for human capacity development. The former aims primarily to deliver into the science system (or the national system of innovation) the next generation of South African researchers, while the latter attempts to redress historical imbalances in the research sphere and cultivate an emerging generation of research leaders.

While the potential value of post-graduate students’ studies and research outputs and impacts are varied and numerous, and of value to a wide range of stakeholders including at national level and, of course, the NRF, commonality lies in the value, first and foremost, to the students themselves. The value of additional studies is therefore captured in this analysis (refer to Part 2 of this report) through the additional earnings potential of students in receipt of higher qualifications. This value in turn has a positive externality of greater income tax receipts for the government. It is these values that were modelled in this analysis.

Given the limited scope in this evaluation for extensive valuing efforts, the postgraduate student focussed valuation
analysis was based only on a ‘rates of return to education’ modelling of the potential future economic value associated with higher educational qualifications, with reference to the Human Capacity Development Scholarships and Fellowships Funding Instrument. The total value (private returns to students in the form of higher incomes) and society (in the form of additional income taxation) has been estimated to equate to R1.85 billion for NRF funding for the HCD free-standing scholarships for Master’s, PhD and post-doctoral students supported between 2008-2012. The headline return on investment ratio for these scholarships ranges around a mean of 0.9, with the value for doctoral studies the lowest.

Although this appears to imply that for every Rand invested by the NRF into the bursary scheme, less than one Rand of value has been created, very significant societal values of national interest have been excluded. Future studies could focus on the broader value created for recipient students and their wider networks – for example the intrinsic well-being value of education, i.e., the extent to which continuing their studies enriches the lives of students and their families; the impact of continuity in studies on their institutions, especially in view of issues of critical mass and sustainability; and the impact of more highly qualified researchers on the national science and innovation system. If in future the wide variety of economic, social and environmental values created by the uptake of research outputs is taken into consideration and calculated in a credible manner, a share can be assigned to HCD (and to others, including Thuthuka) in proportion to the number of scholarships holders (relative to colleagues) present in that institution.

It is probable that students from a lower socioeconomic status levels are more likely to stop studying in the absence of NRF funding. There is an opportunity for NRF to increase their rates of return on investment through improved targeting of students for whom alternative forms of funding are less accessible. However, this would require a trade-off with supporting the best performing students – something possibly not warranted within the larger national objectives that NRF are trying to achieve.

The focus of Thuthuka in attempting to redress historical imbalances in the research sphere suggests a potentially interesting avenue for further research that examines the value of unleashing (previously wasted) potential. Although it was not done this time, this avenue of research could draw on the literature around the broader value of reducing inequality and the personal and social well-being value that redress creates not only for the recipient student, but also for their close family and possibly their local community.

5.4. VALUE OF THE RESEARCH CONTRIBUTIONS

In this study, the value of research oriented funding instruments such as the CoE, SARChI and NEP/NNEP was modelled via a case study approach. The wide variety of economic, social (health) and environmental values created by the research outputs of the different institutions supported by NRF cannot be easily aggregated; it is essential to be able to work with a precise scientific output or set of outputs (research findings) with some cohesion between them.

Valuing research impact is a difficult undertaking for many reasons, including the unpredictable diversity of potential ripples from a single piece of useful research, the likelihood that many impacts may not have as yet materialised at the point of study, and the different values stakeholders might attach to the results of its application. Of the eight quite diverse research-oriented case studies, five had one or more impacts where direct economic value could be readily calculated. Within the limitations of the evaluation only a few aspects were valued; the input costs and risks were not included.

The cases were selected purely to be illustrative of the spectrum of possible impacts in the various portfolios (their selection criteria are listed in the previous chapter); in several cases already-prominent examples of impact were used to determine what these might have yielded in terms of ‘monetisable’ value.

In future a more systematic stratified case study approach can be used to identify estimates for sector specific values for those themes, sectors or fields prioritised by national interests or by the CoE, SARChI or NEP/NNEP Funding Instruments.
Results of the valuing of the research contributions in the case studies
(for details refer to Part 3 of this report)

- The results showed that the creation of sustainability guidelines for the wildflower industry, one of the many initiatives of the Centre for Invasion Biology, contributed benefits of R42 million a year to a variety of stakeholders, with the total economic value likely significantly higher.

- The potential avoidance costs of another *Sirex* woodwasp outbreak in non-native pine plantations through a solution by the Centre for Tree Health Biotechnology – one of many they have in hand - is between R1-1.2 billion, although the full economic value is less than zero if full opportunity costs are included.

- A spin-off company from the Centre for Biomedical TB Research – a very small part of what CBTBR has achieved to date - creates R28 million worth of benefits per annum.

- One of three research programmes of SARChI Chair Prof Linus Opara has added an estimated R65 million of direct and indirect benefits to the economy, with a further R90 million estimated until 2018.

- SARChI Chair Prof Kelly Chibale mobilised R100 million, employs tens of people and has the potential to make a major contribution to eradicating a disease that costs Africa US$12 bn per year.

- One high-field NMR spectrometer managed by Prof Graham Jackson at UCT contributed in varying measures to projects with very significant economic and strategic benefits – including the work of Prof Chibale and the development of a unique meningitis vaccine by Prof Neil Ravenscroft, and several others not addressed here - ultimately saving tens of thousands of lives across Africa.

- The other case studies on the work of SARChI Chair Prof Viness Pillay and the surface characterisation facility at UFS showed the many strategic (and potentially direct economic) benefits that flow from excellent research and human resource development, yet economic value is often limited by lack of interest among potential users, the feasibility or cost of application within a weak take-up environment, or other factors beyond the scientist’s control.

