International overview of arrangements for national support of R&D

Options for African Nations.

Paul van Gardingen &
Anna Karp

The University of Edinburgh
Centre for the study of Environmental Change and Sustainability (CECS)
Crew Building
West Mains Road
Edinburgh EH9 3JN
United Kingdom

Email: p.vangardingen@ed.ac.uk

Executive Summary

This report is designed as one of a series of briefing papers prepared for NEPAD's Office of Science and Technology (NEPAD-OST) designed to support the implementation of Africa's Science and Technology Consolidated Plan of Action (CPA).

The CPA contains provision to provide advice to African governments on science and technology policy. The resolutions of the 1st African Ministerial Conference on Science and Technology (AMCOST) held in Johannesburg, South Africa in 2003 included a commitment "to pursue all measures possible to increase public expenditure on research and development to at least 1 percent of GDP per annum". NEPAD-OST commissioned this review as an overview of global trends in national expenditure on R&D in OECD and selected Asian countries (China, India and Malaysia). The review was designed to identify the kinds of economic and legal instruments that are used by countries to fund R&D and discuss the role of private sector in funding R&D (Research and Development). The review was expected to draw lessons and make specific recommendations on ways to enable African countries to achieve the 1% of GDP expenditure on R&D.

The review is based on primary analysis of data describing the R&D activities of the selected countries along with a review of the policy environment and institutional arrangements for R&D. A series of specific recommendations are presented.

It is concluded that whilst the 1 % target is ambitious, it is consistent with those of many other countries and is achievable in the longer-term. It is suggested that an additional target for GERD (national Gross Expenditure on Research and Development) should be introduced to recognise the very important role that the private sector should play in funding and implementing R&D. The review recommends that AMCOST may wish to consider establishing a target for GERD that is achievable in a medium-term timeframe.

It is important that R&D activities are fully integrated within plans for national social and economic development. This would help to recognise the range of national stakeholders that are potentially involved with R&D. For example within the public sector, this could include departments of agriculture, defence, environment, energy, finance, higher education and transport, all in addition to any department with direct responsibility for science and technology. Furthermore, the private sector is important, for example in OECD countries, on average the private sector activity is two times greater than that of the public sector.

The public and private sectors are seen to have complementary roles in promoting R&D (or S&T) and increasingly these groups work together. Governments have a role to create suitable enabling environments that promote collaboration in R&D and in the provision of infrastructure required for such activity.

Governments need to develop and implement policies that create a conducive environment for R&D activity. Placing R&D within the concept of innovation and linking this to wider targets for economic and social development can be helpful. Within most African nations, this would best be done by linking investment plans for R&D (or innovation strategies) into national poverty reduction strategy papers.

Investing in education systems is one of the most important prerequisites to improve economic development in Africa. Plans to enhance R&D activity in Africa must be linked with those to revitalise education, especially higher education. Universities around the world are playing a vital role in driving innovation, through provision of R&D and meeting the demand for trained staff. The new role for higher education is clearly seen in this report, through the trend of increase R&D activities by HEIs in most OECD countries and the knowledge-driven economic development in the Asia countries of China, India, Korea and Malaysia included in this study.

Summary of Recommendations

	Recommendation	page
1	AMCOST may wish to consider placing the target for public expenditure of 1 % of GDP within a wider framework which addresses national Gross Expenditure on Research and Development (GERD). This would help to address the need to provide incentives for enhanced investment by the private sector.	15
2	AMCOST may wish to consider creating an interim target for GERD that is realistic, achievable and timebound.	15
3	Some African nations may initially need to exceed the 1 % of GDP target for public expenditure on R&D when additional investment is necessary in order to overcome constraints related to the development of necessary infrastructure and human capacity.	15
4	African nations should review R&D needs and existing provision across government and the private sector. The development of a national science and innovation strategy would help to articulate the opportunities for R&D to contribute to national social and economic development.	18
5	Investment plans for R&D (or S&T) should be linked into national development plans, including Poverty Reduction Strategy Papers (PRSPs, or there equivalent) where these are available.	18
6	The appointment of scientific advisors (or panels) in government will help to promote the case for investment in R&D.	18
7	The ability of and opportunities for African higher education institutions to undertake R&D should be enhanced.	18
8	Governments need to create a conducive environment for R&D activity. Government R&D expenditure should be linked to wider targets for national economic and social development. Policies will need to address issues of taxation, IPR, trade rules, the impacts of globalisation and should be designed to promote cooperation between the private and public sectors.	26
9	Direct government investment in R&D activities should continue to be an essential component of national innovation strategies.	26
10	Additional investment in education from primary through to higher education and life-long learning will be required to develop the human resources which will be essential to build national R&D capacity.	26
11	Governments need to work with the private sector to develop the infrastructure necessary to support growth in R&D activity.	26
12	Governments should provide funding and other incentives to promote technology transfer from government and university R&D to the private sector.	29
13	Governments should consider opening up the market for provision of public funded research to the private sector.	29

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Abbreviations

Abbreviation	Definition
AMCOST	African Ministerial Conference on Science and Technology
ASIF	African Science and Innovation Facility
AU	African Union
BERD	Business Expenditure on Research and Development
CGIAR	Consultative Group on International Agricultural Research
CGIAR	Consultative Group on International Agricultural Research
CPA	Africa's Science and Technology Consolidated Plan of Action
DAC	OECD Development Assistance Committee
DFID	Department for International Development
EC	European Commission
GDP	Gross Domestic Product
GERD	Gross domestic Expenditure on Research and Development
HEI	Higher Education Institution(s)
HIPC	Highly Indebted Poor Country
ICT	Information and Communications Technology
IP	Intellectual Property
IPR	Intellectual Property Rights
MDG	Millennium Development Goal(s)
NEPAD	New Partnership for Africa's Development
NEPAD-OST	NEPAD's Office of Science and Technology
NIS	National Innovation Strategy
OECD	Organization for Economic Cooperation and Development
PPP	Public-Private Partnerships
PRSP	Poverty Reduction Strategy Paper
R&D	Research and experimental Development
S&T	Science and Technology
SME	Small and Medium Enterprise (s)
STI	Science Technology and Innovation
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WHO	World Health Organisation

1 Introduction

1.1.1 Africa's Science and Technology Consolidated Plan of Action (CPA) was adopted by the 2nd African Ministerial Conference on Science and Technology (AMCOST) held in Senegal, September 2005. NEPAD and the African Union (AU) were given responsibilities to support implementation of the CPA

1.1.2 The current paper has been produced as part of a series of background documents designed to feed into a process to implement the CPA through support being provided to NEPAD's Office of Science and Technology by the United Kingdom's Department for International Development (DFID).

1.2 Purpose of the review

1.2.1 It aims at providing an overview of global trends in national support for Research and Development (R&D) in OECD and selected Asian Countries (China, India Malaysia and Korea) with the aim of developing specific recommendations to enable African countries to achieve the expenditure target of 1 % of GDP.

1.2.2 This review distils a set of basic principles that will assist African nations to increase overall expenditure on R&D (Box 1). Other papers in this series include a review of international experience on regional programmes for science and technology (van Gardingen and Karp, 2006a) and a survey of options for funding regional S&T in Africa (van Gardingen and Karp, 2006b).

> *Instruments and institutions for national financing of R&D*
>
> A global survey and analysis of experiences. This paper shall provide an overview of global trends in national expenditure on R&D in OECD and selected Asian countries (China, India, Malaysia and Korea). It will identify the kinds of economic and legal instruments that are used by the countries to fund R&D. The paper shall also discuss the role of private sector in funding R&D and kinds of incentives that OECD and Asian governments provide to attract private funding to R&D. It will draw lessons and make specific recommendations on ways to enable African countries to achieve the 1% of GDP expenditure on R&D.

Box 1 Terms of Reference for the Study

1.3 A target of 1 % of GDP for R&D in Africa.

1.3.1 The 1st AMCOST meeting held in Johannesburg, South Africa in 2003 led to a commitment for all African nations to move towards allocating at least 1 % of GDP as public expenditure in support of R&D (Box 2).

Extract from the
Declaration of the First NEPAD Ministerial Conference on
Science and Technology

We hereby commit to:

1. **Acknowledge** the need for science and technology to be championed as priority instruments of economic and social development at the highest level of our governments;
2. **Emphasize** the need for science and technology policies and strategies that lead to sustainable development and the eradication of poverty;
3. **Resolve and commit** to find ways and means of strengthening, individually and collectively, science, technology and innovation systems of our countries to attain sustainable development and integration into the global economy;
4. **Reaffirm** our commitment to promote within our countries scientific and technological innovations and their application, particularly in the eradication poverty; seeking solutions to food insecurity, malnutrition, homelessness, unemployment, lack of affordable energy and the fight against disease, especially HIV/AIDS, tuberculosis and malaria;
5. **Establish** appropriate enabling conditions for scientific and technological advancement of our countries and the continent;
6. **Establish** a Council of Ministers of Science and Technology as the policymaking and overall governance body for science and technology in the framework of NEPAD

….

