

Evolution of the South African Science, Technology and Innovation System 1994-2010: An Exploration

Hendrik C Marais* and Magdal Pienaar**

Abstract

This paper is part of a longitudinal project on the evolution of the South African science, technology and innovation (STI) system since 1994, the year that marked the end of apartheid government. It was hypothesised that the overarching national (and international) commitment of the post-1994 government to reform society to become an inclusive system serving the needs of all would impact on four of the main pillars of the STI system, viz. national policy objectives, funding of the system, the human resource composition (specifically race) and steering/control mechanisms. The research approach consisted of qualitative analyses of official published information. The analyses supported the hypothesis with regard to policy changes, the transformation of the human resource base, at least at managerial and executive levels, and the tightening of steering of the public STI system. It was found, however, that funding of the system relative to GDP in effect stalled while new policies were put in place. Funding has started rising moderately since 2001. The paper concludes by identifying six sets of developments that both individually and in combination would probably influence the further evolution of the STI system.

* Professor, Graduate School of Technology Management, Faculty of Engineering, University of Pretoria, Pretoria, South Africa. Emails: hc.marais@up.ac.za and marais.stnetwork@gmail.com

** Manager, Strategic Planning and Reporting, National Research Foundation, Pretoria, South Africa. Email: magdal@nrf.ac.za

Keywords: Innovation Policy, National System of Innovation, R&D Expenditure, Research Funding, South Africa.

JEL Classification: O30, O31, O55.

1. Introduction

Officially the end of the apartheid political system in South Africa came in 1994 when the African National Congress of Nelson Mandela won a landslide victory in the first democratic election, afterwards to take over the reins of political power. In principle, that change of political power represented a change from an overtly pro-white system of discrimination – also at the level of the science, technology and innovation (STI) system - to a democratic black majority government. In the words of Mandela: “Let each know that for each the body, the mind and the soul have been freed to fulfil themselves. Never, never and never again shall it be that this beautiful land will again experience the oppression of one by another...” (1994: 3). Political developments, such as these in South Africa, offer an opportunity to study the influence of political transformation on selected dimensions of the STI system.

Several overviews of the South African science, technology and innovation system have appeared in recent years. These reviews vary considerably in objectives, scope and focus and provide useful insight into the interaction between radical political change and the science, technology and innovation system. The OECD (2007) produced its country study of South Africa in 2007 which offers a comprehensive overview of the system as is. The background report to the OECD final report also offers a useful local perspective on the system (NACI, 2006). Mouton (2006) sought answers to the following three questions: Whose demands were being addressed by the post-1994 system, how research agendas were constructed and which were the dominant modes of knowledge production?

This paper reports on a component of a longitudinal project started in 1999/2000 (Marais, 2000) that will be completed in 2011. The paper is structured as follows: Main features of South Africa and its science, technology and innovation system, conceptual framework, hypothesis, research approach, policy objectives, funding of the system, human resource equity in the system, steering of the system, conclusions, future perspectives, and final comment.

2. Main features of South Africa and its STI system

The following thumbnail description of South Africa offers a context for the rest of the paper.

Geo-political characteristics

Geographically, South Africa lies at the southern tip of the African continent at the coordinates of 29 00 S, 24 00 E and covers approximately 1 219 090 square kilometres. In 1994 it became a constitutional democracy with an executive president and a two-house parliament; it consists of nine provinces; the most recent election took place in April 2009 which the African National Congress won by 66% of the vote. The most recent census showed a population of 48.5 million people (Presidency, 2008): African: 38 565 100; Coloured: 4 379 200; Indian: 1 243 500; White: 4 499 200 (Statistics South Africa, 2008a); 60% of the population lives in urban areas and 40% in rural areas (UNICEF, 2007). South Africa's adult literacy rate in 2006 was 74.4% (Presidency, 2008). The country has eleven official languages and 8.2% of the population listed English as their first language. In 2007, about 5.7 m people were living with AIDS, and over 350 000 deaths were recoded as due to AIDS (CIA, 2009).

The economic dispensation can be described as a free market one with a strong and active labour union movement and much debate about stronger government interventions to alleviate the plight of the deprived parts of the population. Some of the major economic indicators are: GDP - 2007: R1 994 billion, i.e. \$283 billion; GDP per capita - 2007: R41 120 or \$ 5 815 (Presidency, 2008); mean per capita income (2007): R1 514; inflation rate (March 2009): 5.4 % (Statistics South Africa, 2009); unemployment rate (first quarter 2009): 23.5 % (Statistics South Africa, 2008b); Gini coefficient (2007): 0.66 (NACI, 2008b); relevant competitiveness ranking (NACI, 2008b) -- GCI ranking (2008): 44th out of 127 countries and IMD ranking (2008): 53rd out of 55 countries

In short, South Africa is a relatively complex country characterised by a large rural and disadvantaged section of its population with all the characteristics of that. It can be described as a developing or middle-income country.

The science, technology and innovation system

Against the above background the main features of the current South African science, technology and innovation (STI) system can be summarised as follows (cf. OECD, 2007 for a general overview):

- Three central government ministries are extensively involved in science, technology and innovation, viz. the departments of Science and Technology, Trade and Industry and Higher Education and Training.
 - A regional innovation systems strategy is currently being developed
 - International cooperation: 47 bilateral agreements being serviced
 - GERD: 0.95%
- Public research institutions: 8 Science Councils (DST, 2009a)
 - Researchers: 2 255
 - Others: 3 543
 - R&D expenditure: R2 744 718 000 (16% of Gross Expenditure on R&D; GERD)
- Government (museums, departments, etc. and excl. science councils) (DST, 2009a)
 - Researchers: 1 111
 - Others: 1 813
 - R&D expenditure: R1 021 355 000 (6.2% of GERD)
- Higher education institutions: 23 universities (DHET, 2009; DST, 2009a; NACI, 2008b)
 - Researchers: 27 746
 - Others: 4 287
 - Total number of students: 761 087 (in 2007)
 - Number of master's and doctoral enrolments (2006): 51 223
 - Number of master's and doctoral degrees awarded (2006): 9 158
 - Science, Engineering and Technology (SET) enrolments (2006): 211 584
 - SET graduations (2006): 35 555
 - R&D expenditure: R3 298 808 000 (20% of GERD)
- Private/Business sector (DST, 2009a):
 - Researchers: 8 227
 - Others: 9 240
 - R&D expenditure: R9 243 165 000 (55.9% of GERD)

- Productivity of the science, technology and innovation system (ASSAf, 2006; NACI, 2008b):
 - Publications (in ISI journals – in 2006): 4 971
 - Patents (in 2005): 125
 - Technology balance of payments (in 2006): \$ 1 278 300 000 (payments); \$ 456 000 000 (receipts)
 - Accredited South African scientific/scholarly journals: 255

The above information shows that South Africa has a lot in common with middle income countries when it comes to its main science, technology and innovation characteristics.