Sustainable research institutions require a critical mass of researchers – staff, students and partners - to create an enabling environment for academic and research activities, helping to maintain mutual support and allowing researchers to keep abreast of recent advancements and debates. Follow-up studies that explore the value of sustainability may provide further supporting evidence for the value to educational institutions and to national interests of increasing the throughput of post-graduate students across the human capital development pipeline.

A recurring caveat for all use-inspired research case studies is that without effective implementation, the estimated value of the research can be significantly undermined. For this reason, the evaluation team was hesitant to speculate about potential value that has not yet been realised through successful implementation.

Finally, it is also critical to consider the strategic value of the benefits and impacts – those that are not readily monetisable, but still of great significance in building a healthy science and innovation system through contributions from the higher education sector. This is discussed in detail under the sections on the value propositions for each of the funding instruments and cases in Part 2 of the report.
6. STRATEGIC FINDINGS AND CONSIDERATIONS

6.1. WORKING TOWARDS SOCIOECONOMIC IMPACT

Analysis of the change logic (‘theory of change’) of each funding instrument - as described in NRF planning and reporting documents and by some of their influential designers - shows a significant emphasis on research outputs that impact on the scholarly arena, and on human capital development in relevant areas. Much less attention is given to research results with potential or actual application outside the scholarly environment, or to any explicit effort to ensure delivery of market-attractive high level human capital into the national science and innovation system - other than the assumption that studying under competent or excellent researchers will produce the needed resources for the country at this time. With the exception of the Centres of Excellence, these funding instruments provide no real incentives or demands in this direction.

This is not necessarily problematic. It is a strategic choice based on perceptions of what makes for a sound science and innovation system in a country. But as none of these funding instruments were designed with potential use of the research as a priority (e.g. as in the case of THRIP), the implications have to be understood when attempting to assess contributions to socioeconomic impact. Under these circumstances, achieving many research breakthroughs with immediate or near-term application outside the scholarly environment is unlikely. The consequences for a country in need of technological and industrial development can be dire. For example, graphene technology, developed in the UK, is seen as a new wonder material with extraordinary application potential. Yet by 2015 the UK has applied for just around 1% of the approximately 25,000 graphene-related patents worldwide. The comparable figures are 6% for Japan, 18% for the US, 25% for Korea and 29% for China.

The socioeconomic impact of NRF will therefore be primarily seen in the number of appropriately skilled, high level men and women delivered into the science and innovation system (including the next and emerging generations of scholars) – ideally inspired, entrepreneurial, original and/or innovative, having bright new ideas and working productively in areas of national priority.

### Eight factors that enhance the chance of socioeconomic impact in an NRF context

1. Self-motivated, highly capable and influential research leaders who are committed to contributing to resolving local, national, African or global challenges; strengthening the capacities of men and women for this purpose; and inspiring those around them to follow suit.

2. ‘Boundary-spanning’ research leaders with a critical mass of diverse collaborators nationally and internationally, and a diversity of postdoctoral fellows and students who direct their work into coherent, strategic multi-, inter- or trans-disciplinary programmes with a use-inspired lens.

3. Research leaders with sufficient infrastructure, funding and institutional support to take risks with their field of research or with specific initiatives.

4. Research leaders who can ensure implementation of effective engagement and communication strategies that make good use of modern technology as well as old-fashioned relationships.

5. Recognition by influential actors coupled with nuanced measurement of the value of research contributions towards socioeconomic impact.

6. Clear direction and incentives from NRF and other influential funders and institutional or national decision-makers;

7. A stable, coherent enabling national and institutional policy environment, coupled to resourcing opportunities that encourage use-inspired basic and applied research on national priorities; and

8. An enabling environment for take-up of the research results by industry, government and/or other influential institutional actors who can influence the development of the country.
What will increase the chance of socioeconomic impacts (i.e. following from research findings) through these (and other) funding instruments? The success cases and qualitative information across all five funding instruments confirmed the notion that at least eight factors work in combination to enable such impacts (see box).

This means that as many as possible of these eight factors should be encouraged and enabled - otherwise the impact of research findings outside the scholarly environment will be severely limited. It also means that requiring scientists to achieve socioeconomic impact in the absence of a sufficiently enabling environment will be unfair.

Many DST and/or NRF initiatives have already been set up in a manner that that makes use of these eight factors, including the CoE and SARChI funding instruments. Many scientists have responded positively – even though the spread of such contributions is still quite uneven, and there are too few signs of dynamic intellectual property generation and exploitation for commercial benefit. Yet much is beyond the control of NRF; there is only so much that it can do. There is also a fine balance to be kept and trade-offs that need to be considered; too much pressure cannot be brought to bear to produce socioeconomic results when the science and innovation (or research) system is still quite fragile. Furthermore, a slew of in-depth studies have clearly highlighted over the past decade the difficulties in getting influential actors to use research, while the potential of academic research to contribute directly to national development is also being seriously questioned.

The significance of working towards socioeconomic impact is therefore best expressed in the evidence provided by renowned UK-based Korean economist Ha-Joon Chang, who postulates that a country can be viewed as ‘developed’ only if its high income is based on superior knowledge embodied in technologies and institutions, and that such a state of development can be sustained only with effective, efficient institutions and productive enterprises that can collectively (in synergy) accumulate and use knowledge, and harness and expand the social and technological capabilities that both enabled and followed from the transformation.

It is imperative that enough people are delivered by the higher education system with such capabilities and inclination. This is part of the socioeconomic impact that NRF funding instruments can promote and support; university scholars are generally trusted to deliver such people into the science system.

From this perspective the NRF has a pivotal, albeit limited role to help ensure that enough men and women are educated with such capabilities and inclination. This is at the core of its potential for socioeconomic impact, and a major part of its value proposition. But this implies helping to ensure the delivery of a very specific type of person into the science and innovation system.