8. **Reaffirm** our commitment to pursue all measures possible to increase public expenditure on research and development to at least 1 percent of GDP per annum.
9. **Resolve** to develop the appropriate policy and regulatory environment including protection of intellectual property, to encourage private sector investment in research and development.

….

Box 2. An extract of key commitments made by the 1st African Ministerial Conference on Science and Technology.

1.3.2 The commitment to increase the level of public expenditure to 1 % of GDP made by the 1st AMCOST meeting will be analysed through comparison with OECD and the selected Asian countries.

1.4 Contextual approach

1.4.1 This paper aims to provide policy-makers, especially those based in Africa, with information and a series of recommendations to help promote investment in R&D on the continent. The analysis has been framed within the context of the commitments made by the 1st AMCOST meeting, including specifically the need to demonstrate links to economic development, sustainable development and the reduction (or eradication) of poverty.

1.4.2 The approach adopted in this review starts with a recognition that Africa's context and starting point (economic and social development) are different from those in the OECD and Asian countries used for reference in this study. The natural, infrastructure, human, financial and knowledge resources of African nations presents a diverse set of challenges and opportunities.

1.4.3 Africa's development challenges, which encompasses economic growth the reduction of poverty and social development require African solutions. It was within this context that NEPAD was first established. It is important that this approach has been extended to this report, which has used analysis of data and descriptions of successful approaches elsewhere to inform debate, rather than being considered the basis of "solutions" to be transposed directly into the African context.

2 Methodology & Definitions

2.1.1 The paper is based on analysis of primary data, largely those collected by the Organisation for Economic Cooperation and Development (OCED) and supplemented as necessary with data collated by the World Bank and United Nations system.

2.1.2 The most extensive set of indicators on R&D are collected by the OCED are part of their Main Set of Science and Technology Indicators which are collected using a standard methodology described in the "Frascati Manual" (OECD, 2002). The definition of R&D is presented as Box 3. This definition of R&D covers a range of activities of which science and technology (S&T) is only one component.

Definition of Research and Experimental Development (R&D)

"Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

Box 3 Definition of Research and Experimental Development (R&D) (Frascati Manual, OECD, 2002)

2.1.3 One of the main macro-level statistics is the Gross domestic Expenditure on Research and Development (GERD, Box 4). This is used to measure overall R&D activity within an economy. The OECD notes that international comparisons are frequently done by comparing GERD (or similar measures) with a corresponding economic series such as Gross Domestic Product (GDP). This is the source of the frequently used ratio of GERD to GDP. The OECD does however note, that "such broad indicators are fairly accurate but may be biased if there are major differences in the economic structure of the countries compared" (OECD, 2002). This caution must be recognised when comparing African nations with major OECD economies. For example, the 2005 OECD Science, Technology and Industry Scorecard (OECD, 2005b) comments on the high level of R&D for the services sectors (e.g. financial sector, tourism) in many OECD economies.

GERD

GERD is total intramural expenditure on R&D performed on the national territory during a given period.

Box 4 Definition of Gross domestic Expenditure on Research and Development (GERD), (OECD, 2002).

2.1.4 The macro-level indicators such as GERD are broken down into a range of finer detail indicators. This report presents data on the sources of funding for GERD, and the types of organisations undertaking R&D activities. There is considerably more information available and this may be relevant to future analysis.

Breakdown of GERD

By source of funds:

- Financed by business enterprises;
- Financed by government;
- Financed by other national sources;
- Financed from abroad.

By performance sector

- R&D performed by the business enterprise sector
- R&D performed by the Higher Education sector
- R&D performed by the Government sector
- R&D performed by the private non-profit sector.

Box 5 Breakdown of GERD used in this study (derived from (OECD, 2002)).

2.1.5 The breakdown of GERD provided as Box 5 is relatively easy to understand and where necessary can be supplemented with the definitions contained in the Frascati Manual. One important point is that the expenditure attributed to Higher Education institutions only relates to research activities, either conducted by staff or PhD-level students. Teaching activities are specifically excluded.

2.2 R&D data issues.

2.2.1 The OECD dataset (OECD, 2006a) is the most comprehensive set available that has a high degree of reliability and comparability between countries. This said, there are still a number of problems associated with the data. These are expanded in relevant OECD publication and on-line data bases.

2.2.2 For the purposes of this study, there was no single year that could provide adequate coverage for all countries. The year of 2003 was selected as the most recent reference year and where necessary these data were supplemented from earlier years. This has resulted in a synthetic dataset, but this process would have very limited impact on any conclusions.

2.2.3 Among the non-OECD countries in this study, only China has data of sufficient quality to be included in the main OECD dataset. The data for China is still limited in extent and does not contain detail on sources of funding for GERD.

2.2.4 Data for India and Malaysia were obtained from a dataset collated by UNESCO's Institute of Statistics[1]. It should be noted that these data should not be considered to be directly comparable with those collated by the OECD.

2.3 Macroeconomic data

2.3.1 Simple macroeconomic data were collated from the World Bank's World Development Indicators (World Bank, 2006). A reference year of 2003 was used to be comparable to the OCED data. In addition to GDP (in current US$) this dataset provided information on the number of researchers working in the economy.

[1] Data available from http://www.uis.unesco.org/ as part of their project on S&T statistics.

3 Global trends in national expenditure on R&D

3.1.1 The analysis presented in this review, considers the current status and past trends in national R&D expenditure in OECD and selected Asian countries (China, India, and Malaysia[2]). Table 1 presents selected macroeconomic and social data whilst Table 2 examines national R&D expenditure.

3.2 Analysis of current R&D expenditure (2003)

3.2.1 The macroeconomic data (Table 1) show that the most of the world's largest developed economies (USA, Japan, Germany, France and the United Kingdom) have overall levels of R&D expenditure exceeding 2 % of GDP, the exception being the United Kingdom (1.9 %). China as the largest emerging economy has expenditure of 1.3 % of GDP, and this is increasing rapidly (Figure 4).

3.2.2 The highest relative levels of R&D expenditure with values of 3 % or greater are seen in Finland, Japan and Iceland, though the Iceland data can be considered to be a reflection of the structure of this low-population country and high levels of employment in the R&D sector.

3.2.3 The emerging economies such as China, India, Malaysia and Mexico have very much lower levels of researchers engaged in R&D activities, but the data cannot distinguish if this is a result of insufficient availability of trained individuals or lack of demand. Data on mobility of researchers and research students suggest that it is likely that the issue is lack of supply (OECD, 2005b)

3.2.4 China has the highest annual GDP growth rate (10 %) closely followed by India and then Malaysia. Within the OCED, Greece has the highest growth rate. Table 2 shows the breakdown of expenditure and activity within the study countries. It is seen that in 2003, only Iceland exceeded the nominal value of 1 % of GDP public expenditure on R&D. Sweden and Finland had values exceeding 0.9 % of GDP whilst the highly industrialised countries of France, Germany and USA had public R&D expenditure of between 0.8 and 0.9 % of GDP. The OECD average was 0.7 % of GDP. It is also important to note that in these countries, government R&D expenditure can be heavily biased by defence R&D, a situation most obvious for the USA and United Kingdom (54 % and 32 % of government R&D expenditure respectively in 2003).

3.2.5 The breakdown of sources of financing for R&D shows that the proportion funded by industry is typically two times higher than that funded by government. The OECD average contribution by industry was 62 % of GERD. Countries with a larger proportion of agricultural activity in the economy tended to have a lower proportion of industrial investment in R&D.

3.2.6 The way that R&D activities are implemented show similar trends. Across the OECD and Asian economies around two third of all R&D activity is undertaken by the private or business sector. Around 30 % of activity is performed by the Higher Education and Government sectors, but the proportions vary between country. The private non-profit sector (e.g. NGOs) tends to represent a relatively low proportion of overall activity.