3. Conceptual framework

For the purpose of this paper the STI system was defined as a complex hierarchical system of role players interacting within the context of policies and strategies by means of policy mechanisms and instruments towards the production of one or more or a combination of the following: new knowledge, technology, innovation and appropriate human resources. Public STI policy can be defined as the political course of action with regard to the generation, acquisition and application of knowledge to give effect to the government's vision for the country (Marais, 2000: 11; Shils, 1968: ix). The four main pillars of policy, used here, are mission and objectives, funding, provision of human resources and control over the execution of the policy.

4. Hypothesis and research approach

It was hypothesised that the change of political dispensation from an overtly pro-white discriminatory system to a democratic black majority government would especially be reflected in:

1. Changes to the objectives set for the system, such as the promotion of the interests of the previously excluded black section of society;
2. Financial enablement of the system by ensuring sufficient funding to give effect to official objectives;
3. Transformation of the human resource base by actively advancing previously marginalised black scientists and managers; and
4. Steering of the national science, technology and innovation (STI) system to achieve its policy objectives.

It should be noted that this study did not consider the merits, feasibility or time perspective of the political commitments reflected in the hypothesis and the various policy documents.

The research approach consisted of analyses of published information, mostly government reports and public statements by key role players, available in the public domain, supported by reports on the proceedings of parliamentary committees (reflected in the reports of the Parliamentary Monitoring Group, e.g. 2010). Incomplete time series were constructed where possible to determine any trends. Unfortunately, this could not be done in a consistent way, since it often proved difficult to access public documents, while many of them were undated.

The study was conceived as an exploratory descriptive study to identify trends and associations, if any, at a relatively high level of analysis upon which further probing could be done at a later stage.

The pre-1994 STI system was used as implicit baseline of the study, but space limitations did not allow such data to be included in this paper. The following notes are offered as a general orientation, however. The South African STI system up to 1994 was acknowledged to have been:

- Reasonably strong for a middle-income country (explicitly acknowledged by at least two post-1994 ministers of science and technology); and
- Set upon minimising the effects of the country's growing international isolation (incl. academic, science, technology and innovation) by ensuring self-sufficiency.

The human resource component of the system consisted nearly exclusively of pro-establishment white South Africans. It should be noted though that at the level of R&D performers, a significant part of the historically white English universities (research intensive) and black universities (predominantly teaching institutions), and a relatively small part of the historically white Afrikaans medium universities (research and teaching) did not associate themselves with the STI mission of the government of the day.

5. Policy objectives

Dawn of a new dispensation

The sun of the apartheid dispensation set on an ambivalent STI system. The last years of the apartheid regime could be described as an interregnum (Marais, 2000) characterised by dynamics typical of such periods in the history of a country. On the one hand, the government of the day was

marking the pace as it were, not keen to attend to any queries by the public STI system (e.g. on the dysfunctions of the funding system, known as *framework autonomy*), nor committed to institute new and inevitable changes to the system (e.g. implementing a draft innovation policy). This led to considerable frustration amongst the role players.

The government-in-waiting, consisting primarily of the ANC and its main partners at that stage, namely the labour movement (COSATU) and the national organisation of NGOs (SANCO), filled that space quite dynamically by, among other things, commissioning "a review of existing S&T policy (...) and of the institutions involved" (IDRC, 1993: 22-24) with the financial and professional support of the Canadian International Development Research Centre (IDRC). In the wake of its report (IDRC, 1993), the ANC, among other responses, established a science and technology forum, *S&T Initiative*, that brought together all the role players to reflect on the nature of an imminent new system (Marais, 2000). Among the many effects of these initiatives were the following: first, these and related initiatives provided the government-in-waiting (until then largely alienated from the system) a representative overview of the nature and functioning of the system; second, these initiatives established the new role players' legitimacy, symbolic, if not yet real, power and provisional framework for planning a transformed STI system.

Taking office

The new government took office in April 1994 and the new Department of Arts, Culture, Science and Technology (DACST) was established with Dr Ben Ngubane (member of a minority party) and Ms Winnie Mandela (leader of the ANC Women's League) as the first minister and deputy minister, respectively; Mr Roger Jardine (formerly the national coordinator of the ANC S&T planning department) was appointed as first director-general of the new department at the age of 29.

The *White Paper on science and technology: Preparing for the 21st century* (DACST, 1996), was the first comprehensive policy document produced by that department. It represented a significant rotation of the STI axes yielding the following 'new' dimensions: (i) Innovation became the *leitmotif* of the policy; the system being described as a national system of innovation - apparently the first time done by a government; (ii) Key central functions were policy formulation and control, public resource allocation and initiation of new programmes; (iii) Changing the funding system from formula-based to multi-year zero-budgeting, accompanied by performance criteria and avoidance of micro-management of public research institutions; (iv) Performance measurement by means of peer evaluation and efficiency

auditing; (v) Promotion of human resource development, including mechanisms to redress racial imbalances; (vi) Levelling of regional inequalities.

The new dimensions deviated significantly from those of the apartheid government whose last significant policy documents dated back to 1988. In the space of two years the publication of the 1996 *White Paper on S&T* was followed by a series of other setting-the-baseline reports, including ones on financing and reporting systems, a system-wide review of public sector STI institutions, a national research and technology audit, a national R&D survey, and the establishment of an innovation fund.

Policy commitments made during the first four years of the new democratic government can be summarised as follows: (i) Focussing on innovation without neglect of basic research; (ii) Priority driven resourcing; (iii) Redressing human resource inequities; and (iv) Performance monitoring and evaluation of public research institutions.

The *White Paper on S&T* set parameters for the evolution of STI policy and system in the country over the next 14 years. The following paragraphs offer, first, an abridged overview of main events that directly or indirectly may have impacted on STI policy and its deployment and, second, a summary of the main policy and strategy developments.

Important events since 1998

Establishment of the National Advisory Council on Innovation in 2000 (NACI)

This council was appointed to advise the minister and the government on a wide range of matters pertaining to innovation policy and systems in the country. The NACI Act specified that the director-general of DST would also serve as chief executive officer of the Council thereby limiting, if not diluting, the organisational and critical functions of the Council (cf. Marais, 2000; OECD, 2007; NACI, 2002a and 2008a). In this and other respects, this act is significantly more restrictive than that of, for instance, the Council of Higher Education (Marais, 2000; Pistorius, 2008).

