SCIENCE AND TECHNOLOGY IN A DEMOCRATIC SOUTH AFRICA:

What Has the New Government Inherited and What Are the Major Policy Challenges?

David Kaplan
Policy Research Unit, School of Economics,
Cape Town University (South Africa)

South Africa's scientific and technological capacities are considerable, certainly by comparison with other African countries, but even by comparison with many of the NICs (New Industrial Countries). *The first part of this paper outlines these capacities, in a comparative perspective* - detailing the resources committed to S&T (Sciences and Technics), S&T outputs and (very briefly) indicating the human resources dimension. Even at this general descriptive level, it is clear that the S&T "system" is beset with fundamental problems requiring corrective policies. A number of first order policy objectives are therefore derived.

South Africa's considerable S&T capacities are embedded in a diversified and sophisticated institutional structure. *The second part of this paper extends the analysis to the inherited institutional structure and strategies of S&T* – the present policies, management system for S&T and (especially briefly) a consideration of the principal S&T performers. A number of additional problems besetting the S&T system are evident and further policy objectives are derived.

As with many facets of South African life, S&T has become a highly politicised issue. Organisations outside of government concerned with S&T development have emerged. The new government will therefore seek to realise its policy objectives for S&T within the context of an active civil society. Moreover, the new government has inherited a system which harbours considerable resistance to change and will operate under significant economic constraints. The approach taken by the new government will necessarily reflect these economico-political factors. *The third part of this paper will assess the manner in which and the extent to which the new government has sought to address the policy objectives outlined here in the first four months of its office.*

This paper is concerned therefore to survey the new government's inheritance with respect to S&T; based on an assessment of that inheritance, define the likely policy objectives of the new government and finally, outline how government, in its first few months of office, has sought to restructure the S&T system to meet these new policy objectives.

South Africa will need to develop an S&T system which simultaneously supports the emergence of an internationally competitive business sector and the enhanced provision of infrastructure, such as housing, clean water and domestic electricity. In particular, in a context of extreme social disparities, enhancing access to infrastructure for the disadvantaged is the heart of the government's commitment to a highly politicised constituency. This requires a fundamental re-focusing of existent S&T activities and necessitates that civil society is, in some way, represented and consulted in the identification and definition of S&T priorities.

The State of Science and Technology in South Africa: Establishing First Order Policy Objectives

Inputs

South Africa currently devotes R 2.8 billion (approx. $US 0.8 billion) to all types of R&D (Research and Development). This represents fractionally more than 1 % of GDP (2). Overall expenditure on R&D and business expenditure on R&D in South Africa – as a share of GDP – is comparable with a number of the NICs.

Over the last decade or so, however, total R&D spending has shown a pronounced tendency to decline. R&D has declined more rapidly than capital expenditure and R&D personnel as a percentage of the workforce has also declined. This is in sharp contrast with most of the NICs, and is of particular concern to a country which is seeking to increase the relative and absolute importance of manufacturing based exports.

Moreover, by contrast with the Asian NICs, much of South Africa's technology thrust can be described as "mission-oriented" ie. focused on radical innovations needed to achieve clearly set out goals of national importance (3). The goal has been "strategic" – defined as limiting the degree of foreign pressure that could be exerted on the apartheid regime, by establishing capacities in certain key areas. Most important have been technology development in respect of atomic energy and armaments (4). It is not possible to calculate precisely the importance of R&D expenditure in these areas, but R&D in armaments *directly* exceeds R 290 million (or more than 10 % of total R&D spend) and 22 % of the Business sectors's spend on R&D (5). A recent authoritative report on the defence industry put the total expenditure on all types of defence research and development at R420million per annum (6). It is not clear how this figure was derived, but it represents approximately 15 % of South Africa's total spend on R&D. Government has invested heavily in atomic energy culminating in the provision of highly enriched uranium for nuclear weapons and South Africa's nuclear power plant. Over the past 26 years, over R 14,600 million has been invested (more than in total R&D). While the R&D component of this expenditure is not known, it is certainly considerable. Atomic energy and armaments together therefore absorb a considerable part of the resources currently invested in R&D. Apart possibly from a few areas related to minerals processing, armaments and atomic energy are the areas of greatest national technological capabilities. However, both areas are far less "appropriate" to the post-apartheid dispensation.

Outputs

Output measures are in principle more significant than input measures in that they indicate the efficiency of the resources committed. But, accurate output measures are particularly difficult to compile and the following should be regarded as "proxies".

1.2.1 Science Outputs

The number of South African publications in the SCI is just under 4,000 per annum. This increased steadily until 1987, but has declined since then.

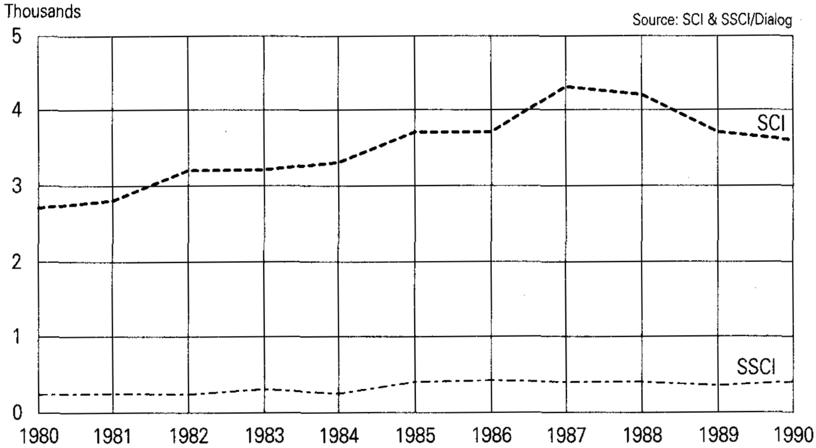


Figure 1. Number of South African Publications in the SCI and SSCI

South Africa's share of total world SCI is currently a little over 0.5%. South Africa's share rose to 0.6% in 1986, and remained at this level until 1988, declining thereafter. South Africa's share of SSCI publications have been essentially stable since 1985.