It also means that all academic scholars’ outputs and approaches cannot be measured with the same yardstick for success, although there has to be sufficient rigor and detail in evidence for progress in desired directions across a funding instrument grants portfolio.

Of course this does not mean that everyone should strive to do applied research, but that scientists – and especially leading scientists - should conduct at least ‘use-inspired’ work, able and motivated to consider the potential of their work and inspire others in their team, and in particular their students, to do the same. How the leaders in science in South Africa conceptualise and approach their work is critical not only for the way in which they situate and promote their research for uptake, but in how they influence the mindsets of the next generation. And the generations are changing as the world evolves. Although the HCD Scholarships and Fellowships study showed that the majority of sampled emerging scientists are still motivated by the quest for new knowledge, prominent scientists who promote and embody the notion that research can be a major contributor to the wellbeing of the nation or the planet, or a lucrative career for entrepreneurial thinkers and doers, can draw more top students into the field.

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46 Policy and strategy coherence should of course follow. Contributions to effective solutions for society, whether in policy, strategy, technology or practice, should be treated as of equal significance as high quality publishing. NRF and its co-actors who work with national strategies and resource allocations should be deliberate – and to some extent already are - in their effort to cultivate such mind-sets and capabilities, to some extent to counter the mad rush to publish at the expense of other critical considerations and types of impact. THRIP provides for one such strategy, but socioeconomic impacts are facilitated by many actors other than formal industry.
On a cautionary note, the following aspects deserve ongoing attention in NRF and in national policy and strategy initiatives. They will also influence the valuing of the impacts to which the NRF funding contributed:

i. Both research and experience show that the relationship between the availability of high level human capital, research, innovation, productivity and growth – in other words, the link between research interventions and their ultimate impact - is highly nonlinear and dependent on the articulation between these components. This is also dependent on extent to which scientists delivered into the science system are not only able to generate new knowledge, but know very well how to use knowledge for purposes of national development.

ii. HCD scholarship and fellowship holders, as well as Thuthuka grant-holders appear to equate innovation with original work – even when a widely used definition to the contrary is provided. This is of concern, further confirmed by the fact that a limited percentage felt that their studies and work with leading scientists “inspired and enabled [them] to innovate”. The question has to be frequently asked (and addressed) what can be done to enable policy and strategy coherence and targeting in order to promote such awareness as well as a research and development culture that will effectively influence the social, cultural, economic and environmental wellbeing of the nation. Synthesis of different case studies that clearly highlight pathways to success and the obstacles encountered, coupled to appropriate valuing might provide useful insights and help create awareness for this purpose.

iii. Although relevant changes and socioeconomic impact have been observed in this study (i.e. the presence of the change), it has not been feasible determine the full significance and scope of the change, i.e. all the attributes and achievement of targets (quantity, duration, frequency, qualities) that embody ‘success’. What has become clear is that the performance of grant-holders especially in SARChI and Thuthuka differs quite dramatically in several important instances, including in terms of productivity and the leveraging of funding. This demands nuanced analyses in order to get a fuller picture the performance of each funding instrument and the diversity of impacts it promotes, tied to specific contexts.

6.2. MANAGING FOR SOCIOECONOMIC IMPACT

Socioeconomic impacts that follow from the application of research are normally reflected in the sphere of interest. They tend to be hard to trace, with convoluted and unpredictable pathways from research findings to impact, which can be positive or negative. The NRF and its grant-holders cannot held responsible for them, but they can be held responsible for planning and managing their work in a manner that makes it more likely that their respective outputs (whether people or new knowledge) will be taken up within and especially outside the scholarly environment; however, in doing so the limitations posed by insufficient national policy coherence, poor implementation of national strategies or international policy and other strategic challenges need to be considered.

This implies that both the NRF and grant-holder strategies have to be guided by the extent to which socioeconomic impacts are being sought as part of strategic objectives, and provide effectively for trade-offs if necessary (for example, keeping intellectual property confidential rather than publishing widely requires giving equal recognition to both types of achievement).

Of the five funding instruments, only the Centres of Excellence have been designed and implemented with as one of their main charges contributing to solutions beyond the scholarly environment. This shows in their results; nearly all have had success in this regard (some extraordinarily so, as the case studies indicate - and several of the other Centres have similarly impressive results).

A number of the Research Chairs have achieved the same, and it is obvious that many of the facilities funded through the NEDP/NNEP would also support work that has the potential to lead to socioeconomic impact. Yet in the absence of benchmarks or targets in this regard, and with the limited cases available, it is unrealistic to make an assessment of the extent of the success achieved. In future, with the current insights in hand it will be easier to stratify portfolios and conduct more comprehensive studies.
At this point the most that can be said is that with the exception of the Centres of Excellence, the NRF funding instruments studied have not been managed for socioeconomic impact. This is among others demonstrated by the dearth of systematic monitoring information, special studies or evidence-based evaluations that can shed light on the matter.

Every funding instrument has a portfolio of grants, each with different attributes and trajectories towards impact. Depending on circumstances, progress in terms of performance will vary; so will the potential for, and kinds of impact. It might be useful to switch to thinking more about managing a “portfolio” than managing “grants”.

Part of the purpose of this evaluation was to get a better grasp of the diversity of grants and the impacts that emerge from each funding instrument. It was also essential for the credibility this study: rather than cherry-picking a few case studies to get the most impressive results, the portfolio analysis enabled better insight into the different types of impacts that could be relevant for valuation. Such classification and subsequent mapping of subgroups within the portfolio also informs the team managing and overseeing the funding instrument. It makes it easier to understand what changes each portfolio has been bringing about in what contexts. It facilitates stratified sampling for reporting, evaluation and other management purposes. It helps to identify, and assess the reasons for, differences in performance. It can help to highlight intermediate outcomes or impacts that indicate whether the grant-holder or subgroup is making progress towards impact as expected. It can also help to highlight in a timely manner where strategic or operational adjustments are needed to achieve better or more appropriate impacts at portfolio level.