NACI review of the implementation of the White Paper on S&T (2002)

In 2002 NACI initiated a review by an international panel to assess the success of the implementation of the *White Paper on S&T* (NACI, 2002b). In general, the review was positive about the range and nature of policies, strategies and programmes initiated by the department up to that time. However, one of its main reservations concerned the lag in implementation of policies, which the report attributed to a shortage of appropriate human resources.

Science and Technology becoming a separate ministry and department (2004)

The third ANC government took office in 2004 and split the ministry of science and technology from that of arts and culture and in doing so created the first separate ministry of S&T in the country's history. This move, on the one hand, raised the political status of science and technology considerably and allowed the ministry to focus exclusively on promoting STI and increase its human resource capacity, on the other. The new department was subsequently allocated the oversight function of science and technology across government departments.

OECD review of the South African National System of Innovation (NSI) (2007)

In 2007 the OECD published its country report on the South African national system of innovation (OECD, 2007). This was to a large extent a review of the policy, strategy and institutional landscape and was based on an extensive and comparative analysis and evaluation of the STI system. One of the conclusions read: "The key story has been about reshaping a relatively strong innovation system serving one set of social, economic and political goals towards another strong system serving a very different set of goals" (OECD, 2007: 4). The report identified the following shortcomings of policy responses to the situation South Africa was facing at the time: (i) Over-emphasis on the role of public R&D institutions at the expense of business technology and innovation in the NSI; (ii) Stretching resources too thinly over too many priorities, often preventing a critical mass being reached; (iii) "Too little connection between strategies and their implementation"; (iv) Limited vertical specialisation and differentiation between organisations responsible for governance of the system; (v) Limited horizontal interaction and coordination between organisations involved in the governance of the system; (vi) Very limited integration between national level policy on the one hand and provincial and local innovation policy and organisations on the other.

Appointment of a new Minister of S&T (2009)

The inauguration of the fourth ANC government in 2009 saw for the first time an ANC member, Ms. Naledi Pandor, filling the portfolio of S&T. The previous ministers responsible for this portfolio were from small minority parties. It is generally anticipated that this fact would increase the potential impact of the ministry. Another advantage the minister is bringing to her new portfolio, is the fact that she served as Minister of Education in the previous government and in that capacity had gained a great deal of insight

into the role of the higher education system in the NSI. The possible effects of her appointment are further explored in a later section of this paper under the heading, *Future perspectives*.

Main policy developments

The *White Paper on S&T*, moderated by various events, led to a wide range of strategies, programmes and policy related developments. Some of the more important ones include a national R&D strategy; sharply increased international networking (e.g. 47 bilateral agreements); regular institutional and programme reviews; at least six sector specific strategies (e.g. biotechnology, advanced manufacturing and indigenous knowledge); new agencies (e.g. the Technology Innovation Agency and the Space Agency); new research facilities and infrastructure (e.g. the South African Large Telescope); several new R&D support programmes (e.g. the South African Research Chairs Programme); regular R&D and innovation surveys; and, downstream, the redirecting of the portfolios of several PRI programmes (e.g. the Council for Scientific and Industrial Research's poverty programme and the introduction in 2001 of a directed/strategic research programme by the national funding agency, the NRF).

To recapitulate, the following summary can be drawn from the preceding overview of policy developments since 1994:

- The liberation struggle brought a whole range of commitments and expectations, also about the role of STI.
- The new role players in the democratic government were reasonably well prepared to take over the public STI functions.
- The period up to approximately 2000 produced essential policy initiatives, but the implementation lagged behind.
- The policy initiatives were predominantly focussed on the upper end of the innovation value chain – i.e. knowledge production – notwithstanding the original commitment to innovation.
- The primary focus within the innovation context was mostly on competitiveness rather than on development of the disadvantaged component of the population.

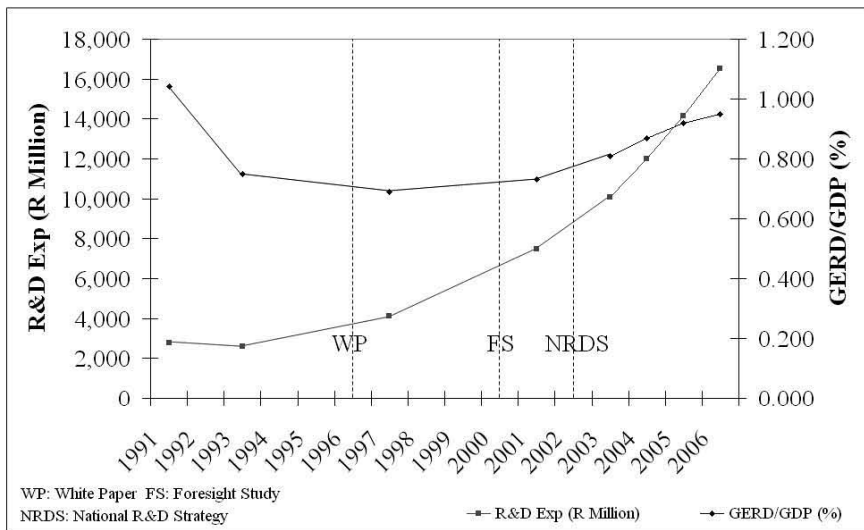
The black majority government has succeeded in changing the nature and direction of science, technology and innovation policy in the country and it did so in line with early commitments to promote the interests of the previously disadvantaged black majority. There is agreement amongst policy analysts, however, that the government has not been as successful in implementing its new policies as it has been in developing them. It appears

that lack of resources has been the main reason for this. The following two sections discuss this issue.

6. Funding of the STI system

The *White Paper on S&T* committed the government to funding the public component of the NSI on a competitive basis. This section offers a brief overview of developments with regard to financial aspects at both departmental level and national levels. Figure 1 summarises the R&D Expenditure before and after the 1994 change of government.

Figure 1: R&D Expenditure and Intensity (1991/92 – 2006/07)



Sources: DNE, 1993; FRD, 1995, 1996; DACST, 2000, 2002, and 2004; DST, 2008 and 2009a

The following comments are relevant in interpreting the GERD/GDP ratios in Figure 1:

- (i) The significant decline between 1991 and 1994 could be ascribed to the sharp decline in defence related R&D on the one hand and methodological differences between those two surveys on the other.
- (ii) The stabilisation between 1994 to 2002 might be interpreted as a period during which the pre-1994 'business' (without the defence component) was continued, since there were not yet new missions for the different sectors; new initiatives were mostly funded by top-slicing

existing budgets (cf. Marais, 2000). It might also imply that the STI system did not share fully in the growth of the economy that followed the democratisation of the country in 1994.

- (iii) The steady rise since 2002 is probably a function of economic growth in general and the implementation of new strategic initiatives that followed in the wake of the *National R&D Strategy*, these included the government's commitment to attain the magic 1% by 2010 (Expressed in constant 2000 values, however, the growth has been much slower since 2000; DST, 2009a).