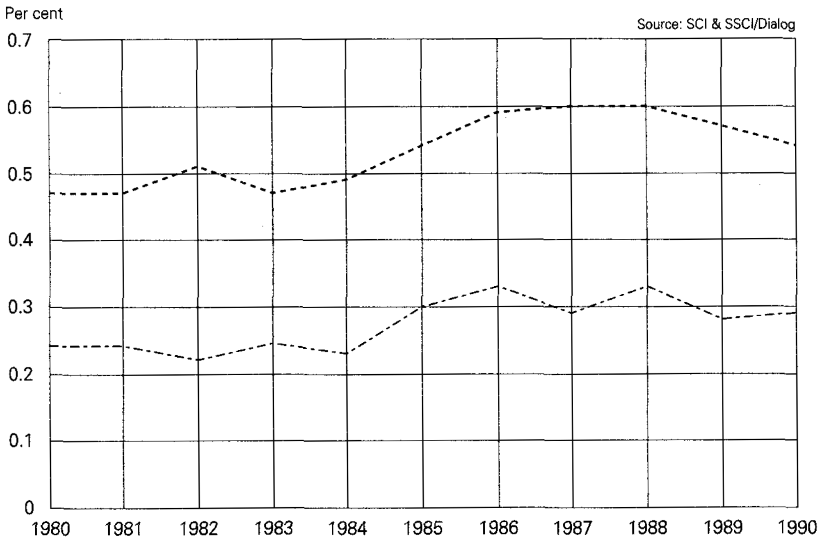


Figure 2. World Share of South African Publications in the SCI and SSCI

South Africa's share of publications in the SCI is large by comparison with that of the East Asian NICs, and especially by comparison with other African countries.

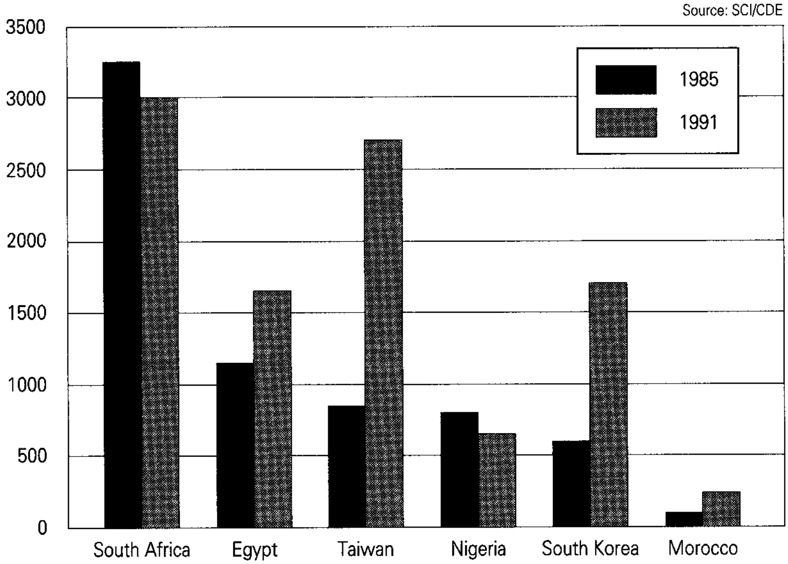


Figure 3. Relative Position of South Africa in Terms of Publications in the SCI

Technology Outputs

South African origin patents registered in the US are currently running at approximately 120 per annum. The number of SA patents rose by 63% between 1976 and 1989 (total foreign origin patents rose 75%) but have declined since then.

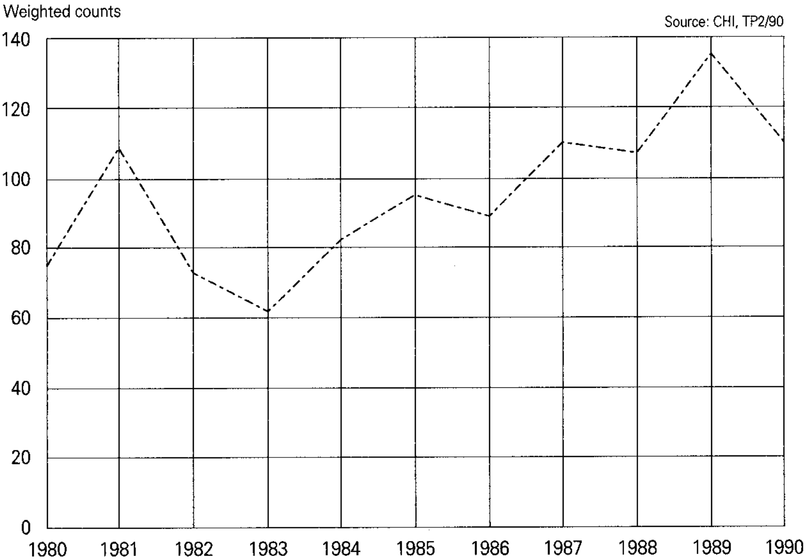


Figure 4. South African Patents Granted in the Usa, 1980-1990

In the 1963-75 period, South Africa was the 17th largest country of origin for patents registered in the US and in 1989 South Africa was the 19th largest country. In 1963-75, South Africa accounted for 0.34 % of all foreign patents registered in the US and in 1988-89, South Africa accounted for 0.29 % of all foreign patents registered in the US (7). South Africa is responsible for approx. 16 % of the patents granted to southern hemisphere countries in the US -second largest but well behind Australia.

