Africa's Plan of Action for Science and Technology and Indicators: South African Experience

Michael Jeffrey Kahn[1]

Abstract

The African Union (AU) Commission and the New Partnership for Africa's Development (NEPAD) have set out a "Consolidated Science and Technology Plan of Action (AMCOST, 2005)" to promote socio-economic transformation. Monitoring and evaluation of that Plan is central to its success. To that end this paper deals with the problem of generating applicable science and technology indicators based on South African experience. The starting point is a brief discourse on South Africa's innovation policy followed by discussion of the importance of indicators, after which we move to problematizing the conduct of internationally comparable surveys of research and development (R&D) and innovation activity in emerging economies. Suggestions are offered regarding ways of controlling for estimation especially as registers are often incomplete. The paper concludes with brief comment on the prospects for the unfolding African Science, Technology and Innovation Indicators process.

Key words: *Research and development, Innovation system, GERD, BERD*

Résumé:

La Commission de l'Union Africaine (UA) et le Nouveau Partenariat pour le Développement de l'Afrique (NEPAD) ont mis en place un « Plan d'Action consolidé sur la Science et la Technologie » pour favoriser des changements socio-économiques. Le suivi et l'évaluation de ce Plan sont indispensables pour son succès. C'est dans ce cadre que s'inscrit cet article qui traite du problème de production d'indicateurs sur la Science et la Technologie tout en s'appuyant sur l'expérience Sud-Africaine. Il aborde d'abord la politique d'Innovation de l'Afrique du Sud suivie ensuite de la problématique issue de la conduite d'enquêtes internationalement comparables sur les activités de Recherche et Développement (R&D), et d'Innovation dans les pays émergents. Des propositions sont faites sur le processus d'estimation notamment en ce qui concerne les données manquantes. Le papier conclut enfin par un bref commentaire sur les perspectives offertes par l'Initiative sur les Indicateurs africains sur la Science, la Technologie et l'Innovation.

[1]Executive Director of Knowledge Systems and Head of the Centre for Science, Technology and Innovation Indicators (CeSTII) at the Human Sciences Research Council, Private Bag X9182, Cape Town 8000, South Africa. E mail: mkahn@hsrc.ac.za

Mots clés: *Recherche et Développement, Système d'Innovation, DIRD, DERD.*

Africa's Science and Technology Policy and Indicators

The African Union (AU) Commission and the New Partnership for Africa's Development (NEPAD) "Consolidated Science and Technology Plan of Action (AMCOST[2], 2005)" articulates Africa's common objectives for science and technology as one of the means to promote socio-economic transformation of the continent and its integration into the world economy. The Plan rests on three pillars - capacity building, knowledge production, and technological innovation. All three can only be managed insofar as policies, strategies, plans and measurement synergize. This is recognized in the Plan that seeks to improve "the quality of science, technology and innovation policies of African countries through processes that promote sharing of experiences and policy learning" (AMCOST, 2005: 10). This is to be dealt with through Programme 5.1.

Box 1: Programme 5.1 African Science, Technology and Innovation Indicators Initiative (ASTII)

Science, technology and innovation (STI) indicators are crucial for monitoring Africa's scientific and technological development. They are useful for formulating, adjusting and implementing STI policies. Indicators can be used to monitor global technological trends, conduct foresight exercises, and determine specific areas of investment. An example is the target of a ratio of R&D spending to GDP of 1% for African countries. (AMCOST, 2005: 38)

This paper deals with the role of such monitoring and the generation of applicable indicators the better to inform both management and communication. The contribution is based on five years experience gained in rebuilding and developing South Africa's science and technology indicator system. Accordingly the starting point must be a brief discourse on South Africa's innovation policy. This is followed by a general discussion of the importance of indicators, after which we move first to R&D indicators and then to the problem of measuring innovation activity. The discussion is placed in the context of an emerging economy making the transition from closed to openness. The paper concludes with some comment on the unfolding ASTII process.