Interestingly enough, the budget of DST, the government department primarily responsible for funding STI, shows a relatively sharp rise since 2000/01, that is, from just under R1 billion to R3.1 billion in 2007/08.

The above analyses show that relative investment in the STI system stagnated, although the absolute amount of money increased more than eight-fold. The decline in gross expenditure on R&D probably inhibited the government from giving full effect to all its intentions as represented in new STI policy directions and initiatives, since there were simply many other and more pressing national imperatives that had to be addressed.

7. Human resource equity

The *White Paper on S&T* undertook to correct race imbalances in the provision of human capital. (One result of this policy objective is that all government entities have to report on the racial composition of their staff, notwithstanding the overriding ideal of creating a non-racial society – racial transformation is a key performance indicator.) The following information allows a provisional assessment of the progress or otherwise the government has made in this regard, viz. the staff composition of the key department DST (Table 1), the management cadre of universities and public research institutions (PRIs), the racial composition of the research force in government and PRIs (Figures 2 and 3), the national work force in STI (Figure 4), and scholarships and research grants awarded by the country's main research funding agency, the National Research Foundation (Figures 5 and 6).

Civil servants

The data on the composition of the key department involved in science, technology and innovation are reflected in Table 1 and cover the period before and since the Department of S&T was separated from the branch Arts and Culture. It is clear that newly appointed African staff accounted for

most of the approximately 30% growth in personnel. To gain a fuller perspective on this finding, reference should be made to an earlier study covering the period up to 2001 (Marais and Pienaar, 2001) that showed a black:white ratio of 11:8 in the management cadre. In 2009 this ratio has changed to all almost 7:1.

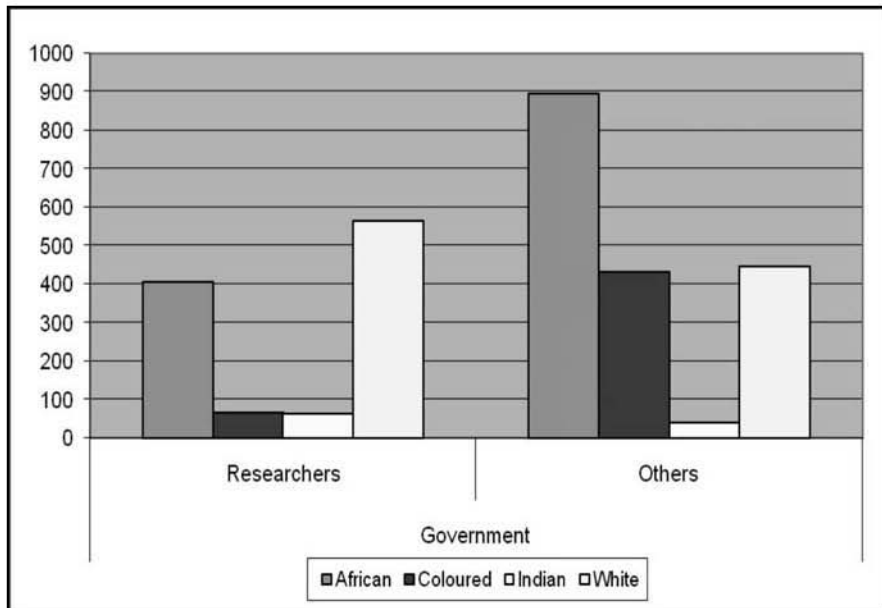
Table 1: Racial Categories of Staff of the Department of S&T

Category	2000/1*	2002/3	2003/4	2004/5	2005/6	2006/7	2007/8
African	221	91	140	147	173	221	255
Coloured	42	10	12	16	13	19	20
Indian	11	7	12	14	16	17	18
White	182	23	26	32	30	34	31
Total	456	131	190	209	232	291	324

Sources: DACST, 2001; DST, 2004, 2005, 2006, 2007, and 2008

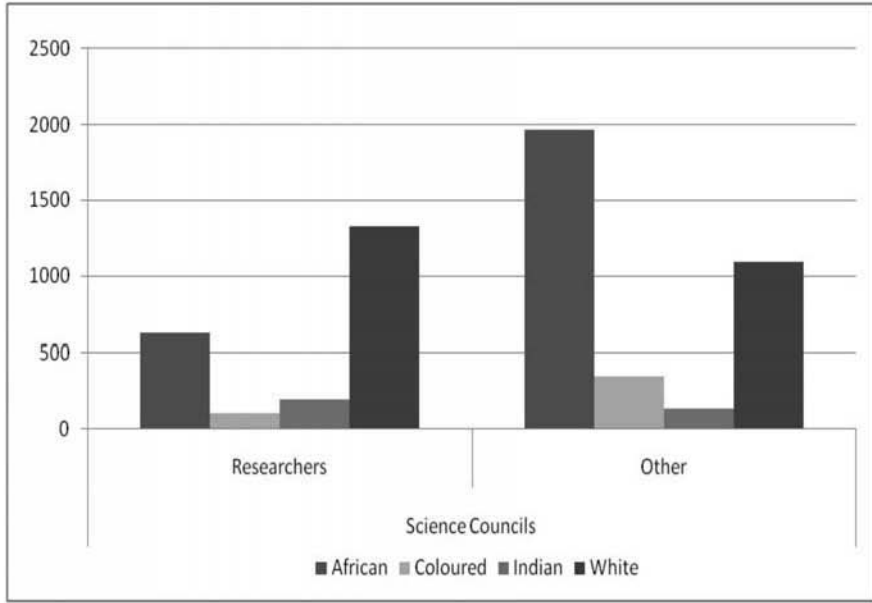
Note: *Including Arts and Culture branch of the Dept. of Arts, Culture, Science and Technology

Figure 2: Racial Composition: Government



Source: DST, 2009a

Figure 3: Science Councils (PRIs)