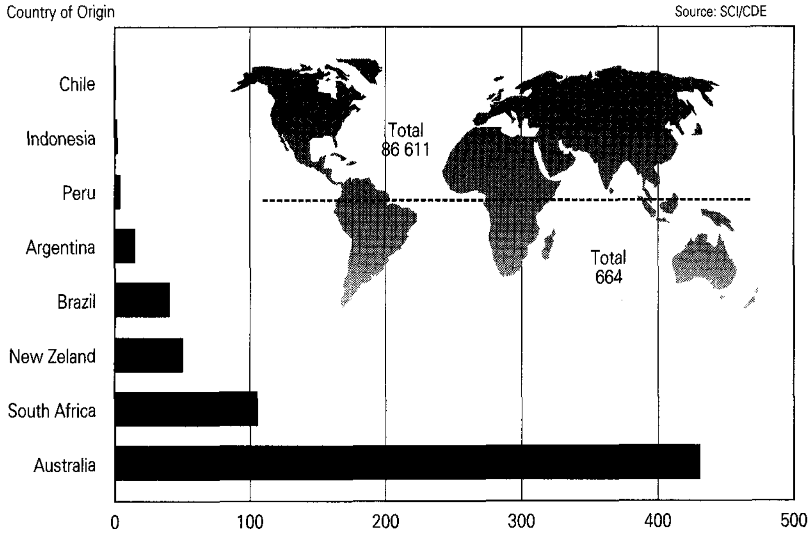


Figure 5. Southern Hemisphere Countries with Patents Granted In the USA, 1990

South Africa certainly dwarfs the international patenting of the rest of Africa.

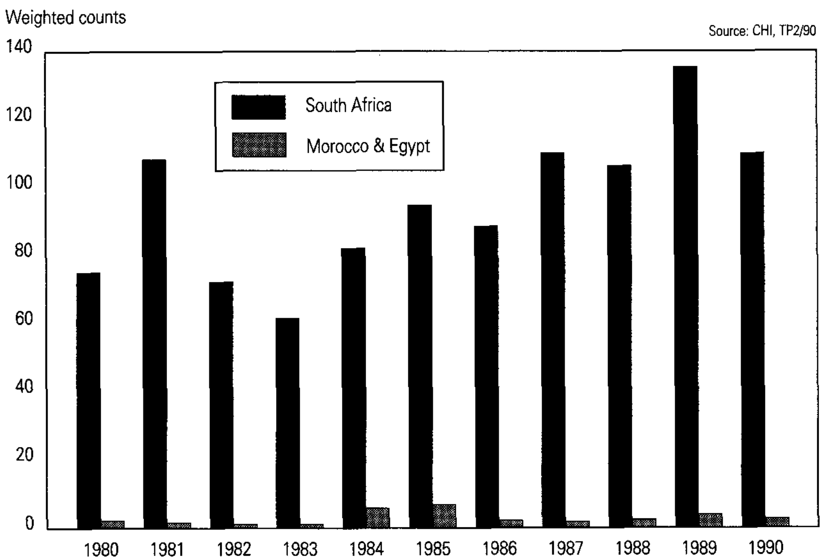


Figure 6. African Patents Granted in the USA, 1980-1990 (all classes)

Domestic patents are a much weaker indicator and, because of national differences in patenting procedures and requirements, cannot be definitively used for comparative purposes. Nevertheless, South Africa ranks ninth out of thirty major countries in the number of its domestic patent applications (8). Patents for local inventions have been rising in the 1980s (although this stabilised after 1987), while foreign patents have tended to decline. In 1980, local origin patents were 38 % of the total registered domestically; by 1988 they were just over 50 % of the total (9).

Science and Technology Outputs Compared

With science output proceeded by the share of South African publications in the Science Citation Index and technology output by the share of South African patents in the USA, in the 1970-88 period, South Africa contributed 5 times as much in science as in technology. By comparison with a number of NICs, South Africa has a higher science output, a higher output of patents (with the exception of Taiwan), but a lower ratio of patents/science output (10).

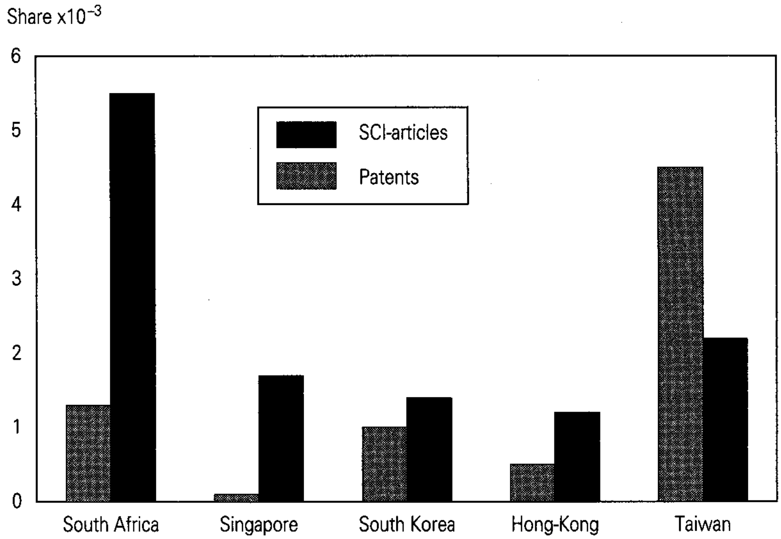


Figure 7. Relative Share of Science and Technology Output; South African and the Asian NICs.

Human Resources

All the indicators suggest that, despite a relatively high technological, and more particularly a relatively high scientific output, by comparison with other countries, South Africa has relatively few scientists and engineers actively engaged in R&D.

South Africa's human resources to support R&D are comparatively very poorly developed. This is evident at all levels. To take just one indication of this, in 1988, SA had a total of 100,000 scientists and engineers – a little under 3,000 per million population. This compares with Korea 8,706 (1986), Singapore 15,304 (1980) and Brazil 11,475 (1980). Moreover, the gap is widening. Comparisons of graduating engineers per annum, reveals even more sharply, South Africa's poor performance by comparison with the NICs and indeed with a number of African countries.