[2]African Ministerial Council on Science and Technology

South Africa's Innovation Policy

A year before the first democratic elections the Canadian International Development Research Centre sponsored a review of the South African science and technology system (Van Ameringen, 1993) that found a fragmented set of institutions whose orientation was not aligned with the country's development needs and whose staff excluded the majority of the population from participation. The White Paper on Science and Technology (DACST, 1996) set about transforming that situation.

One of the White Paper thrusts was to introduce the theoretical schema of an innovation system. This theory understands innovation to be a non-linear process involving knowledge production and transfer among a set of actors including higher education institutions, government research institutes and the private sector, the performers of research and development (R&D)[3] and innovation[4]. Government plays the additional role of setting and developing the framework conditions that should enable innovation through appropriate policy. Knowledge workers, the researchers, administrators and technicians are keys to the success of any system of innovation, so that issues of their availability and mobility are crucial.

A second thrust was to emphasize the importance of capacity development to redress the gross racial imbalances among personnel. As to policy instruments, the Innovation Fund was established to provide a mechanism for competitive funding of R&D, whilst a National Advisory Council on Innovation was enacted to provide policy advice to the Minister and thence to Cabinet. Measurement was a key theme of the White Paper, both at institutional and system level. At institutional level a Performance Measurement System was introduced for the Science Councils[5] that required annual reporting against a set of Key Performance Indicators. But attention to system measurement was delayed until the National Strategy for Research and Development (DST, 2002) was ready for tabling. In the same year the Department of Science and Technology established the Centre for Science,

[3]R&D is the resolution of scientific or technological uncertainty. It uses scientific methods to add to the stock of knowledge or to develop new technological products and processes.

[4]Innovation is the dissemination of a new product or process in an organisation or market.

[5]The Science Councils are: Africa Institute of South Africa, Agriculture Research Council, CSIR, Council for Geosciences, Human Sciences Research Council, Medical Research Council, Mintek, National Research Foundation, South African Bureau of Standards.

Technology and Innovation Indicators (CeSTII) in the Human Sciences Research Council to become a centre of excellence for science, technology and innovation indicators. CeSTII set about building expertise to conduct both R&D and Innovation surveys. Policy makers were fully aware of the value of evidence-based policy and set about ensuring that a robust platform for their sustained production was in place.

The above S&T policies together with other policies for the restructuring of higher education, labour relations, macro-economic stability, micro-economic fine-tuning, incentives toward business R&D, and the encouragement of foreign direct investment constitute South Africa's innovation policy. The external OECD review (OECD, 2007) expressed satisfaction that the major elements of a modern innovation policy were in place.

Why indicators?

Government interest in having access to indicators should turn on their value for promoting good governance. The public expects governments to show accountability for the spending of public funds and demonstrate their effective and efficient application. Effective application is the ultimate objective; the proximal is coordination of plans and budgets and sound financial management, the latter being the domain of the independent auditor. In this paper one is interested in effectiveness. This is assessed through the monitoring and evaluation of programmes and projects. So for example Logical Framework (Ortengren, 2003) planning methodology requires the use of "objectively verifiable indicators" to specify the attainment of project objectives. Unfortunately, unless properly institutionalized, evaluation is easier said than done as it is still common for projects and programmes to lack specific evaluation criteria. Moreover in deciding on evaluation criteria it will be necessary to have some benchmarks for reference that in turn implies standards for comparison. Last is the goal of "joined up policy." It is to these information deficits that indicators speak.

Indicators are statistics. They may be direct measures as is the case in the natural and life sciences, they may be demographic or they may be indirect proxies for complex phenomena as is the case in economics (and innovation policy). They should be objectively measurable, maintainable, standardized, and up-to-date. Importantly the meta-data that underpin their construction should be available for public scrutiny lest confidence be jeopardized. The commonest science and technology (S&T) indicators include gross expenditure on R&D (GERD) and its ratio to GDP, human resource data both absolute and in relation to the workforce, and

the various focal areas of R&D. The UNESCO Institute for Statistics has collected such S&T data for many years and presents information for 18 of the 54 African states.