Source: DST, 2009a

Chief executive officers: Public research institutions and universities

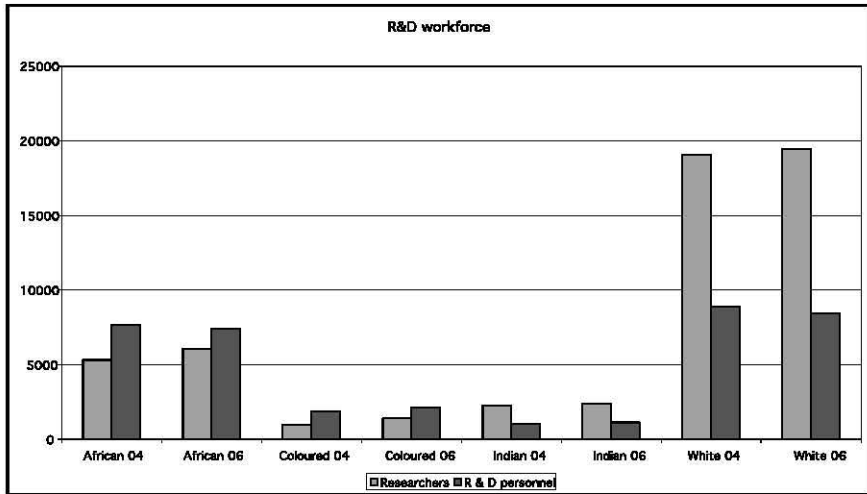
Ministries, with support of their departments, are directly responsible for the appointment of the chief executive officers of PRIs and one might expect that the trend seen in DST would also be reflected in the composition of the top cadre of the PRIs. Seven of the current eight presidents/chief executive officers are black and one white. By way of comparison, Marais and Pienaar (2001) reported that while there was no black senior manager in 1994, blacks represented 63% of the senior management cadre in 2000. The transformation has indeed been comprehensive. The councils of universities are responsible for the appointment of vice-chancellors. By the end of 2009, 21 of the 23 vice-chancellors were black and two were white.

Researchers

The staff composition of government research entities and PRIs (science councils) are separately shown in Figures 2 and 3. Inspection of these figures clearly shows that white researchers are in the majority in both sectors, while Africans represent the majority in the non-research component of staff.

The next question is what the profile of the national R&D workforce looks like. Inspection of Figure 4 shows that there were nearly four times as many white as black researchers in the system in both 2004 and 2006. Although the absolute number of black researchers has increased since 1994, it is likely that it would still take a considerable period of time before the ratio would change significantly.

Figure 4: R&D Workforce (2004-2006)



Sources: DACST, 2004; DST, 2009a

Grants, bursaries, scholarships and research grants

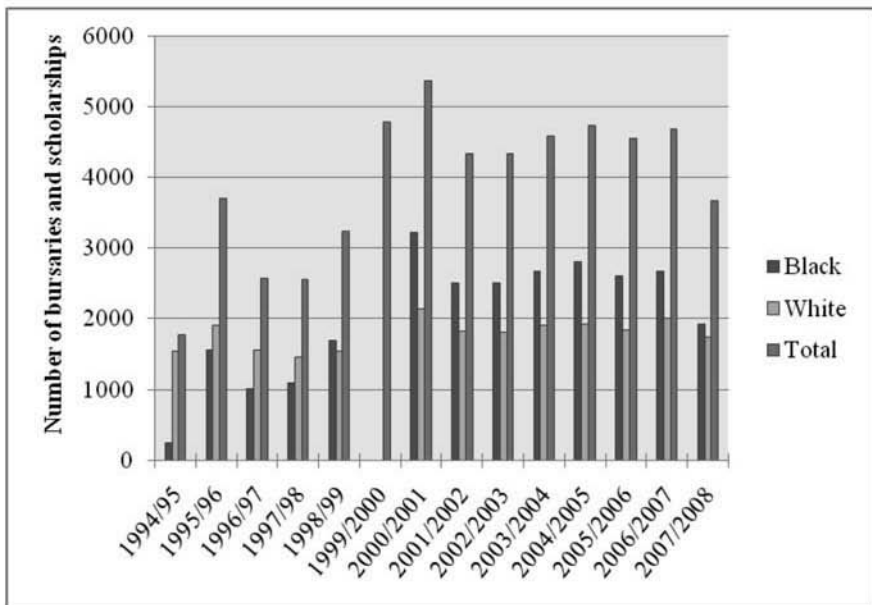
A potentially useful indicator of the future human capital pipeline is student support offered by the main public funding agency, the National Research Foundation (NRF). Table 5 reflects information on NRF bursaries and scholarships for the period 1994-2007.

At least three observations are relevant in the context of the current analysis. First, the number of black scholarships awarded in the natural sciences and engineering increased sharply after 1994 – the political watershed year. Second, in 1998/1999 the number of black bursars and scholarships for the first time exceeded that of whites. Third, the incorporation of the social sciences and humanities in the new funding agency, the National Research Foundation, in 2000 further reinforced the position of black students, and 2007/09 recorded a narrowing of the gap between the number of bursaries and scholarships to black and white students. Figure 5 indeed suggests

deliberate attempts at strengthening black representation in the human capital pipeline.

The distribution of NRF research grants could be taken as an indication of peer-reviewed research activities, especially at universities. NRF grants range from support for the attendance of conferences to large research grants for senior researchers. Information on NRF research grants (2001-2008) can be found in Figure 6.

Figure 5: Bursaries and Scholarships Awarded by the NRF (1994-2008)



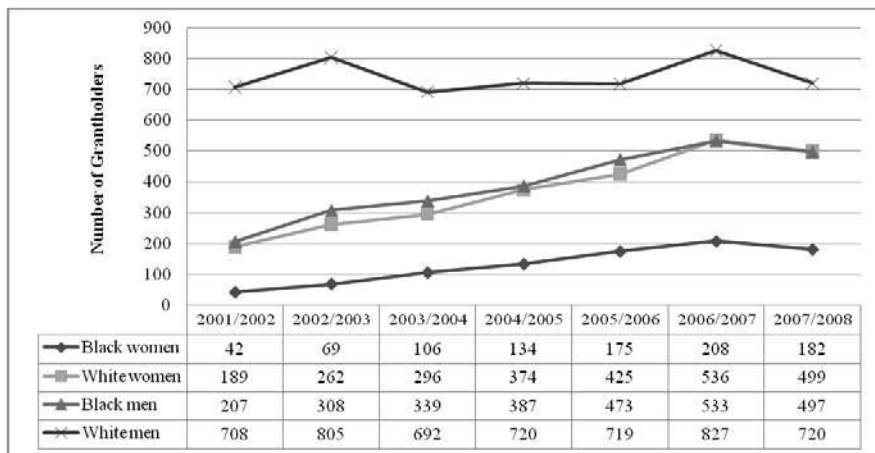
Sources: FRD, 1995a to 1999; NRF, 2001 to 2008

Notes: 1994-1999: Reflects the support for Natural Sciences and Engineering from the former Foundation for Research Development. The data for 2000/2001 to 2007/2008 include the Social Sciences and Humanities.

Analysis of Figure 6 shows several relevant trends. First, the number of research grants awarded to black women and men as well as to white women has more or less doubled between 2001/02 to 2006/07. Second, grants to black men and white women increased considerably relative to grants to white men over the past six years, although the latter received approximately 50% more grants than black men and white women. Third, black women received significantly fewer grants than the other three categories of researchers.