[2] The terms of reference for this study included Korea. As Korea is an OECD member, it is analysed within that grouping

	GDP, (million $ US)	GDP growth (%)	Population (million)	GERD (% of GDP)	Researchers in R&D (per million)
Australia	527,417	3.7	19.9	1.6 [1]	3,670 [1]
Austria	255,240	0.7	8.1	2.2	2,968 [2]
Belgium	304,228	1.2	10.4	2.3	3,330
Canada	856,526	1.9	31.6	1.9	3,597 [2]
China	1,640,962	10.0	1,288.4	1.3	663
Czech Republic	90,602	3.2	10.2	1.2	1,544
Denmark	211,081	0.7	5.4	1.2 [3]	4,611
Finland	161,780	2.3	5.2	3.5	7,992
France	1,789,133	0.8	60.0	2.2	3,213
Germany	2,443,420	0.0	82.5	2.5	3,206
Greece	173,219	4.7	11.0	0.6 [5]	1,390
Hungary	83,149	3.4	10.1	0.9	1,496
Iceland	10,396	4.2	0.3	3.0	6,627
India	600,615	9.0	1,064.4	0.9 [4]	119 [4]
Ireland	152,129	3.6	4.0	1.1	2,608
Italy	1,468,317	0.0	58.0	1.2 [3]	1,213
Japan	4,291,124	1.3	127.6	3.1	5,287
Korea, Rep.	608,148	3.1	47.8	2.6	3,187
Luxembourg	27,038	2.9	0.4	1.8	4,301
Malaysia	103,952	5.4	24.4	0.7 [1]	299 [1]
Mexico	639,076	1.4	102.3	0.4 [1]	268 [1]
Netherlands	512,727	-0.9	16.2	1.9 [5]	2,349
New Zealand	80,024	3.6	4.0	1.2	3,405 [6]
Norway	220,603	0.4	4.6	1.7	4,587
Poland	209,849	4.0	38.0	1.0	1,519
Portugal	147,303	-1.1	10.4	0.8	1,949 [5]
Slovak Republic	32,665	4.0	5.0	1.0	1,782
Spain	880,990	2.9	42.0	1.1	2,195
Sweden	301,553	1.5	9.0	4.0	5,333
Switzerland	321,798	-0.4	7.3	2.6 [7]	3,601 [7]
Turkey	240,376	5.8	70.7	0.7 [1]	341 [1]
United Kingdom	1,797,786	2.2	59.6	1.9	2,706 [8]
United States[9]	10,951,300	3.0	290.8	2.7	4,484 [10]

Table 1 Macroeconomic and population data.

Source: World Bank World Development Indicators, 2003 data (World Bank, 2006)
[1] Australia. Malaysia, Mexico, Turkey: GERD and Researchers in R&D (2002);
[2] Austria and Canada: Researchers in R&D (2002);
[3] Denmark, Italy: GERD (2002);
[4] India GERD (2000) and Researchers in R&D (1998);
[5] Greece, Netherlands, Portugal: GERD (2001);
[6] New Zealand: Researchers in R&D (2001);
[7] Switzerland: GERD and Researchers in R&D (2000);
[8] United Kingdom: Researches in R&D (1998);
[10] United States: Expenditure data are limited to Federal expenditure and exclude most capital costs.
[10] United States: Researchers in R&D (1999).
Data not available shown as "..".

	GERD (% GDP)		Source of funding (%)				Performance Sector			
	Total	Govern ment	Industry	Govern ment	Other national	From abroad	Business Enterprises	Higher Education	Govern ment	Non-Profit
Australia[1]	1.7	0.7	48.8	42.4	4.7	4.1	51.2	26.7	19.3	2.8
Austria[2]	2.2	0.8	43.9	34.7	0.4	21.0	66.8	27.0	5.7	0.4
Belgium[3]	1.9	0.5	63.4	22.0	2.5	12.1	70.7	21.2	6.8	1.2
Canada	2.0	0.7	47.5	34.5	9.9	8.1	53.0	35.7	11.0	0.3
Czech Rep.	1.3	0.5	51.4	41.8	2.2	4.6	61.0	15.3	23.3	0.4
Denmark	2.6	0.7	61.3	26.5	2.7	9.5	69.7	22.8	6.8	0.7
Finland	3.5	0.9	70.0	25.7	1.1	3.1	70.5	19.2	9.7	0.6
France	2.2	0.9	50.8	39.0	1.8	8.4	62.6	19.4	16.7	1.3
Germany	2.5	0.8	66.3	31.2	0.3	2.3	69.7	16.9	13.4	..
Greece	0.6	0.3	30.7	47.4	3.8	18.1	30.1	48.1	20.9	1.0
Hungary	1.0	0.6	30.7	58.0	0.4	10.7	36.7	26.7	31.3	..
Iceland	3.0	1.2	43.9	40.1	1.5	14.5	51.8	21.3	24.8	2.1
Ireland	1.2	0.4	59.5	30.4	1.6	8.5	66.9	25.2	7.9	..
Italy[4]	1.2	0.5	43.0	50.8	..	6.2	48.3	32.8	17.6	1.3
Japan	3.2	0.6	74.5	17.7	7.5	0.3	75.0	13.7	9.3	2.1
Korea	2.6	0.6	74.0	23.9	1.7	0.4	76.1	10.1	12.6	..
Luxembourg	1.8	0.2	80.4	11.2	0.2	8.3	89.1	0.4	10.5	..
Mexico[5]	0.4	0.2	29.8	59.1	9.8	1.3	30.3	30.4	39.1	0.2
Netherlands	1.8	0.7	51.1	36.2	1.4	11.3	57.4	28.1	14.5	..
New Zealand	1.2	0.5	38.5	45.1	9.6	6.8	42.5	28.5	28.9	..
Norway	1.8	0.7	49.2	41.9	1.5	7.4	57.5	27.5	15.1	..
Poland	0.6	0.4	30.3	62.7	2.4	4.6	27.4	31.7	40.7	0.2
Portugal	0.8	0.5	31.7	60.1	3.2	5.0	33.2	38.4	16.9	11.5
Slovak Republic	0.6	0.3	45.1	50.8	0.7	3.3	55.2	13.2	31.6	0.0
Spain	1.1	0.4	48.4	40.1	5.8	5.7	54.1	30.3	15.4	0.2
Sweden	4.0	0.9	65.0	23.5	4.3	7.3	74.1	22.0	3.5	0.4
Switzerland[6]	2.6	0.6	69.1	23.2	3.4	4.3	73.9	22.9	1.3	1.9
Turkey[7]	0.7	0.3	44.9	48.0	6.3	0.8	33.7	58.9	7.4	..
United Kingdom	1.9	0.6	43.9	31.3	5.4	19.4	65.7	21.4	9.7	3.2
United States	2.7	0.8	63.8	30.8	5.4	..	69.8	13.7	12.4	4.1
Total OECD	*2.3*	*0.7*	*61.8*	*30.4*	*4.8*	*..*	*67.7*	*17.4*	*12.3*	*2.6*
China	1.3	0.4	60.1	29.9	..	1.9	62.4	10.5	27.1	..
India[8]	0.9	0.7	23.0	74.7	2.4	..	23.0	2.4	74.7	..
Malaysia[8]	0.7	0.2	51.5	32.1	4.9..	11.5	65.3	14.4	20.3	..

Table 2 Research and experimental development expenditure and implementation

Notes: OECD data from 2003. OECD Main Science and Technology Indicators (OECD, 2006a) except for India (2000) and Malaysia (2002) which have been derived from UNESCO's project on S&T Indicators (http://www.uis.unesco.org/). [1] Australia all data 2002; [2] Austria, performance data 2002: [3] Belgium, source of funding data 2001; [4] Italy, Total GERD 2002, source of funding 1996; [5] Mexico, all data 2001; [6] Switzerland, all data 2000; [7] Turkey, all data 2001; [8] India and Malaysia, estimate of government expenditure on R&D (as % of GDP) calculated from data in this table. More detail on the collection of data and their associated quality can be found in the Frascati Manual (OECD, 2002) and the OECD website (http://www.oecd.org). Please note that the breakdown of percent funding and performance may not sum to 100 %. Data not available shown as "..".

3.3 Trends for funding R&D in OECD & Asian Countries.

3.3.1 Trends in R&D expenditure are shown for selected countries as Figure 1 (OECD average, Canada. Finland and France) and Figure 2 (Japan, Korea, United Kingdom and USA). These show what tends to be gradual increases in GERD as a percentage of GDP with the exception of the expanding economies of Korea and Finland where there have been significant industrial development over the period.

3.3.2 There has been a common trend of a shift towards an increasing proportion of R&D expenditure being financed by industry and hence reduction in the share financed by governments. This does not necessarily equate to a reduction of government expenditure, just that the growth of financing by industry has exceeded that of government. Simply put, industry is placing a higher value on R&D investments than is government.

3.3.3 The trends in the performance of R&D activities also show common patterns in nearly all OECD countries shown (Figure 3). The proportion of R&D undertaken by industry has remained relatively constant with an OECD average of just over 60 %, but in nearly all countries there is a shift with the proportion of R&D performed by higher education institutions increasing and government institutes decreasing. The underlying data show that this trend reflects decisions by both government and private sector funders, who are placing more contracts with institutions of higher education.