The two "standard" surveys of S&T activity are that for R&D, which is codified in the *"Frascati" Manual* (OECD, 2002) and that for Innovation, which is codified in the *"Oslo""Manual* (OECD, 2005a). These manuals were developed by the OECD work group of National Experts on Science and Technology Indicators. As such they reflect the socio-political-economic environment characteristics of the OECD member states, especially the existence of well-maintained systems of national statistics. South Africa has observer status at the OECD and has conducted surveys following the guidelines in both these manuals.

Learning to conduct R&D surveys

South Africa conducted its first survey on R&D in 1966, and produced surveys on a fairly regular basis through to 1989/90. At that point a restructuring of the science system began and together with the instability of the transition to democracy resulted in the responsibility for the R&D Survey migrating among four institutions over the next decade. In fact no R&D surveys were published for 1995/96 and 1999/2000. Accordingly CeSTII faced a blank canvas when it began its work on the 20021/02 R&D survey, a situation that is likely to be common for many other African states. By that stage no institutional capacity to conduct the survey remained within government; likewise there was no institutional memory among the intended R&D performing respondents.

R&D surveys seek to estimate the inputs to research and experimental development according to agreed criteria. The inputs are financial, namely expenditures, not budgets, and the people that do the R&D. In addition the surveys look at spatial and demographic data, the origins of the funding and the research fields to which it is applied. The surveys naturally lend themselves to the inclusion of items for other matters of interest, for example age, gender and staff mobility, R&D collaboration, and the use of various incentives. While the "Frascati" manual provides guidelines it is not prescriptive and statistical agencies will always have to make decisions regarding what data is collectable, taking into account resources, timelines, and availability of such data.

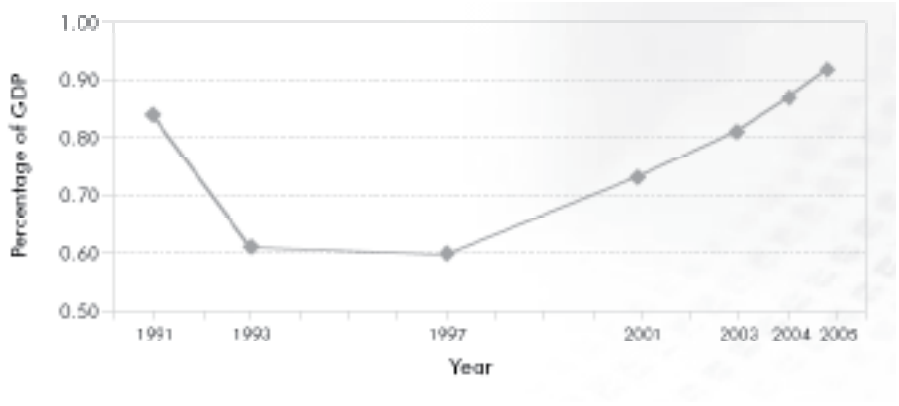
The most fundamental problems in designing such surveys are to determine who the performers of R&D might be and how to draw the bounda-

ries between different sectors. In South Africa the sectors are higher education institutions (HEIs), Science Councils (SCI), Government research institutes (GOV), the business sector (BUS) and not-for-profits (NPOs) organizations. It is straightforward to obtain a list of public sectors R&D performers so that one may speak of a census of R&D performers. But in emerging economies business registers are a rarity, and if they exist are often incomplete and are based on fields that do not assist the R&D survey. The solution is to accept that the business (and NPO) sector must be covered through purposive surveys.

In South Africa the 2001/02 R&D Survey was effected without access to an official business register, let alone a register of business R&D performers. The starting point was the 1991/92 database of business R&D performers. This was augmented with the listed companies on the Johannesburg Securities Exchange and lists of recipients of government direct incentives for R&D. Onward referrals by peer organizations proved to be a very useful means of tracking down large R&D performers. An underlying problem of consistency of the unit of measure (UOM) could not be adequately resolved. In some cases the respondent was a group, and in others an enterprise that was part of a group, with a corresponding under-representation of the scope of the coverage. A total of some 2000 potential business sector R&D performers were identified. They were contacted telephonically and a majority was eliminated as non-performers of R&D. They remain on the database and are re-assessed from time to time. One of the major successes of the survey of business was to obtain quality information on defence and aerospace R&D. This was achieved by recruiting a retired senior defence force officer who had the necessary industry contacts and trust for basic information to be conveyed to the survey. He visited the major defence contractors and persuaded them to provide the high-level information that the survey requires. Being high-level it contains no trade secrets.