In short, it provides for better understanding and managing a portfolio of grants towards the desired performance results and expectations of impact. This was emphasised when the evaluation team found that the average number of SARChI outputs was very unevenly distributed, with only a few of 47 Chairs responsible for nearly 50% of the peer reviewed outputs; a similar trend can be observed in the case of Thuthuka grant-holders. Without nuanced analyses of performance and trends the situation would not be well understood; stratification and mapping can help in this process. It is also imperative to have a clear yet nuanced understanding of what ‘success’ would look like when managing a funding instrument portfolio with a diversity of performance measures and desired impacts. Given the different contexts, objectives and capacities of grant-holders, all grants cannot be treated in the same way. Yet there should also be some coherence in the evidence used by peer review panels during expert opinion reviews and other types of evaluations.

This means collecting and working with data and information beyond rudimentary analyses for reporting or for use only in five year reviews. It requires an evidence-seeking and learning culture within the management team, a willingness to work with different types of data and information on a regular basis, a commitment to collecting only useful information that is indeed used, and an interest in providing detailed and useful feedback at least once a year to grant-holders as a collective, if not as individuals.

The evaluation team found that a significant amount of information collected by some of the funding instrument teams appears not to be (regularly) used; it is hence not readily available or updated. Some information is also collected or reported in a manner that may undermine its utility and credibility.47

There are thus inefficiencies in the system that can be detrimental to management performance and to external perception. It is likely not necessary to collect more information; instead, what is available can be better organised and kept updated for maximum utility at any given moment.

How it is done should be driven by need and envisaged use: for on-going learning for strategic and operational decision-making, for accountability (reporting), and for use in external reviews and evaluations. The classification, mapping and analysis of a portfolio of grants can be based on different permutations and combinations of quantitative and qualitative information based on envisaged use - demographic, financial and output data; progress, outcome, impact and thematic information; and review results.

It is also imperative to search for proactively and track potentially unintended negative consequences that may, if allowed to grow, stymie certain types of impact, or demand trade-offs. Traces have been found in some of the funding instruments - from professional envy; potential over-concentration of resources in specific groups compared

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47 The evaluation team has a series of experiences that they can bring to the attention to the management teams of specific funding instruments.
to results; or insufficient attention to the sustainability of the intellectual infrastructure and results. This issue has not been comprehensively studied, but it is raised as reminder of the need to ensure that the negative does not overshadow the positive, and to deal with tensions and trade-offs in a timely manner.

Such classification and stratification will in future also be very valuable for socioeconomic valuing or ‘value for money’ (VfM) type studies, which are likely to become increasingly common. It is of little use to cherry-pick a research programme or project within the grants portfolio of a primarily research-oriented NRF funding instrument. Organising the portfolio into groups and randomly or purposefully selecting representative cases from each based on pre-determined criteria will provide for a more credible and useful approach. This will also facilitate the sampling in capacity strengthening funding instruments such as the HCD Scholarships and Fellowships.

6.3. VALUING NRF CONTRIBUTIONS TO SOCIOECONOMIC IMPACT

As noted earlier, the value proposition of the NRF refers to the value that it has delivered, or promises to deliver, in order to satisfy national interests.

The portfolio analyses of each of the five funding instruments confirmed that there are essentially three streams of changes that relate to, or can be translated into socioeconomic value at national level. In conventional technical terms they span the spectrum of changes, from outcome to impact levels along so-called “impact pathways”. This means that the desired end state as a result of NRF funding instrument support – that of societal change - is not the only type of change that should be valued. This significantly enhances the value proposition of NRF funding instruments - in other words, the value that they deliver, or promise to deliver, in order to satisfy national interests.

Of course not all research or work in the higher education sector will have such value - only those contributions that are of the relevance, quality and utility to make a real difference to national objectives, and/or that are well positioned to be taken up beyond the academic sector.

Furthermore, only some of the value created through these changes can be monetised, i.e., readily translated into direct economic benefit. Such economic valuing faces two primary challenges: (i) some changes are of a strategic nature, but too intangible to calculate in financial terms, and (ii) some of the longer-term, wider societal impacts can be monetised, but here the trajectories to impact are frequently too convoluted and slow to unfold, with too many influencing factors, making it much harder to estimate the NRF contribution.

Planners and policy-makers need to be mindful of these issues when embarking on any ‘value for money’ type calculations.

The value proposition of the NRF is its ability – with DST support - to encourage and support the higher education sector in a manner that enables a variety of national benefits or impacts. It contributes to benefits and impacts

1. with strategic value
2. with direct or indirect economic value
3. with wider societal value.

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48 As can be expected, these contributions are aligned with what has been found elsewhere, e.g. the valuation of research of the Natural Environment Research Council in the UK (2006).

49 A calculation of the value proposition for each will require an assessment of the balance between the benefits / impacts, and the costs or risk involved.
Contributions to benefits and impacts with Strategic Value

These contributions are largely difficult to monetise, yet yield intangible strategic benefits with intrinsic value. When investment in science is diminished or falls away, these contributions are also sacrificed.