3.3.4 Equivalent data for the Asian non-OECD countries are shown as Figure 4. These data show steady increases in expenditure, but in all cases current expenditure is well below the current OECD average. The trends on performance of R&D are informative. China shows very significant changes with a rapid increase in R&D activity performed by business enterprises linked with the liberalisation of the Chinese economy. India in contrast appears to have very high government activity. Data for Malaysia show the importance R&D effort performed by the business sector, but the trends are non-conclusive.

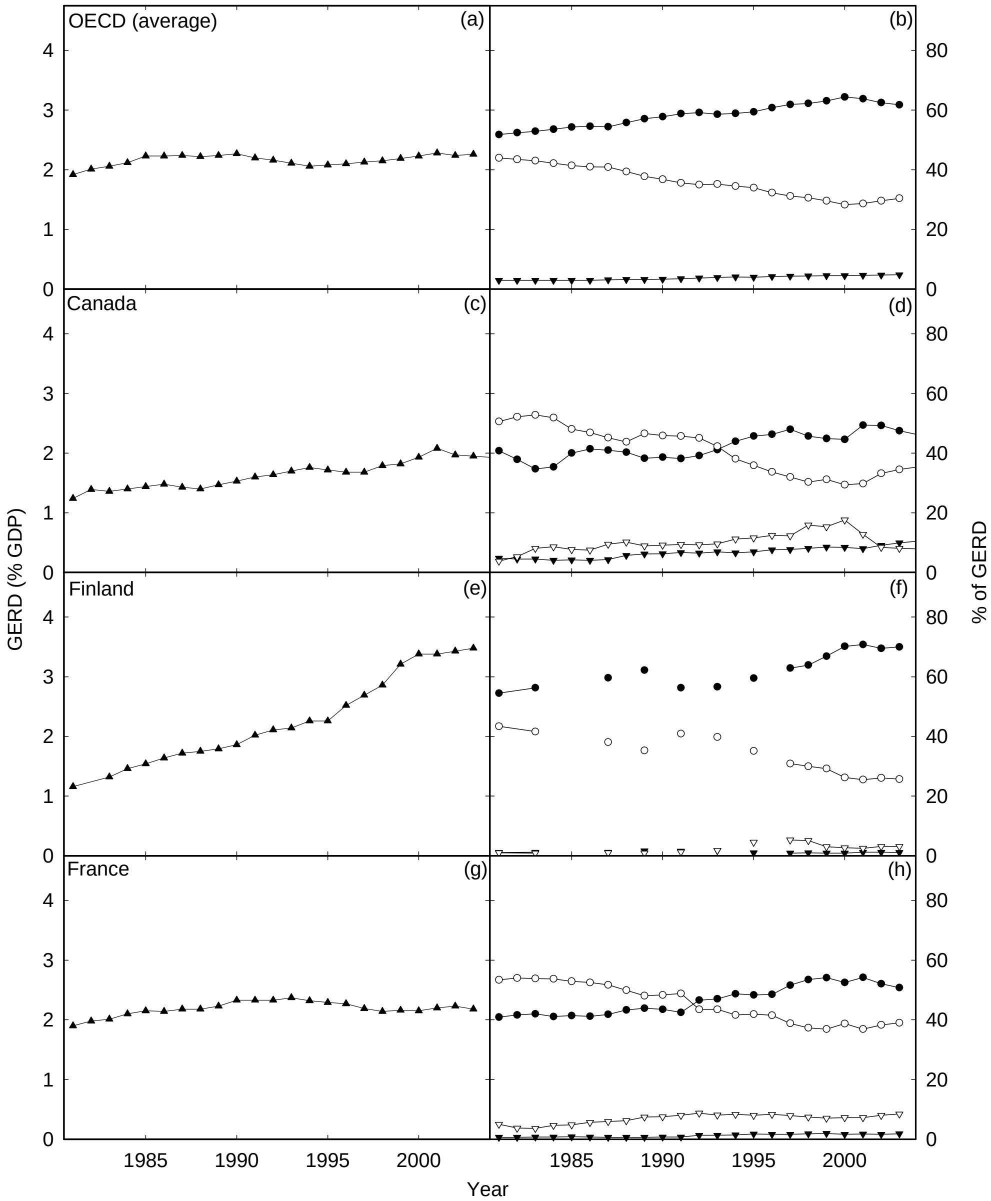

Figure 1 Gross Domestic Expenditure on Research and Development (GERD). GERD as a percentage of Gross Domestic Product (GDP, a, c, e, g).
Sources of GERD (% of total, b, d, f, h), financed by industry ●, government ○, other national sources ▼ and financed abroad ▽。
Source: OECD Main science and technology indicators. (OECD, 2006a)

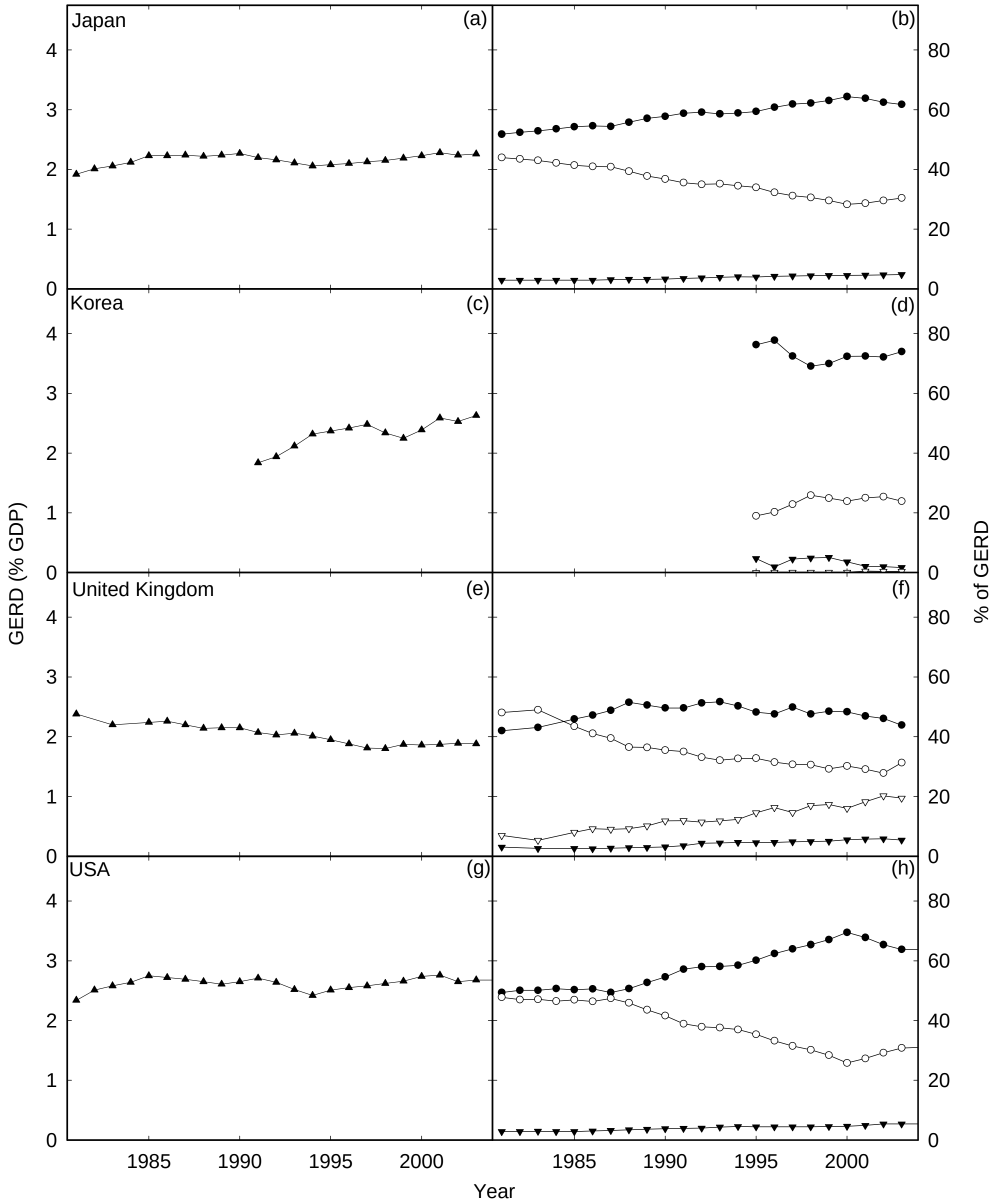

Figure 2 Gross Domestic Expenditure on Research and Development (GERD). GERD as a percentage of Gross Domestic Product (GDP, a, c, e, g). Sources of GERD (% of total, b, d, f, h), financed by industry ●, government ○, other national sources ▼ and financed abroad ▽。