This experience shows that obtaining responses from the business sector requires patience and determination. This is a labour intensive process – a simple postal survey would be doomed to failure. From inception to completion this first survey took two years to design, plan and execute. The final tally of 137 completed business questionnaires for the 2001/02 R&D Survey was regarded as providing a representative picture.

Diagram 1: Gross expenditure of R&D to GDP, 1991-2005



Source: HSRC, 2007a.

The 2001/02 R&D Survey (Diagram 1) is regarded as the baseline survey for the series that CeSTII started. It was followed a year later by publication of the 2003/04 R&D Survey, after which the surveys became an annual requirement. The high-level results are hosted on an open access web site (HSRC, 2007a). Having learnt how to do the first survey it became possible to complete the next in half the time. Diagram 1 also shows the extent to which the GERD: GDP ratio fluctuated as the responsibility for the survey migrated among different service providers.

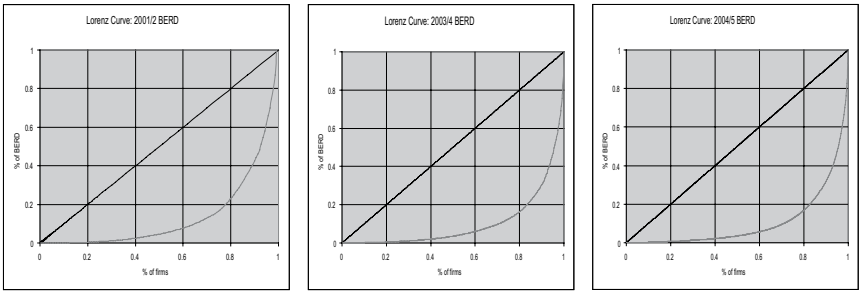
The care with which the 2001/02 R&D Survey was executed was attested to in the declaration of its results as Official Statistics as of July 2005. In the same month South Africa's S&T data for the first time were included in the authoritative *Main Science and Technology Indicators* (OECD, 2005b). As Official Statistics the survey is a protected activity and all staff involved take an oath of secrecy.

The conduct of the R&D surveys is a process of continual learning. As improved coverage of the HEIs was attained it became possible to do consistency checks across the universities and thereby to detect anomalies. To an extent the same applies across whole sectors as well. A case in point is the ratio of labour costs to current expenditure. A rough rule of thumb has that these are roughly equal – one's salary must be matched by other expenditure to keep the enterprise running irrespective of whether it is a university, NGO or business. Very wide divergences in this ratio for the universities that arose through varying accounting practices were found. Accordingly their research information staff were invited to a series of workshops that

agreed on a common approach. This is of course only possible where one is dealing with manageable numbers of institutions – for business consistency checking relies on different approaches such as the development of item norms. A second difficulty in assessing the HEIs is the matter of determining researcher time on task (Sirilli, 1998) a matter that is settled in some countries by the use of time factors (StatCan, 2003).

The 2003/04 R&D Survey brought in 366 business questionnaires; that for 2004/05 attained 511 and the 2005/06 survey achieved 605. The 2003/04 R&D Survey is certainly more representative than the baseline survey. This raises two questions: is the increase in business expenditure on R&D (BERD) being driven entirely by the increase in coverage and at what point will/should the coverage saturate? To answer the first question the panel of 366 firms of 2003/04 was tracked going forward. It was found that individual R&D expenditures fluctuated but that the average expenditure showed real growth of around 10%. In addition there is no linear relationship between the growth in coverage and BERD. A consistency check is provided by calculating the Gini coefficient and Robin Hood index for enterprise R&D.