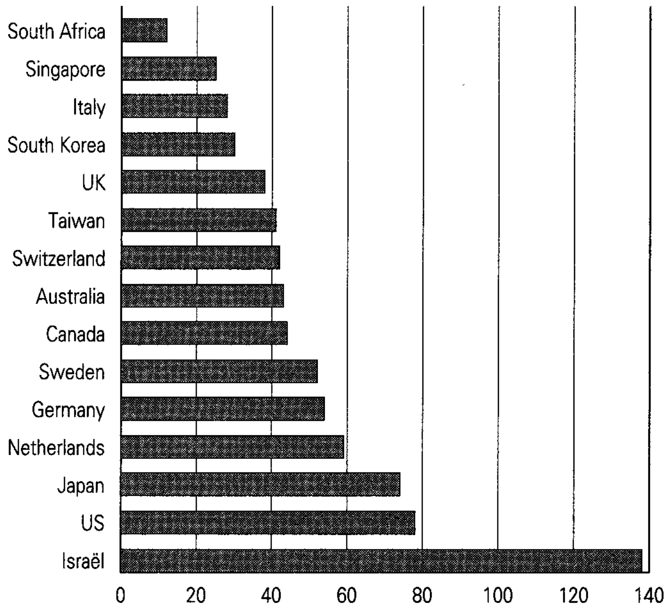


Figure 8. Scientists and Engineers Engaged in R&D per 10,000 Labour Force; South Africa and Selected Countries

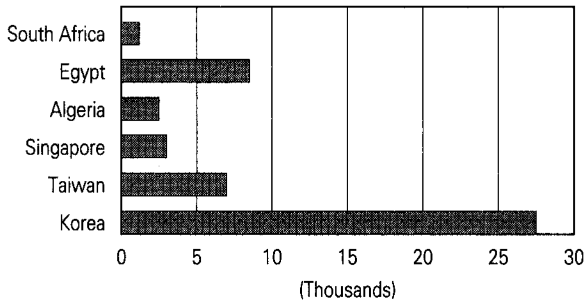


Figure 9. Graduating Engineers per Annum; South Africa and Selected Countries

Moreover, Blacks are severely under-represented in the ranks of scientists and engineers. To take but one indication of this. Of a total of 3,123 graduates employed by the science councils in South Africa, 2,975 or 95% are White (11).

Conclusions and First Order Policy Objectives

- Despite a reasonable commitment of resources to formal technological effort (R&D), the indications are that currently R&D spend is declining significantly. Moreover, much of South Africa's R&D is focused in mission-oriented projects, especially armaments and atomic energy which are now much less appropriate.
- Scientific output is relatively high.

- There is strong evidence of 'an imbalance' as between scientific and technological outputs.
- Human resource provision is inadequate and racially skewed.

Within the context of an economic policy which aims for the rapid development of a more value added manufacturing industry and reversing racial imbalances, four first order policy priorities emerge.

1. **Reverse the decline in the commitment of resources to formal technological effort.**
2. **Re-direct technological capacities established in mission-oriented research programmes to more appropriate areas.**
3. **Ensure that scientific advance is more effectively translated into potential applications.**
4. **Expand the education and training of skilled technical persons (especially of engineers) and redress racial imbalances in provision.**

The Management of S&T, Government Policy and the Principal S&T Performers in South Africa

This section provides a brief outline of the management and strategies of the current S&T system, government policy and the principal S&T performers. The focus is on the problems that are likely to beset the system and the performers in meeting the multiple objectives outlined above.

The Management of S&T

Until very recently, government management of science and technology was divided – responsibility for science rested with the Department of Education, while technology was the responsibility of the Department of Trade and Industry. The key mission-oriented research institutions, notably Armscor (for armaments) and the Atomic Energy Corporation (AEC), are separately funded and managed with no reference to broader S&T policies or the impact of these developments for S&T capacities. In addition, a high degree of autonomy is granted to the universities, both in respect of their teaching and research programmes. South Africa's S&T system is therefore highly fragmented. Moreover, there is no organisation with oversight of the entire system. This has a considerable negative impact upon the management and operations of the entire S&T system.

> *"... the absence of any organisation with oversight of the entire national innovation system... meant that nobody was responsible for monitoring the ongoing health of the S&T system. In turn this meant that feedback and control measures were lacking so that it became practically impossible even to measure the health of the system."* (12)

The absence of organisational oversight and a clear mechanism for setting national goals, means that the various S&T performers are denied thematic guidelines for their operations or any criteria against which they can measure their own effectiveness. Lack of representation for S&T at national level has had further adverse consequences. At the macro level, policy has been made without reference to its impact upon the development of local S&T capacities. Moreover, there has been no effective "lobby" for S&T at the national level. This has impacted on government funding for S&T, which as a share of the overall government budget, has been declining for more than a decade.

In a wide variety of ways, the S&T system was designed to underpin the apartheid regime. One manifestation of this was the racial and gender composition of the system and notably the lack of representation of the disadvantaged communities. This lack of representation had an "internal logic" in the apartheid era since the system was not designed to meet the needs of the disadvantaged. However, it has left an unfortunate legacy of a lack of popular legitimacy and awareness of the importance of S&T. More importantly, in the post-apartheid dispensation, when government's declared aim is to marshall all the resources at its command to enhance the access of the disadvantaged to social and physical infrastructure, far more popular representation is necessitated (13).

In summation:

"At this point in time therefore the S&T system lacks an explicit broad national focus and no organisational mechanism exists to define and coordinate government's S&T activities." (14)

Moreover, the system lacks the legitimacy, transparency and effectiveness which derives from more broad based representation.

Government Policy for S&T

There is a defined management system and set of policies governing science (15). A Science Vote is determined and allocated to the budgets of the various science councils via the responsible government department. The key source of advice to government on science policy is an advisory body – the Scientific Advisory Council (SAC). This body has been subject to a number of criticisms – lack of transparency, composition of its membership, limited oversight of the system (no oversight of technology but also no oversight of dedicated research facilities which are established within various government departments and which are not funded via the Science Vote) and the SAC's location within the Department of National Education (16). The determination of priorities for science development and funding is particularly non-transparent.

The IDRC Mission concluded it assessment of the SAC:

"The overall impression we gained is that of a body which devotes its energies to matters of detail within the existing system, rather than taking a broad view, and tackling many problems which confront South African S&T.