Source: OECD Main science and technology indicators. (OECD, 2006a)

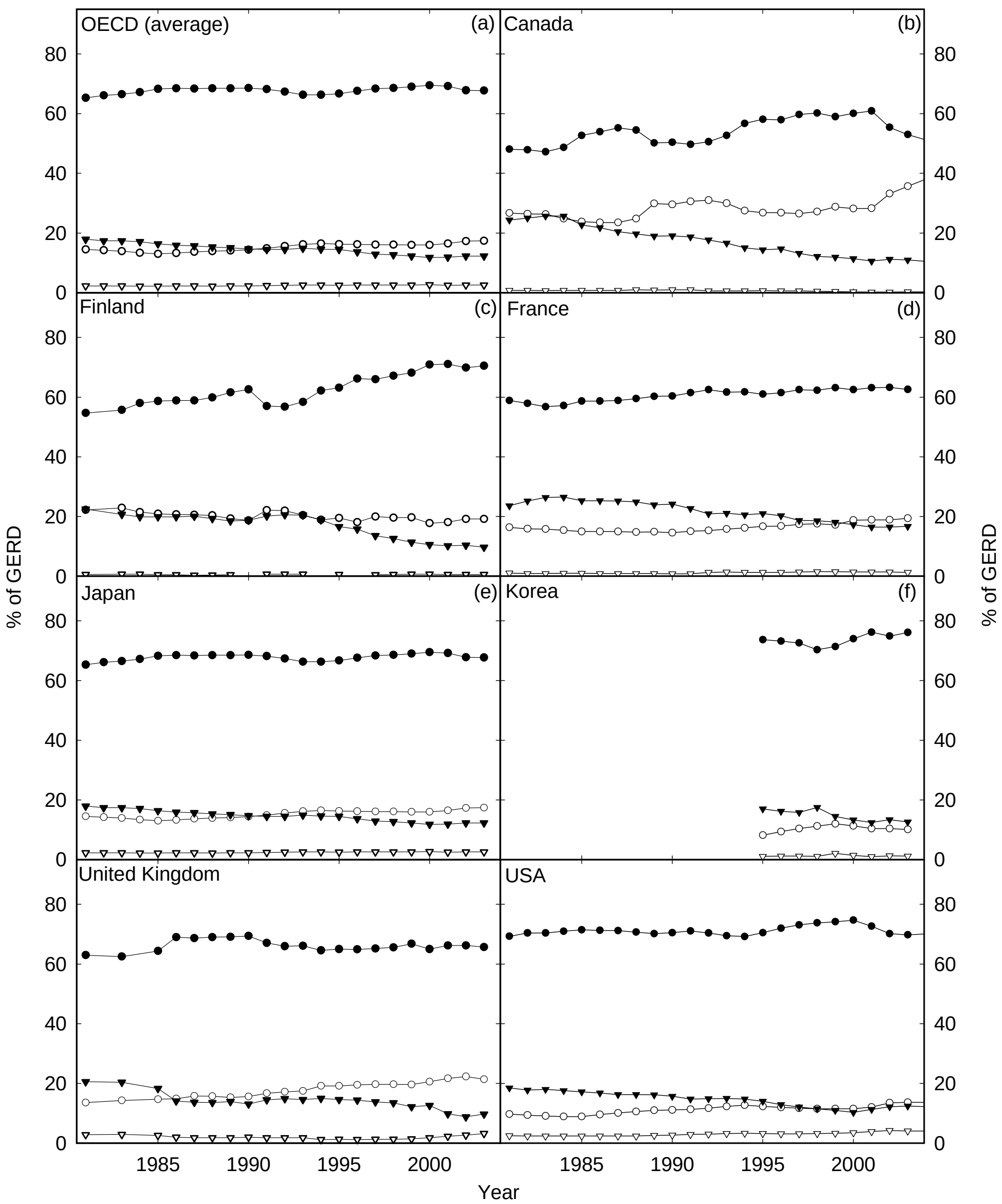

Figure 3 Percentage of GERD performed by activity sector:
Business enterprise sector ●, higher education sector ○, government sector▼, private non-profit sector ▽.
Source: OECD Main science and technology indicators. (OECD, 2006a)

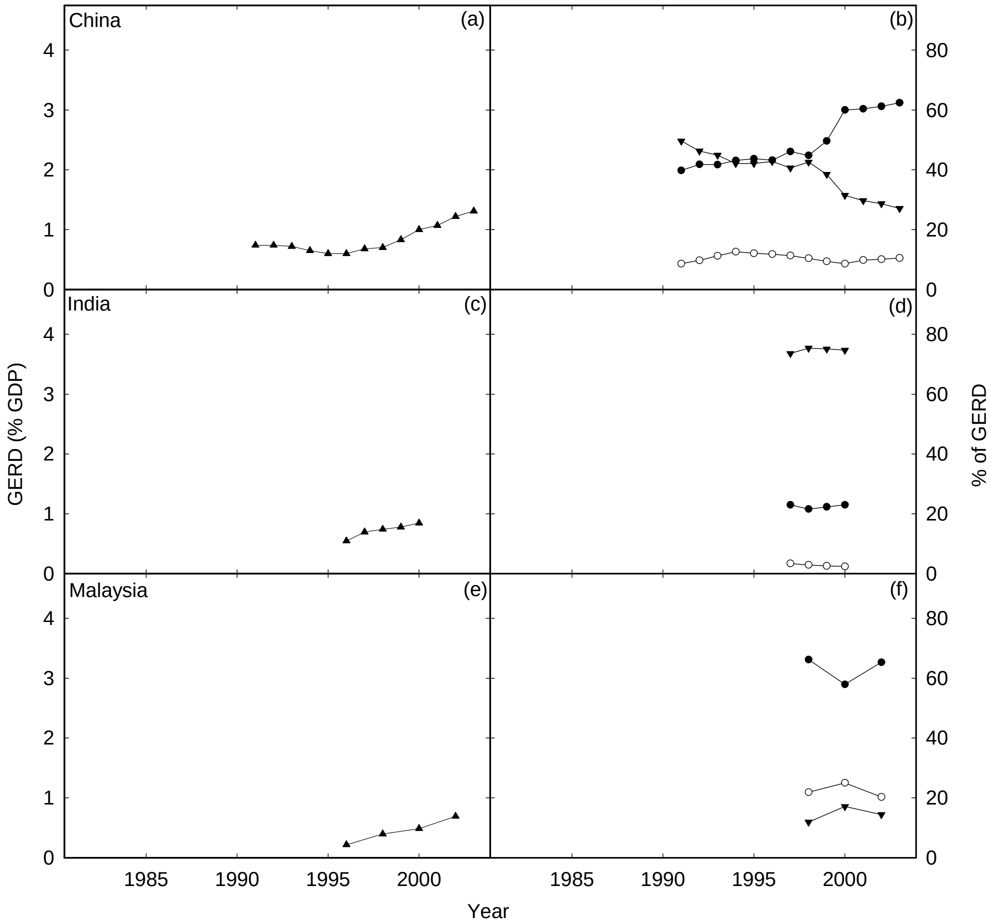

Figure 4 R&D statistics for selected non-OECD Asian countries. GERD as a percentage of GDP, a, c, e). Percentage of GERD performed by activity sector, (b, d, f: Business enterprise sector ●, higher education sector ○, government sector ▼, private non-profit sector ▽.)
Sources: OECD Main science and technology indicators. (OECD, 2006a) and UNESCO Institute of Statistics, Science and Technology Indicators project, http://www.uis.unesco.org/

3.3.5 The state of science and technology in OECD countries is summarised in the OECD S&T scoreboard (OECD, 2005b). The overall trend of increased investment in R&D is seen to be benefiting from significant increases in private sector investment, whilst in some countries public sector investment is stable or even decreasing. Within the public sector there is also a shift to increase the proportion of R&D undertaken by higher education institutions.

3.3.6 The statistics documented in this report provide a number of clear trends:

- An increasing proportion of national GDP being allocated to support R&D activities.
- The relative importance of the private sector is increasing in nearly all countries, both in terms of funding and performing R&D activities.
- The Higher Education sector is responsible for delivering an increasing proportion of national R&D
- Traditional government research institutes are decreasing in importance.

3.4 Relevance and lessons for Africa

3.4.1 The 1st AMCOST meeting set a target for public financing for R&D of 1 % of GDP. This report has shown that within the OECD, only Iceland meets this target (Sweden and Finland are within 0.1 % of GDP of the target). Even the world's largest economy, the USA has a level of Federal public expenditure of 0.8 % of GDP with much of this being allocated to military activities. This raises the question of if the target is relevant to Africa?