- The empowerment of emerging and next generations of researchers with attributes that can help transform the national science and innovation system
- Institution strengthening, enabling a higher profile of, and lower turnover in universities in core expertise in priority areas
- Strengthening of the national science base through external contributions, such as additional funding, infrastructure and other types of in-kind resources, collaborations and the gaining of foreign expertise
- Strengthening of national capabilities to generate high quality, useful knowledge that can be applied towards socioeconomic solutions, through boundary spanning leadership, a critical mass of appropriately skilled scientists, mutually beneficial international relationships that provide i.a. for reverse knowledge flows to institutions, and mitigation of the risks inherent in frontier research (normally not funded by industry)
- Towards transformation of the national science and innovation system through appropriately skilled, confident, innovative and motivated role models; and through changes in the public perception of academic scholarship and research expertise
- Enabling evidence-informed decisions in policy-making, and in strategy and practice in business, government and civil society
- Positioning South African science in the national, regional and global arenas through greater awareness of cutting edge science and its contributions, reputation building, and enhanced competitiveness in science and innovation.

Contributions to benefits and impacts with Direct or Indirect Economic Value

These contributions are feasible to monetise and/or translate into economic value. The benefits can accrue to individuals, specific groups, an institution or a specific sector, and be reflected locally, nationally or internationally. The following are examples of such contributions from the case studies:

- Foreign direct investment and foreign exchange earnings
- Job creation or enhanced incomes among impoverished communities
- Income accruing from technological breakthroughs, innovative ecosystem services, patents or other forms of intellectual property licensed or sold
- Tax contributions, and indirect revenue for support industries
- Avoidance of future loss, for example in income or biodiversity
- Savings through efficiency gains, higher retention rates, and high level facilities and training opportunities in South Africa rather than abroad
- Additional earning power of masters and doctoral graduates, and the economic multiplier effects resulting from their spending
- Additional earnings resulting from international postgraduates/postdoctoral fellows studying in South Africa
- Delivery or retention of market-attractive researchers for the national science and innovation system.

Even though monetisation of such direct or indirect economic value is feasible, there are many challenges, including the possible off-set of positive benefits with negative consequences or impacts; job creation in developing countries that may come at enormous cost to potential income from national resources stripped by international conglomerates; or technological breakthroughs with unforeseen destructive side-effects, such as the Asian Green Revolution that brought soil and health problems that will continue for generations to come.
It is therefore extremely important that such calculations are done appropriately, ignoring the temptation to follow only rosy scenarios. It is also very risky to make calculations based on projections of use. These can turn out very differently from what has been expected; the realisation of potential is usually dependent on the confluence of many different factors. It is much better to focus on calculating that which has been achieved. This will require NRF to engage with several available valuation and evaluation methodologies appropriate for the task\(^{50}\).

Contributions with wider societal value refer to the socio-cultural, environmental and economic impacts resulting from the adoption and application of technologies, policies and practices, often after the generation and use of secondary or tertiary knowledge products. These contributions can therefore be several degrees of separation from the initial generators of the knowledge. Pathways are convoluted and usually impossible to predict, except in cases that do not require responses from people, such as the application of vaccines, medicinal drugs or malaria bed nets.

The benefits and impacts can in many cases be monetised, but often with great difficulties, and the assumptions made are often highly controversial. The biggest challenge is to determine the causal pathways and scope of contributions by a funding organisation such as NRF.

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<th>Contributions to benefits and impacts with Wider Societal Value</th>
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<tr>
<td>▪ Enhanced wellbeing and quality of life of men, women and children across society as a result of increases in national income, or improvements in the health system</td>
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<tr>
<td>▪ Increased national economic output resulting from increased productivity or reduced morbidity</td>
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<tr>
<td>▪ Improvements in population health</td>
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<tr>
<td>▪ Enhanced societal harmony</td>
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<tr>
<td>▪ Wellbeing improvements among the families of better qualified postgraduates from impoverished communities</td>
</tr>
<tr>
<td>▪ Deceleration of ecosystem / environmental degradation</td>
</tr>
<tr>
<td>▪ The intrinsic value of ecosystem maintenance for national wellbeing.</td>
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</tbody>
</table>

6.4. **THE ROLE AND CONTRIBUTIONS OF THE NRF**

For credible NRF commissioned ‘value for money’ studies it is imperative to understand the nature of its contributions to the impacts identified, and to the extent possible, the scope. This has to be considered in the valuing, as is demonstrated in this study. There has thus been a significant focus on this aspect, both in analysing the grant portfolios and in tracing the impact pathways in the case studies.

The contributions of DST-NRF funding and branding have been defined by many grantholders in SARChI and the CoEs, and during the NEP/NNEP case studies as “transformative”, and by others as “catalytic” rather than “incremental”.

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There is compelling evidence that without the specific type of support that NRF provides through its funding, branding and management approaches (the latter specifically in the case of the CoEs), much less would have been achieved. Furthermore, around 97% of sampled Thuthuka grantees confirmed its role as a significant factor in their success, and around 60% who did not have PhDs attributed the attainment of their degree at least in part to their Thuthuka grant. Of those who received rating, 88% believed that Thuthuka funding played a significant role in their success, or was wholly responsible. Pathways to success have been diverse, with individual researchers having unique needs for support and capacity strengthening.

Importantly, this does not mean that there is real value in all research endeavours; care should be taken not to over-claim the contributions and hence their perceived value. Evidence of effective, even exceptional performance is essential. Not all collaborations are sufficiently productive. Not all awareness creating programmes work. Not all leadership efforts span boundaries. Not all publications contribute to the national reputation in science.

Main reasons for DST-NRF contributions to performance in Science and Innovation:

**Perspectives of CoE and SARChI grant-holders**

1. The NRF funding is enough, long-term and free of project-based conditions, thus releasing time and providing flexibility, including for long-term planning and risk-taking that accompanies shifts in focus or strategy.
2. The NRF gives prestige and brings visibility that increase opportunities for leveraging funding and in-kind resources.
3. The NRF raises expectations, thus motivating better performance and forcing grant-holders to engage with new ways of thinking and doing.
4. It provides the motivation and capacity to span disciplinary, project, sector and country boundaries for better results.