It appears that the SAC, as presently constituted and constrained, is not a useful mechanism for advising on S&T Policy. A new government, committed to participation by all South Africans in debates on public policy, would do well to set up structures appropriate to this kind of political culture – structures which would provide appropriate kinds of advice." (17)

The SAC is heavily science oriented and has effectively ignored technology policy. The Department of Trade and Industry is primarily responsible for technology but, despite a few programmes to promote technological development, there is currently no comprehensive policy with regard to technology (18). The lack of a technology policy has reinforced the limited impact that South Africa's science base has had on technological development.

The Principal S&T Performers

There are four 'sectors' of S&T performers – government (27 %), tertiary education (24.8 %), business enterprises (46.6 %) and non-profit (1.6 %) (19). The non-profit sector is therefore of minor importance and is not described here.

The Government Sector

Government is principally involved in the performance of S&T through its support for the statutory research councils. There are currently eight such councils, contributing to the high degree of fragmentation of the South African S&T system.

Together the councils are funded by government at a cost of over R 700 million per annum. In April 1988, government adopted the system of "Framework Autonomy and Base Line Funding" for the management of the science councils. Government subsidy was to be fixed in order that the science councils would have to secure additional funding from "the market" ie. clients in the public or private sectors (20). This has advanced quite rapidly – for example, the CSIR – the largest of the councils with a focus on industry – secures less than 50 % of its income from the parliamentary grant, placing it amongst the highest ratio of contract income to state funding of all similar institutions (21). Money allocated by the state to the science councils under the base line funding formula, which was designed for their own in-house R&D and for science, manpower and skill development functions, has in fact *fallen* steadily in real terms. As a result, all of the science councils have become ever more dependent on the market for their funds (22).

While it is difficult to measure the efficacy of the science councils in promoting and complimenting the research activities of South African industry, a study of firms which had won national design awards strongly indicated that these firms relied upon their own efforts and received very little support, direct or indirect, from any outside organisations. In some sectors however the science councils have been far more effective. For example, the South African Bureau of Standards, is able to provide standard certification and verification for a wide range of manufactured goods which is accepted in the most demanding of export markets (23). Its services are long established (24) and widely utilised by South African manufacturers, particularly as they expand into new export markets (25). Linkages between the CSIR and the major chemical companies appear to have been close (26). Similarly, the council for Mineral Technology MINTEK has reportedly developed close and productive linkages with industry – particularly in the beneficiation field.

Overall, the science councils have established strong linkages with already well-established, well-resourced and generally technologically sophisticated clients. In effect the market orientation of the science councils has allowed those firms and agents which are already powerful in the market, to have the greatest access to state subsidised technology services. South Africa has a number of very powerful conglomerates resulting in a very high level of economic concentration in most product markets[27]. Market orientation, on the part of the science councils, therefore reinforces and complements existing market distortions.

At base, the rationale for this framework is misplaced. It has been formulated with a mistaken perception of the optimal role of the market in the development of the pace and direction of local technological capabilities. It particularly ignores the requirements but limited market power of small, medium and micro enterprises (SMMEs). The interests of the latter are supposedly taken account of in "special divisions" or "special programs" operated by some of the science councils. But, there is a fair consensus that these are not very effective.

The major policy challenge therefore is to "reorient" the science councils so as to ensure that they are more responsive to the needs and requirements of the disadvantaged communities - especially to the needs and requirements of the SMMEs. This cannot be achieved simply by the science councils grafting on separate divisions to "look after" the SMMEs, but should be inscribed "in the central dynamic" of these organisations. Ways will need to be found to ensure that SMMEs, like larger firms, have the wherewithal to command resources in order to purchase the resources they need for product and process development. Another part of this process will be to ensure that the Boards to which the managements of the councils are, in the first instance responsible, become far more broadly representative and accountable (28).

Government involvement in the armament and atomic energy industries is also very substantial. *The armaments industry* is a leading sector both in terms of technological capacities and in relation to actual (and potential) export earnings. With local expenditures on defence likely to rise only in respect of "manpower" (namely incorporating new personnel into the armed forces drawn from the liberation movements' armed wings), increased sales are dependent on exports. The potential sales on export markets are, for obvious reasons, hard to determine. "However, there are indications that with the lifting of the UN arms embargo, the potential is considerable. The first major publicised export orders are now in place. Oman has placed an order for $ 120 million, principally for artillery. Armscor's own assessment is that"... annual sales could be as high as R 200 million p.a. by 1996 (29). A recent report identifying National Policy for the Defence Industry argues that investment in defence R&D – which is aimed at or near the technological frontier – is largely offset by the considerable potential for export earnings and job creation (30). The report urges that defence expenditure on R&D not be reduced from its present level:

> *"The current expenditure on all types of defence research and development has reached a critical level. Unless it is maintained at approximately the current level of R 420 million per annum, it is Armscor's view that the industry will lose its technological edge and much of its design and development capabilities."* (31)

The report argues further that the defence industry has very considerable technological capacity which, given the right policies, could play a major role in the rebuilding of South Africa' technological base (32). However, apart from indicating the importance of joint ventures and the role of government in formulating a diversification strategy for the armaments industry, and in playing an enabling and regulatory role to encourage the process, the report formulates no detailed policies.

At this point in time, government has no clear policy either on the optimal degree of support for R&D in armaments nor on what policies are desirable in order to ensure that the existing, undoubtedly considerable, technological capacities in this industry could facilitate the development of local capacities elsewhere.

The atomic energy industry, located near the technological frontier, is also a site of very considerable technological capacity. The AEC currently employs over 3,000 people, the largest single concentration of high-level skills in the country (33) – the vast majority of whom are highly skilled. The AEC is currently engaged in a major commercialisation programme. The objective is to render itself free of government funding by the year 2000. However, the commercial viability of the AEC is very questionable. Although commercial sales have been rising rapidly, this is from a low base and in 1992/3 commercial sales were less than one-third (R140million) of state support (R 452 million). Moreover, indications are that the AEC cannot produce enriched uranium at prices competitive on the international market. Market demand for enriched uranium is likely to remain stagnant and the former Soviet states, in particular, are very low cost suppliers. Conversion of atomic energy to "civilian/commercial products thus faces considerable barriers."