3.4.2 Closer examination of data from the United States shows that the value of 0.8 % of GDP for public expenditure on R&D is an underestimate as it only covers Federal (central) expenditure and does not include capital allocations. If both were added to the Federal operating costs it is likely that the 1 % level would be exceeded.

3.4.3 The need to grow R&D activity in Africa means that concepts of "catching up" or "leap frog" approaches are often proposed for R&D strategy. This combined with the need to address issues of human resource development and infrastructure means than in many countries a target of 1 % of GDP may be insufficient to provide the resources required to deliver adequate progress.

3.4.4 Other regional groupings have considered similar problems. Most recently, the European Union defined its Lisbon Strategy for economic development. Increasing national and region investment in R&D was central to the strategy which includes an overall target for R&D expenditure of 3 % of GDP of which one third (or 1 % of GDP) would be funded publicly (European Commission, 2002; European Commission, 2003). The African target is entirely consistent with this approach; however, Europe comes from a very different starting point.

3.4.5 The 2003 OECD average for public investment in R&D was 0.7 % of GDP (Table 2) and the European Union (original 15 members) was also 0.7 % (OECD, 2006a). The only comparative data currently available comes from South Africa which had a value of 0.3 % of GDP in 2001 (OECD, 2006a). Put into context, Europe needs public expenditure to increase by 50 %, whilst South Africa would need expenditure to increase by around 300 %. Is this achievable within a realistic timeframe, considering the other major competing demands on public expenditure?

3.4.6 One way to address this issue might be to place the original target within a revised framework which considers total national expenditure on R&D, effectively developing an additional target based on GERD. This would help by providing a stronger incentive for governments to take action to create an enabling environment for R&D that promotes the contribution of the private sector (see Resolution 5, Box 2).

3.4.7 Targets and indicators only realise their full potential if are achieved and there are ways in place to monitor progress. For these reasons the CPA's Science, Technology and Innovation Indicators project becomes very relevant as it provides a mechanism to monitor progress. Good indicators are often referred to as being SMART, *Specific, Measurable, Achievable or Accessible, Realistic and Timebound.*

3.4.8 If the example of the EU is used as a model, AMCOST's commitment to public expenditure of 1 % of GDP could be placed into a wider target of GERD increasing to become 3 % of GDP. Additionally, tt may be worthwhile considering an interim and more readily achievable time-bound target, such as GERD reaching at least 1 % of GDP by 2015.

3.4.9 These conclusions lead to the following recommendations:

Recommendations

1 AMCOST may wish to consider placing the target for public expenditure of 1 % of GDP within a wider framework which addresses national Gross Expenditure on Research and Development (GERD). This would help to address the need to provide incentives for enhanced investment by the private sector.

2 AMCOST may wish to consider creating an interim target for GERD that is realistic, achievable and timebound.

3 Some African nations may initially need to exceed the 1 % of GDP target for public expenditure on R&D when additional investment is necessary in order to overcome constraints related to the development of necessary infrastructure and human capacity.

4 Institutions that fund and undertake R&D

4.1 Introduction

4.1.1 The institutional landscape of organisations that fund (or support) and undertake R&D is surprising complex in most countries. Much analysis tends to focus on government departments with responsibility for science and technology, but the statistics described in the previous section of this report give a very different picture.

4.1.2 Taking the OECD countries as an example, the private sector is around two times more active that governments in both funding and undertaking R&D (Table 2). In addition, the definition of R&D and consequently GERD (Box 3 and Box 4) shows that R&D covers fields outside the normally accepted definition of S&T, for example including research activities by the financial sector and other service industries. When combined, this means in many countries, the Ministry of Science (or their equivalent) may be a relatively minor actor in determining national R&D activity.

4.1.3 This level of complexity means that this report will only consider trends and common practice and how this may relate to the challenge of increasing investment in R&D in Africa. The discussion will also make a distinction between institutions that fund, and those that implement or undertake R&D activities. The comparisons here can be linked to the categories used by the OECD for their analysis of R&D activities.

4.2 Funding or purchasing R&D

Public sector

4.2.1 All public funds to support R&D will be allocated by a ministry of finance or equivalent. Finance ministries balance the demands from a large number of government departments all competing for limited financial resources. For this reason, requests for budget allocations articulate the expected benefits in relation, for example, to social and economic development.

4.2.2 Two recent examples can be used to illustrate this point. In 2000, the European Union adopted their Lisbon Strategy, targeting growth and employment within members of the European Union, and this contained specific proposals in relation to R&D activity (European Commission, 2000; European Commission, 2003). Under the Lisbon Agenda, the EU intends to increase R&D expenditure to at least 3 % of GDP, with public sector expenditure reaching 1 % of GDP. A similar review was undertaken by the Government of the United Kingdom in 2004 within the context of developing a science and innovation strategy (HM Treasury, 2004). Both of these documents place investment in S&T (or R&D) within the context of the expected economic and social development, rather than the expected scientific outputs.

4.2.3 The United Kingdom's review also presents a useful analysis of the diversity of organisations within government that promote or purchase R&D. Other major economies in the OECD (e.g. United States) have conducted similar analysis of institutions that fund or purchase R&D. Typically, these include departments with responsibility for agriculture, defence, environment, finance, health, higher education, transport as well as the expected science and technology.

4.2.4 In addition to direct purchasing or R&D, government departments can often be clients for knowledge, for example in relation to the development of evidence-based policy. The growing awareness of the role of R&D in government has promoted many countries to develop national science or innovation strategies and appoint scientific (or research) advisors at levels of departments and heads of state.

Private sector

4.2.5 The private sector is the largest source of funding for R&D in the majority of countries discussed in this review. The exceptions tend to come from economies that are either emerging or are highly controlled or protected. China presents an interesting example with very much higher investment by the private sector following the gradual process of economic liberalisation in the 1990s (Figure 4).

4.2.6 Most of the R&D funding provided by the private sector is used to fund research implemented by private sector organisations. Analysis of Business Expenditure on Research and Development (BERD) shows that within the OECD in 2003, 96 % of total BERD was used to fund activities undertaken by private sector research institutions (Analysis of BERD data derived from, OECD, 2006a).

> In 2003 at least 95 % of total business expenditure by OECD countries for research and development was used to fund R&D activities undertaken by private sector institutions.

Box 6 Most business expenditure on R&D is implemented by the private sector.

4.2.7 This illustrates that the private sector does not tend to invest heavily in public sector research. If the private sector does outsource research, it is now increasingly likely to do so through of higher education establishments.

Other national sources

4.2.8 Other sources of national funding for R&D tend to be small (OECD average was 4.8 % in 2003, Table 2). These sources can include charities, not-for-profit organisations and NGOs, but it is likely that there are differences in the way these data are recorded between countries. In a number of countries, charities linked with commercial companies, may play a very important role in funding medical research.

International funding

4.2.9 A number of countries are now benefiting from increases in the globalisation of research. Within the OCED, Austria, Greece and the United Kingdom have nearly 20 % of GERD funding coming from international sources. For the non-OECD Asian economies used in this study, Malaysia has over 10 % of GERD sourced internationally. No data were available for India, but it must be expected that internationally funded research is significant there as well. It is not clear from these data, if there are specific reasons for the differences, but this would merit further study as there may be lessons of relevance to Africa. One theme likely to emerge is the availability of skilled R&D staff.

4.3 Undertaking R&D

4.3.1 The shift towards knowledge or innovation-based economic development has required a shift in the way that traditional R&D organisations work. Within the public sector, some of the largest changes have occurred within universities which have needed to adapt rapidly to become much more market oriented. One measure of this change would be technology transfer metrics which in recent years have documented a large increase in links with industry, patenting and spin-out companies. There has also been significant drive towards using Public-Private Partnerships, for example in the area of health research (OECD, 2005b).

4.3.2 Data from the OECD shows that around two-thirds of research is undertaken by the private sector (68 %, Table 2). Institutions of higher education and government institutions are much less important at 17 and 12 % respectively. In Asia, China and India have similar trends whilst India has much higher activity by government institutions.

4.3.3 The trends over recent years have shown a decrease in direct government activity in many countries, often balanced by increases in the higher education sector. Private sector institutions can benefit from public sector funding, but closer examination of OECD data shows that the total amount is small and often linked to activities such as technology transfer. Typically, the proportion of business expenditure in R&D financed by government is up to 10 % of national BERD, with high values often seen in countries with significant expenditure on defence related research.

4.3.4 The role of other organisations such as non-profit research organisations tends to be low within the OECD (2.6 % of activity in 2003, Table 2). The situation in Africa in currently very different, where international organisations linked with the United Nations system, such as the World Health Organisation (WHO) and Consultative Group on International Agricultural Research (CGIAR) may represent a large proportion of total R&D activity within a country (though this information may not be captured in any relevant national statistics)

4.4 Discussion

4.4.1 Many OECD countries are changing the ways that R&D activities are funded and implemented. A number of important trends are described in this paper and contribute to the recommendations detailed in this section.