To summarise, the information on human capital presented here, indicates that the South African government has been only partially successful in attaining its objective of redressing the racial imbalances in the science, technology and innovation system. First, the demography of the management cadre of virtually all components of the system has been changed from predominantly white to nearly exclusively black. Second, across all sectors of the system the ratio of African to white researchers is still in favour of the white component of the nation, although the gap is narrowing, and the reverse is true for non-research staff. Third, black appointments account for the relatively strong growth in personnel of the relevant government department. Fourth, the majority of National Research Foundation grants still go to white researchers, although there has been a steady growth in the proportion of black researchers since the beginning of 2001. Finally, the situation with regard to NRF bursaries and scholarships is however more favourable, if it is considered that more black than white students hold these bursaries and scholarships. It is clear that the government is committed to correct racial imbalances in the composition of the human resource base, but that it may still take several years to succeed, other things being equal.

Figure 6: NRF Support for Researchers: 2001-2008



Sources: NRF, 2002 to 2008.

8. Steering

The previous sections on policy and steering through financial and human resourcing showed that the extent and success with which the South African government has given effect to its undertakings of the early 1990s has been

variable. This section surveys the mechanisms of control the government Department of S&T uses in steering Public Research Institutions, i.e. science councils, including specific mandates, governance structures, governance guidelines and planning, budgeting and reporting mechanisms and cycles.

Statutory mandate and governance

Public Research Institutions (PRIs) are established, mandated and governed through acts of the South African parliament. They are governed by boards, nominations of which are considered by a parliamentary committee, eventually appointed (including the chair) by the relevant minister and ratified by the cabinet. The president/chief executive officer of a PRI is also appointed by the relevant minister after recommendation by the board and ratified by the cabinet. The respective functions and roles of boards and executive management are outlined in broad terms in the respective institutional acts and the responsibilities of the board are formalised in the Board Charter. The regulatory framework consists of several policies, covering corporate governance (IDSA, 2009; Department of Public Enterprises, 2002), public finance (National Treasury, 2002; 2007) and general civil service prescripts.

Planning, budgeting and reporting control

The main mechanisms used for steering and controlling PRIs immediately before 1994 were formula-based budgeting, annual financial auditing and annual reports submitted to parliament. The first steps towards performance auditing were taken immediately before 1994. The post-1994 government has over the past 15 years in many respects followed international practice for accountability by applying a management model not unlike, e.g., the US *Government Performance and Results Act of 1993* (cf. Cozzens, 1999; Presidency, 2007; OECD, 2006: 191) and evolved a series of steering mechanisms that guide the programmes of the PRIs rather directly. These mechanisms cover the PRI's strategic planning, operational plans and budgets, as well as monitoring and reporting on such activities. The following paragraphs offer analyses of the main trends in this regard.

Strategic planning

By definition PRIs are mandated to allocate a substantial part of their strategic plans to addressing the priorities of government as reflected in a range of documents like the Medium Term Strategic Framework (MTSF; Presidency, 2009) and informs the Medium Term Expenditure Framework

(MTEF). Other key government references PRIs have to accommodate are the *National R&D Strategy* (DST, 2002) and the *10-year innovation plan* (DST, 2007).

Operational plans and budgets

Two planning documents have to be submitted each year by a PRI to its line department, viz. a shareholder's compact and a corporate plan. Each of these is briefly described in the next paragraphs.

The South African National Treasury provides a *Guideline Framework for Corporate Planning and Shareholder's Compact* (2002) applicable to most major public entities. The guideline set out the requirements and format for the Corporate Plan. It also provides a framework for the Shareholder's compact that represents an agreement between government as the majority shareholder of the public entity and the Board of Directors of that public entity.

The annual financial year runs from 1 April to 31 March. Planning commences when the Department of Science and Technology feeds expected revenue and expenses into the national budgeting process that find expression in the Expected National Expenditure. Corporate plans specify the outputs that are to be produced, performance indicators, performance targets and available resources. The Corporate Plan has to be approved by the Minister, and is then presented to the Parliamentary Portfolio Committee for Science and Technology. In addition to the Corporate Plan, the Shareholder's Compact formalizes the relationship between the signatories and focuses on the performance targets.

Monitoring and reporting

Until 1994 the main reporting document expected of a PRI was its annual report. However, each PRI was soon required, as originally intended by the White Paper (DACST, 1996), to submit to the Department of S&T (DST) not only information on financial aspects, but also on its performance in the form of Key Performance Reports (since 2001) and quarterly progress reports (since 2007) in addition to the annual report (audited by the office of the Auditor General). Table 2 offers an overview of the types and frequency of performance reports required of PRIs.

Table 2: Performance Reports to be Submitted by PRIs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec				
<i>Planning cycle for coming year</i>																
Budget submission																
Business Plan																
Shareholder Compact																
<i>Prior year Performance Reporting</i>																
KPI Report																
Annual report																
<i>In-year performance reporting</i>																
Quarterly Report																
Contract Reporting																
<table border="1" style="width: 100%; text-align: center;"> <tr> <td style="width: 50%;">Preparation</td> <td style="width: 10%; background-color: #cccccc;"></td> <td style="width: 40%;">Submission</td> <td style="width: 10%; background-color: #333333;"></td> </tr> </table>													Preparation		Submission	
Preparation		Submission														

All performance reports have to be signed off by the Chairman of the PRI's Board. Official responses by DST normally follow submission of these reports (these were not accessible to analysis in this study): (i) Quarterly report: Feedback to the Board on areas where (incl. specific line items) improvement is required; (ii) KPI reports: Infrequently, DST would provide detailed feedback to the top management of the PRI; (iii) Annual report: It has to be approved by officials of DST prior to printing. Once printed it is analysed by DST, submitted and presented by the PRI to the Minister for approval and finally to the Parliamentary Portfolio Committee for scrutiny. To recapitulate:

- The number of governance and control measures has increased and become increasingly formalised, while there are signs that they are 'audited' in an increasingly detailed way. The increased steering of the system comes close to what Mouton (2006) aptly described as "the increasing homogenisation of research demand in the South African S&T system".
- The above must of necessity require competent human resources with relevant experience and skills at departmental level to monitor

performance and exercise control (without access to the detailed feedback by government to PRIs one could only conclude that a significant responsibility would be expected of the officials involved in this function); the danger of micro-management lurks around the corner.

- Fiscal and performance controls are being aligned and performance reporting has increased in importance.
- The size of the budget may not justify the level of control i.e., the economy and efficiency of exercising control have to be established.
- The advantage of the current approach to steering is that it promotes good governance and transparency, but the obvious disadvantage is that it may result in micro-management especially because the bulk of the budget is ring-fenced.