As with armaments, government has no clear policy on ensuring conversion of the AEC.

The Tertiary Education Sector

South Africa currently has 21 universities and 15 technical colleges (Technikons). Tertiary level research is well-developed in South Africa, and largely funded by government (34). The state subsidy to the universities is three and a half times larger than the subsidy to the technikons. The technikons do very little research (collectively only 1.1 % of total research in the tertiary education sector), while over 70 % of the research is undertaken in just 6 universities (with the top three universities contributing 40 %). The bottom 6 universities contribute under 7 % (35).

Therefore, the research capacities of the tertiary education sector are highly skewed - firstly as between universities and technikons and secondly as between universities. The major research universities have been those who *historically* have catered primarily to white students (36).

The universities are primarily responsible for the high levels of scientific output noted earlier. However, there is evidence to the effect that university science rarely finds any commercial application (37).

The policy implications are clear. Policies are needed to ensure that tertiary level research does not function in isolation but rather is brought into contact with potential applications. This will require increased business sector involvement in university research and perhaps a greater emphasis on the transfer sciences and more government support for application-oriented research.

The Business Enterprise Sector

There are very few areas where South African firms have achieved leading-edge status. This has occurred in those industries (a) where South Africa is a leading international producer and where the particularities of local conditions have necessitated major on-going innovation – principally in some mineral extraction and beneficiation processes (eg. pyrometallurgy) or (b) where, for political/"strategic" reasons, South Africa has developed along a different "technological trajectory" from that pursued internationally and has therefore been unable to obtain the technology abroad – principally in oil from coal synfuel production (38). In these areas, South African firms are significant technology exporters.

Elsewhere however, *the importation of foreign technology* is critical. South African firms have generally acquired good operational capacities in respect of the technologies that have been imported - even in complex technologies. However, licence agreements entered into by South African firms do not generally lead to the transfer of "know-why" capacities – the capacities necessary not merely to operate the technology but to effectively assimilate, adapt and finally transform the imported technology. Licence agreements frequently contain express provisions which retard the local firms' ability to develop their own technological capacities. This reinforces an existent tendency for local firms to passively rely on technology import rather than developing their own capacities. Imported technology therefore tends to displace rather that complement local capacities.

By way of example, the Table below relates to the consumer durables division of one of South Africa's largest industrial companies. The Table indicates the character and prevalence of restrictive clauses. In addition, the limited company spend on own R&D, the absence of training and the tendency to continually renew agreements, all indicate a passive reliance on overseas licensors on the part of the local firm.

Table 1. Some Features of Licence Agreements Entered into by One of South Africa's Largest Manufacturing Companies in Respect of Consumer Durable Products

No of Agreements	8	
Export restrictions	5	(2 others unclear)
Express Tied Purchasing Clause	1	
Length of Agreement10 years or longer	6	(2 others unclear)
Royalty on Sales Average	3.125	
Additional FrontEnd Charges	2	(2 others unclear)
R&D Expenditure as % of Turnover (for the Group)	0.32	
No of LicenceAgreements entailingTraining	0	

Source: Department of Trade and Industry, Register of Licence Agreements.

One major reason why local firms are not aggressive in developing their own technological capacities is that they are oriented to the local market. Moreover the local market is characterised by a limited degree of competitive pressure. In a more open trading environment consequent upon South Africa entering into an agreement of phased liberalisation with the GATT, in order to compete more effectively with imports, and more especially to enter into export markets with differentiated and high quality goods, South African manufacturing firms will have to deepen their capacities in product design and development.

The absence of a policy for technology development has already been noted (39). Creating the incentives and the wherewithal so as to encourage local firms to enhance their technological capacities is however a wider and more complex task. In very important part, this will be dependent on broader macro policies – and most specifically policies with respect to industrial development. Technology policy can only be effective when integrated and sequenced with other policies, ie. when it is conceived of and implemented as an integral part of a far more over-arching industrial strategy. The success of technology policy in the East Asian NICs exemplifies this.

> *"In large measure, the success of Taiwan's science and technology development program can be attributed to the fact that it was formulated within the context of a well-defined industrial strategy. Taiwan's S+T development program... was effective because it was closely linked with, and occurred within, the general context of a national economic plan."* (40)

In brief, there is a critical need to develop a coherent set of policies to enhance technological development in South Africa – most notably at the level of the enterprise – and to locate such policies within the context of a broader strategy for the development of South African manufacturing industry.

Further Policy Objectives

Following the outline of the S&T system (as above) a number of further policy objectives emerge:

1. **Establish a management system for S&T which has the capacity to oversee and coordinate the entire system for both S AND T. This should be able to inter alia identify national S&T priorities and define thematic goals for S&T performers**
2. **Develop a comprehensive technology policy within the context of broader macro, and particularly industrial policies**
3. **Ensure that the science councils become far more responsive to the needs of those who currently command few resources in the market, especially SMMEs**
4. **Develop a clear industrial strategy with respect to the armaments and atomic energy industries ensuring that technological capacities already developed here are effectively 'transfered' to other areas of the economy**
5. **Address the skewness of research activities within the tertiary education sector and, at the same time, ensure that more of this research finds expression in technological and commercial activities**
6. **Enhance the incentives (and pressures) for firms to innovate, inter alia by advancing a more competitive environment and encouraging local firms to rely more on developing their own capacities as opposed to passive reliance on imported technologies.**

S&T Management and Policy under the Government of National Unity

Despite its significant capacities, S&T in South Africa is beset with problems. Its very *raison d'être* is being questioned and the system is necessarily facing a fundamental restructuring.

The creation of a new Ministry – for the first time, South Africa has a Ministry of Science and Technology (which has been combined with Arts and Culture) – provides the focus for developing a new vision for S&T. The Minister is drawn from Inkatha and the Deputy Minister from the ANC. But, what the precise functions of the Ministry are to be, how it is to relate to other "line" ministries and major government programmes such as the Reconstruction and Development Programme (RDP) and even how it is to be staffed, are all matters which are still to be decided. The decisions made will reflect "the play of socio-political forces" as much as the working out of different rational perceptions as to what is desirable.