- S&T (R&D) activities are being placed within the context of innovation strategies that reflect the broad range of actors involved within the public and private sectors.
- The case for public investment in R&D is strengthened through linkage with targets for national social and economic development.
- Many countries have appointed science or research advisors at departmental or head of state level.
- The role and relative importance of private sector R&D is recognised and given a high priority for further development.
- Higher education institutions are becoming increasingly important in delivering R&D activity derived from both government and private sector funding.

4.4.2 These observations should not be transposed directly into the African context. There are, however useful parallels which lead to the following recommendations:

Recommendations

4 African nations should review R&D needs and existing provision across government and the private sector. The development of a national science and innovation strategy would help to articulate the opportunities for R&D to contribute to national social and economic development.

5 Investment plans for R&D (or S&T) should be linked into national development plans, including Poverty Reduction Strategy Papers (PRSPs, or there equivalent) where these are available.

6 The appointment of scientific advisors (or panels) in government will help to promote the case for investment in R&D.

7 The ability of and opportunities for African higher education institutions to undertake R&D should be enhanced.

5 Policies, incentives and investment to promote R&D

5.1 Introduction

5.1.1 Discussions on policies and incentives to promote R&D are often focused relatively narrowly on those specifically targeting R&D activity. This review has taken a broader approach to consider the wider *enabling conditions* that will enhance investment in R&D in African nations (see Box 1). There is also often a tendency to discuss tax regimes and other incentives, without also considering how a broad range of government investment is required to support R&D and to capture the resulting benefits of this investment.

5.1.2 This section discussed the incentives, policies and investments that can be undertaken by governments to promote R&D.

5.2 Innovation Policy

5.2.1 Policies to promote R&D activity should ideally be encapsulated within a wider policy for innovation, and in turn this should address how public investment for innovation will deliver benefits to national social and economic development. Science and technology must move out of any remaining academic "silos" and be seen to be an essential component of the economy. This was captured by the OECD (Box 7) in an early review of approaches used to manage national innovation systems (OECD, 1999).

> "Governments need to play an integrating role in managing knowledge on an economy-wide basis by making technology and innovation policy an integral part of overall economic policy. This requires coordinated contributions from a variety of policies in order to:
>
> - Secure framework conditions that are conducive to innovation, such as a stable macroeconomic environment, a supportive tax and regulatory environment, and appropriate infrastructure and education and training policies.
> - Remove more specific barriers to innovation in the business sector and increase synergies between public and private investment in innovation.
>
> **A new agenda for technology and innovation policy**
>
> Technology and innovation policy should complement broader structural reforms in many fields (*e.g.* competition, education and training, financial and labour markets)…"

Box 7 Integrating innovation into overall economic policy (OECD, 1999)

Intellectual Property Rights

5.2.2 There is increasing recognition of the need to resolve issues of Intellectual Property Rights (IPR) as an enabling condition required to promote investment in S&T. This is most clearly seen within the OECD's largest regional R&D programme, the European Union's Framework Programme. In the 6th Framework programme (running to the end of 2006), all major proposals were required to include IP agreements between partners before the European Commission would issue a contract. This shift in policy was a result partly in response to problems between partners in previous Framework Programmes and also to promote greater participation of the private sector.

5.2.3 Rules relating to intellectual property are required to define distribution of possible financial returns and to facilitate management of access to technological knowledge including the use of patents.

5.2.4 There is, however, a potential conflict in relation to IP created from state-funded research. In some cases there is a default presumption that knowledge generated from state-funded research will be placed freely in the public domain either within the country funding the research or globally. If this is the case, there may be minimal incentives for private sector investment, or even for commercialisation of public-funded research.

Trade rules and agreements

5.2.5 The ability of R&D to contribute to economic development is influenced by trade rules. The growth of high-technology industry in developing countries will often depend on potential market access for exports. This issue has come into prominence during the Doha round of the World Trade Organisation with recently industrialising countries such as South Africa, Brazil and India demanding enhanced market access for high-technology products into developed economies. Another example has been development of high-technology industry in European countries to get access to the entire European Union (the computer and automotive industries are good examples with significant investment by companies from the United States and Japan).

Globalisation and mobility

5.2.6 The EU, USA and many Commonwealth countries have an increasingly mobile and dynamic labour market. Governments are now recognising that mobility of highly trained individuals presents both challenges and opportunities to future development. Within the European Union, for example, the Lisbon Agenda for Europe's economic development makes specific provision to use mobility to drive innovation and development through the EC's Framework Programme (European Commission, 2000; European Commission, 2002; European Commission, 2003).

5.2.7 The European Commission now administers a set of actions designed to promote the benefits of mobility to grow Europe's knowledge-based economy. Specific actions include funds for European researchers to work in other parts of the EU (outside their own country) or in third countries outside the EU. In these cases, mobility is seen as promoting the development of skills and helping to develop long-term research linkages between different institutions and countries. Additional funds are available for non-European researchers to work in the EU with an emphasis on bringing new skills into the EU and once again building long-term research partnerships. The European Commission recognises that mobility actions come with the risk of adding to the "brain drain" from Europe (largely to the United States) and now fund actions designed to give European researchers an opportunity to return to Europe for a period, hoping that this can incentive for Europeans to return therefore reversing the brain drain.

5.2.8 Migration policy is being used by a number of OECD countries to target and attract skilled immigrants and increase the pool of qualified workers in the economy. As an example, changes of migratory policy in Sweden and Australia helped enlarge the skill base in both countries. In the case of the latter, up to 2500 Australian educated international students were granted residency, in the case of the former (OECD, 2003). A similar approach has been adopted in Scotland (Scottish Executive, 2004) were it is now possible for graduates with higher degrees (e.g. Masters or higher) to have a two-year visa extension to reside and work in Scotland; also from 2005 additional scholarships are provided to attract more students to Scotland. There have been more than 2000 successful visa extensions granted since they scheme commenced.

5.2.9 The following issues relating to mobility are of significant relevance to Africa

- Globalisation and mobility of researchers will continue to be an important influence on S&T in Africa.
- The benefits of mobility include acquisition of skills and the growth of international research partnerships.
- The significant risk is that mobility can enhance the "brain drain", especially when countries outside Africa have specific policy and financial incentives designed to attract skilled immigrants.
- African nations need to develop appropriate approaches designed to ***attract and retain*** skilled workers to Africa, including from the diaspora. Experience has shown that the decisions of potential migrants is influenced by a range of factors, such as availability of health and education, tax regimes as well as the obvious issues such as salary and working conditions.

A favourable policy environment for R&D

5.2.10 It is beyond the scope of this study to provide detailed analysis of the range of existing innovation policies and their relevance to Africa. This would require a dedicated study in its own right. In addition, it is likely that no one single approach would meet the needs of all African nations. There are, however, some general issues that emerge from the current review:

- Policies for R&D (or S&T) should be developed within a National Innovation Strategy (NIS) that links R&D with social and economic development;
- Policies need to create an enabling environment for R&D in both the private and public sectors.
- Successful economies have developed policies and incentives that promote cooperation between the public and private sectors to support S&T.
- Government policy legislation and their enforcement need to address Intellectual Property Rights (IPRs).
- Policies designed to support innovation in the economy should be designed to complement those designed to address other structural issues in the economy, for example, infrastructure, education and health. A coherent approach is likely to produce benefits in both directions, for example R&D investment can support the development of structural infrastructure (e.g. ICT), while the same infrastructure can help to build R&D activity. When financial resources are limiting, governments should seek initiatives that have benefits that cross-cut sectors of activity.
- Policy initiatives need to address the opportunities and risks associated with globalisation and the associated mobility of trained individuals.

5.3 Taxation

5.3.1 Tax regimes are often held up as being important elements of potential government policy that promote R&D activities in the economy. Previous analysis of the AU-NEPAD S&T programme have identified the need for reform of tax regimes in African nations to promote S&T activities by the private sector (Teng-Zeng, 2005). Within many OECD member countries R&D tax concessions act as an incentive to increase R&D expenditure by businesses. By 2005, 18 OECD countries had tax subsidies in place. Tax treatments include the immediate write-off of current R&D expenditure, variable tax credits and capital allowances against taxable income (OECD, 2005b). In many countries the tax system differentiates between Small and

Medium Enterprises (SMEs) and larger businesses, with enhanced support provided to SMEs. Other tax incentives may relate to specific initiatives such as the establishment of science parks or innovation hubs which can benefit from reductions in land or property taxes especially during their establishment phase.