9. Findings

This study explored whether and to what extent the South African government, through its Department of S&T (DST), has since the demise of apartheid dispensation in 1994 transformed the main pillars of the STI system to support a non-discriminatory democratic political ideal. Information used to assess developments over the past 16 years included new policy initiatives, funding allocations, human resources profile and control mechanisms applicable to PRIs (science councils). The study was contextualised within the framework of a middle income/developing country with a rather complex socio-economic make-up but a reasonably well developed STI system by the time when the first democratic government came to power in 1994.

The analyses showed: First, that the core STI missions were changed substantially over time. However, the implementation of such policy changes was uneven and tended to concentrate on the upstream part of the innovation value chain, namely R&D and in areas such as space science. Furthermore, a key commitment to utilise STI for the benefit of the disadvantaged sections of the population seems to have been neglected.

Second, the funding of the STI system has grown strongly in absolute terms, but the system does not seem to have really shared in the relatively strong economic growth between 1994 and 2002. To some extent the stagnation of the GERD/GDP ratio may reflect the mismatch between policy development and rigorous implementation. That is, strong policy development has not been accompanied by rigorous implementation.

Third, extensive transformation has been brought about on the human resource dimension in terms of racial transformation. This conclusion applies especially to the top structures of government itself and those institutions over which they exerted direct control. However, at the levels of

professional research staff, whites in that sector still represent a relatively large majority. This also applies to the total R&D workforce. There has been progress in correcting racial imbalances on the input side, as measured by public funds for postgraduate studies and research.

Fourth, the relevant government department responsible for science and technology (DST) has introduced a range of new steering mechanisms and significantly tightened its control on public research institutions. This is in line with intensified government controls in general, that are probably not unique to this country. However, using these monitoring and control mechanisms will eventually put a significant stress on the bureaucracy and the relationship between the elements of the multi-layered system. One can pose the question whether the 1996 *White Paper's* commitment to control without detail management will be upheld.

The qualitative analyses justify the conclusion that the South African government has over the past 16 years partially succeeded in transforming the STI system to correct past discrimination and inequality. It has been especially successful at the policy, governance and management levels but less so at enabling the system financially and in terms of human capital to implement fully all its policy goals.

Future perspectives

The exploratory analyses reported above offer a basis for reflecting on the further evolution of the South African STI system. Three additional sets of information can be added to the qualitative equation which would allow a limited set of cautious perspectives on the future. The additional information included in the following future perspectives are, first, the general policy of the new ANC government as reflected in, among others, public statements by the current Minister of S&T (cf. e.g. Pandor, 2010), second the corporate strategy of the Department of S&T (DST, 2009b) and, third, the current economic crisis. These perspectives are offered without additional discussion.

Development imperative

The South African government's commitment to service the needs of the disadvantaged part of the population (see e.g. Presidency, 2009) can be expected also to effect STI priorities, especially since the STI system appears not to have prioritised the development imperative. This focus can best be summarised under the title of innovation for development. It would cover broad-based innovation, indigenous knowledge systems, public understanding of STI in deep rural areas, etc.

The implementation challenge

At least three reputable assessments over the past decade have noted that the government was very productive with regard to policy development, but that implementation of those policies seemed to lag further behind than what would have been expected. The analyses in this paper did show, though, that progress has been made over the past approximately five years. Future governance of the STI system could be expected to insist on explicit time frames for implementation as well as monitoring and evaluation schedules.

Financing of the STI system

Political commitment to increase GERD to reach 1% of GDP over the short term seems to be very serious. What is not clear at this stage is how deep the impact of the current economic crisis will be. Over the short term, it would seem that the best way for the STI community not to slip back, would be to become more effective and efficient by taking monitoring and evaluation seriously, to consider seriously how research findings can be utilised better – also in the case of curiosity-led research, and to foster collaboration with other professionals, institutions and countries more purposefully, to name but three mechanisms of raising STI impact under conditions of economic uncertainty.

Increased steering

It can be expected that control will be tightened further in the near future. Intensified control can be expected due to the government commitment “to achieve visible and tangible socio-economic development within the next five years” (GCIS, 2009); the creation in the Presidency of a monitoring and evaluation competency to evaluate performance of government; and the expectation to be efficient within the budgetary constraints of the current economic climate. However, the danger of micro-management and the demands this would put on the professionalism of the bureaucracy may become mitigating factors.

New policy initiatives

In June 2010 the Minister of S&T appointed a Ministerial Committee “to review the science, technology and innovation landscape and its readiness to meet the needs of South Africa (and to) assess whether South Africa is making optimal use of its existing strengths and whether it is appropriately

positioned to respond rapidly to a changing global context and thus meet the country's needs in the next 10 to 30 years" (Pandor, 2010). The committee is expected to submit its report before the end of September 2010. It is conceivable that the findings and recommendations of this committee would have important effects on aspects of STI policy in the country.

National dynamics

The above - and other perspectives – would eventually be influenced by the unfolding of the country's future. In this regard, it may be useful to refer to the so-called 2020 Dinokeng scenarios (Dinokeng Scenarios, 2009), that describe three possible futures for South Africa in terms of the relationship between the state and civil society, viz. Collaborative and enabling state, Interventionist and directive state, and the Corrupt and ineffective state. The first scenario would provide an enabling context for STI in future to impact on economic growth and the improvement of the quality of life of all the country's people. The second scenario would require a much stronger human capital base than what is available at present and the end result would probably be increased steering and a narrower definition of the STI mission. The third scenario would probably lead to the collapse of the STI system as described in this paper.

10. Conclusions

The study explored the effects of the democratisation of South Africa after 1994 on the following dimensions of the STI system: policy, financing, human capital and the steering of the system. The research approach consisted of qualitative analyses of official published information. The analyses confirmed, first, that the policy landscape has changed substantially, but that the implementation of such policy changes has lagged behind favouring the upstream part of the value chain, namely R&D on the one hand and high-technology on the other, while innovation for development seems to have been neglected. Secondly, the STI system does not seem to have shared in the relatively strong economic growth of the first two decades after 1994. Thirdly, extensive racial transformation of the human capital dimension, especially at top management level, has taken place. Furthermore, rising numbers of formerly disadvantaged postgraduate students and researchers have increasingly benefitted from public funding. Fourthly, the government has significantly tightened its control on public research institutions.

It would be fair to conclude that the radical political change of 1994 has impacted extensively on the STI system in South Africa, although the government has not succeeded in giving effect to all its STI intentions – a

conclusion corroborated by other studies as well (e.g. OECD, 2007) – but that it seems committed to the further transformation of the system. The extent of its success, however, would depend on dynamic interactions among a range of factors and challenges such as latent internal political tension, the negative impact of the recent economic crisis, and the development needs of the country.