Diagram 2: Lorentz curves 2001/02, 2003/04 and 2004/05



BERD 2001/2		BERD 2003/4		BERD 2004/5	
Gini Coefficient	0.74	Gini Coefficient	0.79	Gini Coefficient	0.79
Robin Hood Index	0.58	Robin Hood Index	0.64	Robin Hood Index	0.63

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Source: CeSTII internal calculations

These show that the Lorenz curve is remarkably constant in shape survey by survey for two reasons – R&D is concentrated in large performers and the few large performers added from survey to survey are compensated by the addition of a larger number of very small performers. The saturation will be open to test once the newly promulgated R&D tax incentive comes into force as this should lead to a regulated flow of information from companies to the tax authority and thence to the survey. However tax compliance is variable and it is quite possible that only the very large performers will be interested or able to benefit from meeting the stringent conditions for reduction in their tax burden.

The complexity of conducting R&D Surveys should not be under-estimated especially in environments with poorly developed information systems and histories of non-compliance. So learning how to do R&D Surveys takes time, patience and the support of the authority that commissions the work.

Innovation Surveys in an emerging economy

Innovation system theory in many ways dates to the work of Freeman (1982) and Lundvall (1985). This was followed by interest in measuring innovative activity that in turn led to the first Oslo Manual in 1993. Innovation Surveys measure the extent of innovative activity in the industry and service sectors of the economy and provide various other measures such as the importance of different sources of information and partnerships for innovation, barriers to innovation and sales of innovative products. Since that time European Union countries have engaged in four rounds of such surveys. The fifth, CIS 2006 is at the planning stage. Other non-EU countries such as Japan, China, Canada, and Australia closely follow the CIS design, while countries in Latin America have developed a related instrument codified in the so-called "Bogota" Manual.

South Africa conducted its first official Innovation Survey for the years 2002/04 starting in early 2005. This survey took some three years to design and implement (HSRC, 2007b) and drew on the experience of two earlier non-official surveys (FRD-ISP, 1996; Oerlemans et al, 2004). It sought to achieve two goals:

- Consistency with the Community Innovation Survey 4 (CIS4) of Eurostat for benchmarking purposes;
- Provision of policy-relevant data for South Africa.

The first was achieved by constructing the required sample and questionnaire as close to the Eurostat/Oslo Manual as possible. The second follows from the sampling methodology.

Unlike R&D Surveys that are inherently purposive in construction, innovation surveys are based on a random sample of firms in agreed industry sub-sectors. By design they only sample businesses that trade in the market. The 2002/04 Innovation Survey is distinguished from the previous unofficial surveys in that the random sample for the first time came from an official source, Statistics South Africa. By late 2004 Statistics South Africa had a reasonably complete Business Register in place based on a consolidated list of company taxpayers with all tax information deleted, and the firms categorized by Standard Industrial Classification (SIC), Class Size and turnover.

The Eurostat CIS4 requires construction of a stratified random sample by firm size as determined by the number of employees, with a cut-off of 10 employees. There is very weak correlation between turnover and the number of employees for the South African firms so there is some restriction in comparability between South Africa and the Eurostat results by firm size, but overall comparison is still possible. Thus the Survey accords with the basic requirement of benchmarking.

The local specification of the stratification layers allows for the innovation behaviour of medium and small sized firms to be examined as a contribution to monitoring the effect of the National Small Business Amendment Act (DTI, 2003).

South Africa is not alone in the problem of the business register: in the absence of an official register the German innovation survey made use of a credit bureau register. This is satisfactory since no German firm could function without a credit rating, so that register is fairly complete, though likely to include defunct companies. The South African sample size (3087) was scaled to match the personnel available to do the survey fieldwork. Their first task was to check the validity of the firm contact information that resulted in the sample falling to 2627 entities. In addition a number of firms were incorrectly categorized and had to be re-assigned by class size with consequent changed in item weights. Once the survey was cleaned the actual fieldwork could begin: postal dispatch of the questionnaire followed by at least two telephonic reminders. The returns saturated at 979 questionnaires, or a return rate of 37.3%. This is the highest achieved for an innovation survey in South Africa.