There has been a considerable ongoing debate over a "new direction" for S&T, notably within an organisation called The Science and Technology Initiative (STI) – a very broad grouping of organisations and groups concerned with S&T. The STI has presented three reports to the Minister. These deal with the issues of affirmative action within the science councils, the governance of the science councils and the management of the national S&T system. As yet, the Ministry has not reacted to the reports.

The directions to be taken by the new ministry, on these and other issues, will become much clearer over the next few months. With this survey paper as a backdrop, recent developments will be outlined further at the Conference.

NOTES

1) Le texte qui suit est le texte de la communication que nous a remis David Kaplan dans le cadre de cette table ronde.

2) DNE, 1993. South African data on R&D are comprehensive and since they are based on the Frascati Manual, internationally comparable.

3) Henry Ergas, 1987, p. 192

4) Oil from coal and, to a lesser extent, telecommunications equipment have also seen extensive technology development, driven by the state on the grounds of their strategic importance.

5) In1991/2, the Defence Department contributed R97million to R&D directly; a further R 51 million was allocated by the different branches of the armed forces to "technology retention projects" and R&D to the amount of R 100 million was supported by capital projects. A further R 30 million was contributed directly by Armscor itself and R 13 million by Denel. This excludes student bursaries and other forms of support on the part of Armscor and, most critically, defence related R&D in the private sector which is not directly supported by Armscor. The data in this paragraph are obtained from Garbers, C.F., 1993.

6) Transitional Executive Council, Subcouncil on Defence, 1994, April. Executive Summary point 7.

7) US Patent Office, 1990.

8) Gerntholtz R., 1990, p. 11.

9) FRD Scientometric Advisory Centre, p. 82-3. The data show a tendency for the number of foreign patentings to fall after 1984. As the authors point out, this may be due to sanctions/disinvestment.

10) Pouris, 1991, p. 28.

11) LHA Management Consultants, Human Resources Composition and Development in the Science and Technology Area, Report for the Science and Technology Initiative Working Group 5, April, 1994, p. 3.

12) Kaplan and de Wet, 1994, p. 11.

13) Such representation is not merely «good politics». Representation in order to gain diversity of insight and expertise is good system engineering practice. Kaplan and de Wet, 1994 (Version 1), p. 43.

14) Kaplan and de Wet, 1994 (Version 1), p. 12.

15) See NATED 11-005(88/06).

16) IDRC, 1993, p. 25. Kaplan and dew Wet, 1994, p. 11-12.

17) IDRC, 1993, p. 26.

18) Garbers, C, 1993, p. A1.

19) These figures are for 1991/2. See DNE, 1993 (93/03).

20) The system was expressly designed to increase the linkages between the councils and industry. "Base line funding of scientific councils has the specific objective of encouraging or even obliging councils to generate their own funds by means of contract research. In this way the free market system is applied as a prioritization mechanism and problems are identified for which the solution has a price in the market." Garbers, 1992, p. 5. See also Department of National Education, 1988.

21) "... our ratio of state funding to contract income places us second amongst the top contract income earners (just behind TNO, the Dutch national research organisation)". Garrett and Clark, 1992. These figures are to be treated with some caution since a part of the income earned outside of the parliamentary grant is from the investment of capital. See here Lutjeharms and Thomson, 1993, p. 11.

22) E.g. for the CSIR, the parliamentary grant declined by 1% in nominal terms between 1991 and 1992. CSIR, Annual Report, 1992, p. 18-19. Most of the science councils (and the universities) received budget cuts, immediately post-the election, to help finance the "costs of transition".

23) Setting and monitoring of standards and ensuring quality of exports and imports is becoming of ever increasing importance in international trade. Not only is there far more emphasis placed on quality generally, but, for a number of manufactured goods, in many major markets, there is a "quality threshold" which must be reached if products are to be accepted, at any price. A standards authority, whose assessments are accepted without qualification in such markets, is a vital constituent of any export effort.

24) Standards, and "specs" e.g. for public sector procurement, from roads to telecommunications, have historically been set very high in South Africa, by comparison with other countries at similar stages of development. It is likely that the setting of "European standards", is traceable to a political economy dominated by "White European" settlers.

25) Interview, South African Bureau of Standards, 7/10/1992.

26) E.g. in the design of a catalyst for Mossgas see here Crompton 1993, p. 39-44.

27) Joffe *et al.* in Baker *et al.* (eds), 1993, p. 101-4.

28) Major recommendation have been made in this regard -see Badat and Prozesky, 1994.

29) TEC, Subcouncil on Defence, 1994 para 2.29. Current sales are said to be in excess of R 500 million.

30) Transitional Executive Council, Subcouncil on Defence, 1994. Executive Summary, point 5.

31) TEC, Subcouncil on Defence, 1994. Executive Summary, point 7.

32) "South Africa has allowed its research and development (R&D) skills and technology base to decline almost everywhere outside the defence industry... Only in the defence industry has there been continuous, substantial investment in R&D technology, plant and skills. Because of the low R&D expenditure elsewhere, this industry contains much of the R&D skills available in South Africa... This resource represents a huge investment of public funds and it must therefore be made available to assist the rebuilding of South Africa's technology base and its manufacturing industry..." TEC, Subcouncil on Defence, 1994, para 2.50.

33) This may be compared with a total of 22,223 man (sic!) years devoted to total R&D in South Africa.

34) In 1989/90 only 10% of funding for tertiary level research was provided by the business sector. Department of National Education, Resources for R&D, p. 54.

35) DNE, 1993. p. 54, Table 2.3.

36) This has been changing rapidly. At the University of Cape Town, for example, the leading research university, more than 60% of the first year intake in science, and 56% of the intake in engineering is black.