Main reasons for DST-NRF contributions to performance in Science and Innovation:

**Perspectives of Thuthuka grant-holders**

1. The NRF enabled grant-holders to dedicate time to research and focus on core research activities by funding sabbaticals and lecturer replacement, fieldworkers and research assistants, small instruments and consumables, and collaborations.
2. The NRF moved many towards NRF rating by helping to set in place a set of conditions conducive to establishing themselves as researchers.

Main reasons for DST-NRF contributions to performance in Science and Innovation:

**Perspectives of HCD free-standing scholarship holders**

1. The NRF allowed students to continue studying and focus on their research without severe financial challenges
2. The NRF allowed a focus on studies in their areas of choice.

The amount, freedom and flexibility provided by DST-NRF funding, coupled to its branding power, places this source of research support in a league of its own which other sectors, such as industry or philanthropy, would find hard to match. Any changes that might negatively affect the role of the NRF in cultivating work towards socioeconomic impact should therefore be carefully considered.
7. RECOMMENDATIONS

It is not always desirable for an evaluation team to make recommendations; the management of an organisation is often best positioned to do so. In this report, many findings have been recorded per funding instrument. The focus in this evaluation has been on how NRF can better achieve and measure socioeconomic impact. It was not an evaluation of each funding instrument, and the recommendations are therefore not aimed at how NRF can in general improve its programming, although some of this can be derived from the detailed findings in Parts 2 and 3 of the report. The focus here is on high-level recommendations only.

1. Carefully consider the extent to which ‘value for money’ type studies should be a focus - and where done, ensure their credibility

The field of determining value for money (VfM) is growing in importance around the world, with limited resources and many competing priorities. NRF therefore has to engage with this type of work. However, it has to be strategic about when and how to conduct such studies. Since assessing the economic impact of investment in higher education and research is complicated and contested, the purpose, intended use and credibility of such studies have to be clear. Conducting a limited number in carefully chosen themes will be very worthwhile, but they have to be credibly conducted, and the value given to them within other strategic imperatives, carefully calibrated.

VfM studies generally show positive economic returns and impacts for research, yet can yield a wide range of estimates; any single calculation tends to be viewed with caution. NRF-initiated VfM studies should therefore have quality assurance systems in place, and should avoid credibility pitfalls such as cherry-picking projects for valuation to demonstrate the best results, using assumptions that suit a certain agenda or considering only success stories and thus not accounting for the negative influences of the research.

Such studies will also require methodological innovations to help address technical challenges. Data on returns on investment collected in one sector cannot be readily applied to another. The benefits can take a long time to accrue, and a large percentage may reside in spill-over effects. It is also very difficult to predict if and when research will have impact; if it is soon after release of the findings, it will be much easier to identify and assess than if it occurs a decade later. Furthermore, investment in higher education and research is a public responsibility. The strategic benefits to which NRF funding instruments contribute are therefore very important, yet they are often not quantifiable and might therefore be lost with a focus only on monetisation, i.e. on financial benefits. This will lead to an under-estimation of the value of research and research capacity strengthening.

Unintended consequences should also be kept in mind. If ‘value for money’ becomes a strong focus for NRF it might be tempting to structure work in a manner that minimises risk and innovative work by encouraging those initiatives with a better chance of achieving high value outcomes and impacts. It might also sacrifice longer-term, more meaningful research for the sake of short-term profile and gain.

The NRF and its various national partners in the national science system are very well positioned to advance this field of work. In order to ensure concrete follow-up after this evaluation, a task force should be initiated to study the findings and their implications, and to propose to the NRF how to pursue this type of work in future for strategic and practical benefit.

In the longer term, NRF and its partners could consider establishing joint “observatories” for this type of impact evaluation, where expertise can reside and innovations can contribute to global understanding of how to conduct this type of work. This will enable the long-term tracking and measuring of the benefits and impacts of research and research capacity strengthening for national interests.

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2. Complement expert opinion reviews with more rigorous evaluations, including for determining socioeconomic impact

The document study for this evaluation has shown that most of the NRF evaluative activities are based on expert opinion reviews. This is quite acceptable in the context of higher education, but the inevitable insufficient focus on rigorously collected and analysed evidence can often be detrimental to quality. Reviews and evaluations commissioned by the NRF should ideally be conducted by a team of evaluation and subject specialists; each brings strengths to the process. NRF should also ensure that when funding instruments are designed, what will be monitored and evaluated is part of the planning, and that data – both qualitative and quantitative – are collected and used accordingly. Too much data are currently collected and not appropriately used, or not used at all.

To address the challenges inherent in determining socioeconomic impact, it will be necessary to experiment with a range of state of the art methodologies. In addition to the different valuation methodologies widely debated and used in these types of studies, it will be important to focus on the ‘softer’ impacts. It can be very difficult to construct comprehensive baselines and credible counterfactuals, and credibly match control or comparison groups. This means working with conventional metrics complemented by newer approaches such as usage and altmetrics, and with significant amounts of perceptual and factual, quantitative and qualitative information for use in methodologies such as theory-based comparative case studies, realist evaluation, general elimination methodology, contribution analysis, process tracing and others. It will also require experienced SROI consultants and evaluators who can manage and select from the range of valuation and evaluation methodologies available, and who can innovate where necessary.

The following can be useful foci for future NRF studies of socioeconomic impact:

1. Further work on its human resources / capacity strengthening contributions (i.e. postgraduate students and next generations of researchers). In particular, valuing Thuthuka has not received sufficient attention in this evaluation, and if an appropriate comparison group can be constructed, it could be a useful next step in furthering this type of work.