Even so, in order to meet the Eurostat requirement of a 70% return rate, this necessitated a non-response survey on a limited range of questionnaire items. The non-response survey attained an 89% return rate. The original returns were then adjusted by weight, missing data were imputed where feasible, and the data set captured onto a standard relational database. The next step will be to conduct deeper econometric analysis.

Essentially the survey demonstrates that South African firm innovative behaviour (52% of firms) is very similar to that of firms of the European Union, except insofar as intellectual property protection is concerned.

Impact on policy, actual and intended

It is too soon to judge how the 2002/04 Innovation Survey will impact on policy, the more so as such surveys do not generate widely used indicators. The survey does provide useful "indications" on the sources of innovation, costs and cost drivers of innovative activity and their contribution to revenue, and the role of public funds in innovation. One surprising finding was the close agreement of expenditure on R&D between the innovation survey and the relevant R&D survey. International experience is that the measures via the two survey approaches tend to differ by as much as 50% over or under-estimation.

What is clear at this stage is that there are demands for the coverage of the Innovation survey to become even more locally relevant, that will perhaps entail some additional sampling of the informal sector especially the so-called "second economy."

The R&D Survey on the other hand provides quantitative data that speak directly to the needs of innovation policy. Policy makers now have data on:

- R&D collaboration between firms and the public sector;
- Foreign inflows for R&D;
- Sources of firms' innovations from the public sector;
- Firms' innovation expenditure met by the public purse.

These findings suggest that many of the parameters of business R&D and innovation activity mirror those of the OECD and EU. The economy is increasingly open with exports now equivalent to 30% of GDP and these parameters are consistent with that development.

The development of a robust and sustainable time series of R&D Surveys has proven its value to the South African government by providing a data platform for the recent OECD Review, the scoping of the Ten Year Plan for Science and Technology (DST, 2007) and associated documents dealing with the human capital development. The indicators that are now publicly available provide the basis of forward extrapolation and estimation of supply.

Business schools teach that "to manage one must measure." What is also true is that measurement generates change among those that are measured and political interest, especially where information may be presented in league tables. Among "the measured" the changes are often at the level of information system design (e.g. the universities), or increased awareness of the full cost of R&D (firms). Being seen to be innovative also takes on quality of its own, since firms do not wish to be viewed as laggards. The African Union has set the GERD: GDP target of 1% by 2010. South Africa is on course to meet that target – how many other African states will? R&D represents both willingness and the means to undertake risk, but for many African states there are much more pressing socio-economic priorities. This may go some way in explaining why the response to the UNESCO S&T surveys is low.

On the other hand innovation is the very stuff of life. By definition bringing a firm into existence is an act of innovation, and it makes no difference whether that firm is in the "first" or "second" economy. This makes innovation surveys less politically sensitive as all countries will be able to demonstrate that they do host innovative firms. On the other hand when one raises the bar and concentrates on innovation that is new to the world market, one is restricting coverage to a much smaller set of trailblazers.

The AU-NEPAD programme on African Science, Technology and Innovation Indicators(ASTII) is seeking to conduct the first continent-wide R&D and Innovation survey that will provide the data for the African Innovation Outlook. The survey will use both the Frascati and Oslo manual guidelines to ensure consistency across countries. The treatment of R&D and Innovation in a single survey instrument potentially allows countries to emphasize one rather than the other, especially as R&D surveys are so time-consuming to conduct. It is thus to be hoped that the survey will achieve a high response rate.

CeSTII supported the NEPAD S&T Office is scoping and setting up the ASTII programme and its experience in performing R&D and Innovation

surveys has also been shared with neighbouring countries of the SADC region. Science and technology policy that does not rest on a sound evidence base is unlikely to achieve demonstrated success, and it is internationally agreed indicators that are central to that success. This short paper has highlighted some of the challenges that indicator development presents – they are interesting and surmountable.

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