References

- Academy of Science of South Africa (ASSAf) (2006), *Report on a Strategic Approach to Research Publishing in South Africa – 2006*, Pretoria: ASSAf.
- Central Intelligence Agency (CIA) (2009), *World Fact Book*, Available at: <http://www.cia.gov/library/publications/the-world-fact-book>.
- Cozzens, S.E. (1999), 'Are new accountability rules bad for science?' In *Issues in Science and Technology Online* (Summer), Available at: <http://www.nap.edu/issues/15.4/cozzens.htm>.
- Department of Arts, Culture, Science and Technology (DACST) (1996), *South Africa's White Paper on Science and Technology: Preparing for the 21st Century*, Pretoria: Government Printer.
- Department of Arts, Culture, Science and Technology (DACST) (2000 to 2004), *Survey of Resources Allocated to Research and Development 1997/98 to 2003/04*, Pretoria: Government Printer.
- Department of Arts, Culture, Science and Technology (DACST) (2001 to 2003), *Annual Reports 2000/2001 to 2002/2003*, Pretoria: Government Printer.
- Department of Higher Education and Training (DHET) (2009), *Education Statistics – 2007*, Pretoria: Government Printer.
- Department of National Education (DNE) (1993), *Resources for R&D: Results of Survey 1991/92*, Pretoria: Government Printer.
- Department of Public Enterprise (2002), *Protocol on Corporate Governance in the Public Sector*, Available at: <http://www.dpe.gov.za>.
- Department of S&T (DST) (2002), *South Africa's National R&D Strategy*, Pretoria: Government Printer (Originally developed and released under DACST).

- Department of S&T (DST) (2005 to 2008), *Annual Reports 2004/2005 to 2007/08*, Pretoria: Government Printer.
- Department of S&T (DST) (2007), *South Africa's 10-year Innovation Plan: Innovation towards a Knowledge-based Economy*, Pretoria: Government Printer.
- Department of S&T (DST) (2008), *National Survey on Research and Experimental Development – 2005/0*, Pretoria: Government Printer.
- Department of S&T (DST) (2009a), *National Survey on Research and Experimental Development – 2006/07*, Pretoria: Government Printer.
- Department of S&T (DST) (2009b), *2009/10 DST Corporate Strategy*, Pretoria: Government Printer.
- Dinokeng Scenarios (2009), *3 Futures for South Africa*, Available at: www.dinokengscenarios.co.za.
- Foundation for Research Development (FRD) (1995a to 1999), *Annual reports 1994/95 to 1998/99*. Pretoria: FRD.
- Foundation for Research Development (FRD) (1995), *Resources for R&D: 1993/94*, Pretoria: FRD.
- Foundation for Research Development (FRD) (1996), *South African Science and Technology Indicators*, Pretoria: FRD.
- Government Communication and Information System (GCIS) (2009), *Statement by President Jacob Zuma on the Appointment of the New Cabinet, 10 May 2009*, Pretoria: GCIS.
- Institute of Directors of Southern Africa (IODSA) (2009), *Draft Code of Governance Principles for South Africa (King Committee on Governance)*, Available at: <http://www.iodsa.co.za>.
- International Development Research Centre (IDRC) (1993), *Towards a Science and Technology Policy for a Democratic South Africa*, Johannesburg: IDRC.
- Mandela, N.R. (1994), *Inaugural Statement, 10 May 1994*, Pretoria: Government Printer.
- Marais, H.C. (2000), *Perspectives on Science Policy in South Africa*, Menlo Park: Network Publishers.

- Marais, H.C. and Pienaar, M. (2001), 'Empowerment in higher education and research since 1994', *Paper read at the Annual Conference of the South African Academy for Science and Arts*, July, University of Pretoria.
- Mouton, J. (2006), 'Science for transformation: Research agendas and priorities in South Africa', In L. Box and R. Engelhard (Eds.), *Science and Technology Policy for Development: Dialogues at the Interface*, London: Anthem Press.
- National Advisory Council on Innovation (NACI) (2002a), *Audit of South Africa's National Advisory Council on Innovation*, Pretoria: NACI.
- National Advisory Council on Innovation (NACI) (2002b), *Evaluation of the Implementation of the South African Innovation Policy*, Pretoria: NACI.
- National Advisory Council on Innovation (NACI) (2006), *The South African National System of Innovation: Structures, Policies and Performance*, Pretoria: NACI.
- National Advisory Council on Innovation (NACI) (2008a), *Review of the National Advisory Council on Innovation*, Pretoria: NACI.
- National Advisory Council on Innovation (NACI) (2008b), *South African Science and Technology Indicators – 2008*, Pretoria: NACI.
- National Research Foundation (NRF) (2002 to 2008), *Annual reports 2001/02 to 2007/08*, Pretoria: NRF.
- National Treasury (2002), *Guideline Framework for Corporate Planning and Shareholder's Compact Applicable to Schedule 2, 3B & 3D Major Public Entities*, Pretoria: National Treasury.
- National Treasury (2007), *Framework for Managing Programme Performance Information*, Pretoria: National Treasury.
- Organisation for Economic Cooperation and Development (OECD) (2006), *OECD Science, Technology and Industry Outlook*, Paris: OECD.
- Organisation for Economic Cooperation and Development (OECD) (2007), *Review of the South African Innovation Policy*, Paris: OECD.
- Pandor, N. (2010), *Press Release on Appointment of a Ministerial Committee*, (9 June), Pretoria: DST.
- Parliamentary Monitoring Group (2010), Available at: <http://www.pmg.org.za> (Accessed on 16 July 2010).

Pistorius, C. (2008), *Providing Science Advice to Government in South Africa: Review and Proposals*, Pretoria: University of Pretoria.

Presidency (2007), *Policy Framework for the Government-wide Monitoring and Evaluation System*, Pretoria: Government Printer.

Presidency (2008), *Development Indicators – 2008*, Pretoria: Government Printer.

Presidency (2009), *Together Doing More and Better. Medium Term Strategic Framework to Guide Government's Programme in the Electoral Mandate Period (2009-2014)*, Pretoria: Government Printer.

Shils, E. (Ed.) (1968), *Criteria for Scientific Development: Public Policy and Political Authority*, Cambridge, Mass.: MIT.

Statistics South Africa (2008a), *Mid-year Population Estimates – July 200*, Pretoria: Government Printer.

Statistics South Africa (2008b), *Quarterly Labour Force Survey – 2008*, Pretoria: Government Printer.

Statistics South Africa (2009), *Consumer Price Index – May 2009*, Pretoria: Government Printer

UNICEF (2007), Available at: www.unicef.org/infobycountry/southafrica_statistics.html.

Acknowledgement: The authors thank the following persons for assistance with accessing, organising and analysing various sets of the indicator data used in this article: Hermi Boraine, Simon Gathua, Heino Heyman, Hazel Namponya and Mpho Manthe.