2. In the SARChI, CoE and NEP/NNEP Funding Instruments, grants based on specific themes or clusters can be studied. The impact maps in this report and stratification of grant portfolios can help to identify appropriate themes or clusters. They can be in a discipline or broad area of work; a national priority area; a specific type of impact expected (e.g. policy changes); a whole Centre of Excellence; or a specific category of NEP/NNEP supported facilities.

3. Using methodologies such as Most Significant Change (MSC), universities can be called upon to select cases based upon a set of criteria developed either by the NRF or by themselves. They can then identify those cases that they believe have had the most impact, which can then be valued and evaluated by a team appointed for this purpose. Similar approaches have been implemented in higher education institutions abroad, but more rigour can be brought to bear by following accepted evaluation practices in this regard.

3. Manage portfolios in order to understand and enable impact

NRF has to have a stronger portfolio management approach for each of its funding instruments. This could consist of any one or more of the following:

i. Work in practice with the change logic or theory of change of the funding instrument. Align planning, monitoring and evaluation as early as possible in the lifetime of the funding instrument. Collect data and information with the change logic, desired outcomes and impacts, and economic valuing in mind – including ensuring a systematic focus on pathways to impact.

ii. Clean up, organise, classify and work more intensively with the data and information in hand in order to gain depth and accuracy, map impacts beyond the scholarly environment; learn; and provide comprehensive and nuanced evidence for planning, monitoring, reviews and evaluations. Much of the data and information NRF collects are not in a useful format, or are underutilised.

iii. Define and classify different types of expected or realised impacts for a specific funding instrument. Map them in different permutations against other attributes of the portfolio. This will enable more nuanced management, analysis and learning around that funding instrument. Such stratification will also greatly assist in similar future evaluation and valuation efforts.

iv. Define more clearly for the portfolio what is meant by “success”, and manage accordingly, including by considering what lies beyond outputs and what can be expected from different types of grant-holders, dealing with appropriately stratified groups in the portfolio in different ways when measuring success, and emphasising engagement strategies to encourage the uptake and use of research findings.

v. Determine to what extent funding instrument strategies and incentives need to encourage grant-holders to understand better, work towards, and track socioeconomic benefits and impacts, rather than pursue impact only in the scholarly environment – or whether this will continue to be an organic process depending on the unique approach and objectives of each grant-holder. If the former, careful consideration should be given to optimising the chance that research will be taken up beyond the academic sector. This has already met with significant success – although the effects are still limited - in the design of the CoE Funding Instrument. Lessons learned from the already extensive and expanding body of work on evidence-informed policy-making, policy influencing and research communication can be fruitfully brought to the attention of the grant-holders.

vi. Stratify the portfolio in a manner that can allow for different types of emphases in managing for impact. In other words, one subset of grant-holders in the portfolio might prefer to focus more on blue sky and others more on use-inspired or applied research (or whatever basis is used for differentiation); these subsets will require different measures of “success” that gives more credence to the differences between fields, types of research and strategies towards impact.

vii. Give grant-holders feedback on the results of interesting analyses. This will ease the pain of data collection.

viii. Ensure that the factors (as identified in this evaluation) that enhance the potential for impact, as well as the role that NRF plays in this process, are well understood, and that they are considered during the design and implementation of funding instruments. Keep an eye on negative influences, consequences or impacts, and take remedial action if possible and necessary.

It will be imperative for such an impact-focused approach to be a support towards achieving institutional and national objectives, rather than over-burden already taxed funding instrument teams and grant-holders with new concepts and reporting requirements. It should be done with the necessary ‘light touch’, and in order to be effective and efficient, maximum value should be obtained from the data these NRF already have in hand. The way in which data and information are organised and managed in NRF requires serious attention\(^53\).

\(^{53}\) The evaluation team has noted a number of inefficiencies that can be discussed upon request.
Such an approach will also require renewed consideration of the role of the evaluation function within the NRF to ensure that this important function is used to its maximum capability.

4. Ensure that the factors influencing the road to impact are considered during funding instrument design and implementation, including the important role of boundary spanning leadership

This evaluation has identified a number of factors - both within and outside the scholarly environment - that influence the achievement of impacts. It has also identified the influence of the NRF towards impact in each of the funding instruments. It will be important to be cognisant of these factors, and to promote those most likely to make a difference.

Boundary spanning leadership is of particular importance. It has been proven to be critical for success in science and innovation, and as noted by Barnard et al., for acquisition and diffusion of local knowledge internationally and vice versa. The concept of boundary spanning leadership might sound like the most recent case of ‘management speak’, but it is an increasingly important concept in today’s highly connected, interdependent world. It is defined as the capability to create direction, alignment and commitment across group boundaries in service of a higher vision or goal, and is widely used to describe any situation where an individual crosses the boundaries of a social group. The nexus between groups can be particularly powerful, and its importance lies in the recognition that leaders in any sector and capacity need to “think and act beyond group boundaries and identities” in order to solve problems, innovate and create new opportunities. It is particularly prominent for innovation, which requires collaboration across all five boundary dimensions - vertical, horizontal, stakeholder, demographic and geographic.

The ability to cross these boundaries enables a bridge to innovative and transformative solutions as part of the interactive processes that connect different actors and agencies in the science and innovation ecosystem. It needs to be rewarded and supported, and hence measured in a manner that benefits national priorities and strategies.

The effectiveness of this type of leadership has been reinforced in this study, most obviously in the work and experiences of the Centres of Excellence and, perhaps to a somewhat lesser extent, in that of the Research Chairs. Time and again the reasons for progress, impact or the “transformative” contributions of the funding instrument in the CoEs referred to the opportunities to increase active and productive cross-disciplinary collaboration, within and across institutions, functions, sectors and countries. Data show the effects of a critical mass of boundary crossing scientists working on shared initiatives that create further opportunities, produce joint outputs, and deliver impacts that otherwise would not have been possible. Its value is also confirmed by a recent study by Thijssen that indicates that collaboration by South African scientists with international actors lead to higher citation rates, i.e. at least to higher visibility.