37) A survey of the characteristics and sources of over 200 significant South African innovations concluded "There was strong evidence of a failure to commercialise significant university-led inventive abilities". Phillips, 1992, p. 32.

38) Crompton, 1993, p. 83.

39) The government did publish a series of discussion papers on the subject, see DTI, 1991. This culminated in DTI, 1992. However, as yet, there is no policy document.

40) Dahlman and Sananikone, p. 213 (Emphasis added). Japan similarly had a very high level of coordination between technology and other policies. "In building up its industrial might, Japan relied heavily on coordinated technology, industrial and trade policies to promote key industries." Office of Technology Assessment (US), Making Things Better. Competing in Manufacturing, Washington, 1990, p. 21.

BIBLIOGRAPHY

Badat, Saleem and Prozesky, Walter. *Science Councils: Towards the Democratisation of Governance.* Report prepared for the S&T I, May 1994.

Crompton, R. *ISP Report on the Chemicals Industry,* 1993.

Dahlman, C. J. and Sananikone. *Technology Strategy in the Economy of Taiwan: Exploiting Foreign Linkages and Investing in Local Capacity,* (Mimeo), Preliminary Draft, 1980 (December).

Department of National Education. *Resources for R&D* (various years).

Department of National Education. *The Science Policy and System of the Republic of South Africa,* Pretoria, 1988.

Department of Trade and Industry (DTI). *Report on Technology Policy and Strategy, Draft II,* Pretoria. 1991, April.

Department of Trade and Industry (DTI). *Innovating Growth,* 1992, May.

Ergas, Henry. "Does technology policy matter?" in Bruce Guile and Harvey Brooks (eds.) *Technology and Global Industry,* Washington DC, National Academy Press, 1987.

FRD Scientometric Advisory Centre. *South African Science and Technology Indicators,* 1990.

Garbers, J. G. "Opportunities and constraints in science policy in South Africa", Center for Science Development, *Symposium on Science Policy and Research Management,* Vol. 1(1), 1992.

Garbers, C.F. *The South African Science and Technology System: Structure and Policy* (Mimeo), Prepared for the S&T I, 1993.

Garrett, G. G. and Clark, J. B. "Science and Technology in Transformation in South Africa", *Transformation,* vol. 18-19, 1992.

Gerntholtz, R. *A Basic Guide to the Law of Patents,* Allegretto, Cape Town, 1990.

International Development Research Center (Canada). *Towards a Science and Technology Policy for a Democratic South Africa, Mission Report,* July 1993.

Joffe, A., Kaplan, D., Kaplinsky R., and Lewis, D. "Meeting the Global Challenge: A Framework for Industrial Revival in South Africa", in Baker, P., Boraine, A. and Krafchik, W. *South Africa in the World Economy in the 1990s,* David Philip, Cape Town, 1993.

Kaplan, D. and de Wet, G. *Proposals for a Future National Science and Technology Management System in South Africa* (Version 1) (Mimeo). Report prepared for the S&T I, May, 1994.

Lutjeharms, J.R.E. and Thomson, J.A. "Commercialising the CSIR and the death of science" *South African Journal of Science,* vol. 89, Jan. 1993.

Motala, Enver. *The Employment Composition and Affirmative Action Programmes of the Science Councils in South Africa.* Report prepared for the S&T I, April, 1994.

NATED 11-007. "The Science Policy and System of the Republic of South Africa." (88/06).

Phillips, Bruce. "Innovations in South Africa: a basis for technological policy guidelines" *Science and Public Policy,* vol. 17 No. 1, 1990, February.

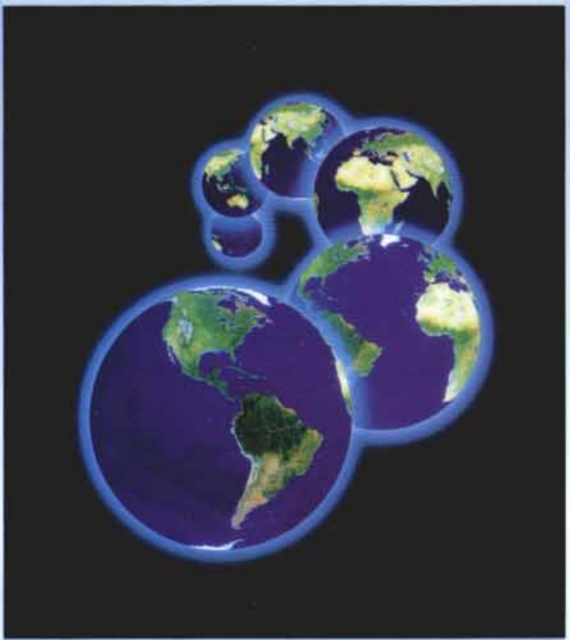
Pouris, A. "Identifying Areas of Strength in South African Technology" *Scientometrics* 21 (1991).

Transitional Executive Council, Subcouncil on Defence. *National Policy for the Defence Industry,* prepared by the Defence Industry Working Group, April 1994.

US Patent Office. *All Technologies Report,* 1990. US Department of Commerce, Washington.

LES SCIENCES HORS D'OCCIDENT
AU XXᴱ SIÈCLE

SÉRIE SOUS LA DIRECTION
DE ROLAND WAAST



VOLUME 5

SCIENCES
ET
DÉVELOPPEMENT

MARTINE BARRÈRE
ÉDITEUR SCIENTIFIQUE

ORSTOM éditions

LES SCIENCES HORS D'OCCIDENT AU XXᴱ SIÈCLE

20TH CENTURY SCIENCES: BEYOND THE METROPOLIS

SÉRIE SOUS LA DIRECTION DE ROLAND WAAST

VOLUME 5

SCIENCES ET DÉVELOPPEMENT

SCIENCES AND DEVELOPMENT

MARTINE BARRÈRE

ÉDITEUR SCIENTIFIQUE

ORSTOM Éditions

L'INSTITUT FRANÇAIS DE RECHERCHE SCIENTIFIQUE POUR LE DÉVELOPPEMENT EN COOPÉRATION

PARIS 1996