This is of course a nothing new in the scientific endeavour; collaborative work is at the core of scientific achievement and it is therefore no surprise that the CoE model, which was created with precisely this in mind, has shown such significant success. However, the question is whether the effort involved, the mechanisms at work and the combined results of spanning so many boundaries have been well established and effectively promoted. From recent documentation studied by the evaluation team it is not clear that the Centres of Excellence, and the model presented by the funding instrument, have received their due credit in this regard. More importantly, it is not clear that (i) enough has been learnt from their experiences in this respect to apply and promote in other or future funding models and incentives strategies, and (ii) sufficient consideration has been given to how this momentum will be sustained after termination of their support. The limitations and strategic implications of what is being done at present have also not been fully understood, for example the very limited collaborations with scientists in Asia spite of the dramatic


57 Ibid
shift of power, expertise and resources to that part of the world, or with Africa in spite of the many shared challenges faced by countries on the continent.

Thus rather than (or otherwise in addition to) obsessing, as many worldwide are doing, with measuring impact or value for money - which can be extraordinarily resource-consuming and technically challenging - NRF can instead, as part of managing for impact, do more to promote boundary spanning leadership as the essence of the scientific endeavour.

Measuring success in this aspect with the appropriate depth needs to be done with nuance in order to be useful for strategic decision-making; at present data in the NRF are not organised or analysed appropriately for this purpose. As this evaluation has just touched on the evidence demonstrating the major role of boundary spanning leadership in the impressive achievements of the Centres of Excellence, NRF could consider initiating an evidence-rich study to investigate this aspect in much greater depth in order to help structure incentives and conditions towards socioeconomic impact.

5. Promote concerted attention to the sustainability and resilience of the science and innovation system and its results

The focus of this study did not allow for consideration of the sustainability of the funding instruments or their models, the intellectual infrastructure established, or their impacts, yet it is an issue that continues to arise. One of the most important management challenges in both the NRF and grant-holder institutions remains how to effectively sustain positive and useful ideas and results that can lead to real impact, emitting from the research supported by the funding instruments amidst ever-evolving contexts and new ways of doing. In some institutions (and in NRF) preparations are under way to devise effective exit strategies for the CoEs and Research Chairs. When the contributions of the NRF as perceived by the grant-holders and scholarship holders are taken into account, the challenge becomes clearer. The NRF funding (in partnership with institutional support) buys time and provides scientists with the freedom and infrastructure to pursue interests within limited and realistic conditions, and to exert ‘boundary spanning leadership’ to a much greater extent. If this type of support falls away, it will be hard to replace from sources other than public funding. This affects the sustainability of the difference made by these funding instruments, as well as the resilience of the science system as a whole – the ability to bounce back and adapt well after evolutions or revolutions in circumstances.

There are many different pathways to the sustainability of ideas, models and impacts. If leading scientists have contributed to the science system over a period of 15 years, their legacy is primarily embodied in their original ideas and useful research findings that have led to scholarly, institutional and/or socioeconomic impacts, in the next and emerging generations of scientists who have the potential to following their footsteps, in the capacities towards excellence and leadership built in these younger generations, and to a lesser extent in the physical infrastructure left behind (which might more quickly become out-dated). These are the aspects of sustainability built into the funding instruments, further shaped by strategies that emerged over time as institutions and other systems adjusted to these funding instrument contributions.

If the grant-holders exit the NRF funding cycles, their legacies will continue primarily through the people they mentored and delivered into the science system. It is therefore imperative for sustainability, and for the increasing resilience of the science system in South Africa, to make sure that the kinds and attributes of people delivered by such leading scientists are what will cultivate new leaders, and in future sustain a knowledge-based economy and society.

Some of the most credible futurists predict that up to 30% of professions currently in the world will not exist in 25 years’ time. This could have a dramatic effect on the young researchers now being cultivated in the system. For NRF to contribute in an informed manner to the resilience of the science system (or national system of innovation), it might need to find innovative ways - together with its partner institutions - to understand to greater depth whether these upcoming scientists are sufficiently empowered with the technical and entrepreneurial capabilities, and the market-attractiveness, demanded by a resilient science system in order to yield dividends from NRF investments for a long time to come. Not only that, but continuous attention will be needed to shaping these scientists’ ‘ecosystem’ or enabling environment (whether social, cultural, policy, institutional or economic) so that they can continue with, and emulate the legacies of their mentors.
It therefore remains essential that the DST, NRF and other national stakeholders work in a coherent manner to (i) promote the uptake of research of quality, and (ii) cultivate confident, market-appropriate, entrepreneurial leaders for the future. The impacts of the NRF funding instruments are successive, from building capacities to contributing to socioeconomic impact on a local, national, regional or global scale. Building from a weak base will make for weak impacts, and so will a serious disconnect between the producers and users of research evidence.

Many recent studies have tried to address the challenge of supporting evidence-informed decision- and policymaking; much can be learned from these. In addition, next generations of appropriately skilled, entrepreneurial or market attractive leaders in science and innovation are critical. They will be the main actors generating socioeconomic impact in future. They will also work in an environment where many types of careers will cease to exist in coming decades. Thus, how current leaders in science and innovation conceptualise and approach their work will sharply influence these generations – and so will those who determine the context in which they work.

Only from a sound base of appropriate human resources, and coherent national and institutional policies and strategies will a sustainable and resilient science and innovation system emerge. The NRF together with DST should be congratulated with establishing and managing initiatives that, although not yet fully realised, already have many elements that contribute to such a system, while also adding socioeconomic and strategic value to national interests.