5.3.2 The importance of tax incentives has been discussed in systematic reviews of innovation in selected developed and developing economies (OECD, 2001; Watson *et al.,* 2003; UN Millennium Project, 2005; UNESCO, 2005; OECD, 2005a). The diversity of approaches used by different countries illustrated in these earlier studies means that the detailed arrangements will not be discussed here. The OECD's comparative study of Austria, Finland, Japan, Netherlands, Sweden and the United Kingdom (OECD, 2005a) provides the most comprehensive systematic comparison of tax regimes within the framework of national innovation systems.

5.3.3 The approach adopted by this study emphasises the need to place R&D activity within a framework of the wider economy. The same approach is necessary in relation to tax regimes; R&D incentives need to be considered within the overall system of taxation relating to business activity in any country. For example, a company is unlikely to respond to R&D incentives if other levels of taxation such as corporation tax or the treatment of venture capital are considered punitive. Similarly, a company is unlikely to invest in R&D to develop new industrial processes in a country if the levels of import or export duties are likely to make the resulting industrial process uneconomic. Finally, even when fiscal measures are seen to be attractive, perceptions of significant transaction costs and potential delays linked to high levels of bureaucracy and corruption may act as disincentives. If businesses are to flourish it is imperative that red tape for their set up is minimized, and that good governance is addressed as a prominent prerequisite to enhance any R&D activity in any economy.

5.4 Government investments or expenditure that promote R&D activity

5.4.1 It has already been shown that government expenditure on R&D tends to represent around one third of direct expenditure in OECD economies (Table 2) and that only one OECD country has government expenditure exceeding 1 % of GDP. It is important to stress that the quantity of government investment in R&D needs to be balanced against its quality and relevance. It would, for example, be theoretically possible for a country to reach a target of 1 % of GDP by employing large numbers of additional scientists, but for these scientists to have very limited impact on economic development if their research was not focused on areas of national need or if they are not provided with necessary infrastructure and operating budgets. It would also be possible to invest heavily in capital expenditure (buildings and equipment), but to find that the education system cannot provide the required numbers of suitably trained graduates and technical staff.

5.4.2 A balanced approach is required to ensure that overall government investment is supportive of innovation. In addition to considering direct investment in R&D, this report also considers education and infrastructure.

Direct R&D investment

5.4.3 Public sector investment in S&T (or R&D) is essential to complement that of the private sector and some cases should be treated as a prerequisite for private sector activity. Whilst businesses conduct the main bulk of R&D activities in OECD countries much of their progress in innovation could have not been possible without earlier public sector investment. Classic examples of this would be the development of all internet-based products which benefit from earlier public sector R&D on ICT. In OECD countries, this link between publicly funded research and private sector is increasingly driving innovation.

5.4.4 The analysis of GERD presented as Table 2 shows that in many countries, the total government allocation to GERD (OECD average of 30.4 %) is similar to the sum of activities undertaken by government and higher education institutions (a sum of 29.7 % based on the OECD averages). Further analysis of these data from OECD countries is presented as Table 3. These data show that several countries allocate a relatively higher proportion of government resources to support R&D activity implemented by business enterprises; as much as 30.6 % in the United Kingdom. These allocations reflect government spending on R&D (i.e. government funded R&D undertaken by the private sector) as well as activities such as technology transfer and support to promote R&D by SMEs. In nearly all countries a significant amount of the government's R&D effort is undertaken by higher education institutions (up to 51.9 % in Ireland).

	Business Enterprises	Government	Higher Education	Private non-profit
Canada	5.6%	42.7%	51.3%	0.5%
Denmark	11.9%	43.4%	43.8%	0.9%
Finland	13.5%	42.8%	42.5%	1.3%
France	25.1%	51.9%	22.2%	0.7%
Germany	20.5%	60.2%	19.4%	..
Greece	4.5%	60.3%	34.7%	0.5%
Hungary	4.0%	47.9%	39.1%	..
Iceland	7.4%	74.6%	13.5%	4.5%
Ireland	9.9%	38.3%	51.9%	..
Japan	4.9%	74.8%	12.2%	8.0%
Luxembourg	20.2%	76.6%	3.2%	..
Netherlands	12.7%	64.8%	22.4%	0.1%
New Zealand	11.3%	60.3%	28.4%	..
Norway	24.7%	49.4%	25.9%	..
Poland	6.6%	51.1%	42.2%	0.0%
Spain	23.7%	50.6%	25.6%	0.2%
Sweden	32.4%	24.6%	41.9%	1.1%
United Kingdom	30.6%	34.7%	25.7%	9.0%
United States	23.0%	40.2%	30.3%	6.4%

Table 3 Breakdown of the destination of government expenditure on research and development for selected OECD countries in 2003.
Data source (OECD, 2006a). Data not available shown as "..".

Education

5.4.5 There have been a number of references in this report to the importance of investment in education to underpin R&D activities. The data analysis presented here, shows that Higher Education Institutions (HEIs) are playing an increasing role in undertaking R&D activities in many economies, in 2003 an average of 17.4 % for the OECD (Table 2). The importance of HEIs has increased in recent years as shown by Figure 3. These data derived from S&T indicators only provide one component of the links between education and R&D.

5.4.6 The education system needs to provide the trained human resources who are essential for expanding the national R&D base. This requires a holistic approach to education that ensures that necessary skills are included in the curricula, that teachers are available and that a proportion of students progress from primary, through secondary and then on to higher education.

5.4.7 Many OECD members are implementing specific programmes to promote science and technology-based education in order to promote greater specialisation in these subject areas. Efforts are being made to increase student performance in mathematics and science based subjects at secondary level. It is also recognised that awareness of the opportunities created within a business sector, for example ICTs can help to promote greater specialisation and research output. This has led to a number of universities based in OECD countries building links with the business sector.

5.4.8 In India, the Indian Institutes of Technology have helped to provide the human resources required for the development of technology-based industry. This approach is often recognised as having contributed to economic development in India but this does not mean that it would be easy to replicate such institutes in Africa. The growth of technological industry in India is placing greater demand on their education system and there are suggestions that demand exceeds the potential supply.

5.4.9 Within Africa, the need to promote science education at all levels and the revitalisation of higher education is recognised within the AU's draft plan of action for the 2nd decade of education (African Union, 2006). It is evident that any plans for African governments to promote R&D activities must be coordinated with those in the field of education.

Infrastructure

5.4.10 The role of infrastructure in promoting R&D activity is well recognised. ICTs are most often cited, but the provision of reliable electricity and water supplies and transport networks can also be very important. There is considerable debate about the optimal role of governments in the provision of such services and practice varies greatly between countries. For this reason infrastructure is not treated as a government responsibility in this report, but instead as an essential part of the wider enabling environment for R&D and associated economic development.

5.5 An enabling environment for effective R&D

Good governance

5.5.1 Good governance and the role it plays to support development activities, are increasingly recognised as being essential in both developed and developing countries. This has led to changes in the role of knowledge in policy-making, for example through the concept of evidence-based policy-making. It has also led to a shift in the way that priority setting is carried out for publicly funded R&D activities with greater engagement with non-scientific stakeholder groups including potential beneficiaries, civil society and industry.

5.5.2 In addition to good governance of R&D activities, it is also required in relation to other components of the wider enabling environment for effective R&D and the development of a healthy African private sector. The tax system and any relevant incentives need to be administered fairly and transparently while levels of bureaucracy need to be minimised to reduce transaction costs.

Policy, incentives and public sector investment.

5.5.3 Governments have an essential role in providing the required policies, incentives and public sector investment to promote the development of R&D activity in their countries and the uptake of resulting benefits. This report cannot provide a simple "recipe" for success because these initiatives will need to be designed to fit on top on existing legislation and government expenditure. The key messages and recommendations of this report have been designed to be generic and adaptable between countries.

Infrastructure

5.5.4 The development, operation and maintenance of infrastructure, including ICT, services, transport networks and financial systems are all essential to the successful expansion of R&D activities in Africa. The private sector is playing an increasingly important role in major infrastructure projects in both developing and developed countries. Worldwide, the concept of Public-Private Partnerships (PPPs) is being promoted as a way of enhancing delivery of the development of national infrastructure.

5.5.5 In addition to what could be considered as enabling infrastructure, R&D activities require more specific dedicated research facilities. This includes physical premises and capital expenditure on equipment and supplies. Building programmes to establish science parks or research institutes may be necessary in Africa, but in many cases the same objective might be achieved through the enhancement of existing facilities.

5.5.6 Most R&D activity will be associated with a requirement for capital expenditure on equipment, supplies and computer software. In Africa, much of this may need to be imported, at least initially. This brings with it, a requirement for foreign currency and a restriction that purchases may be subject to import regulation and duties, and technical capacity for maintenance of equipment. Governments may wish to look at options to ease this potential burden on R&D activities.

Human capacity: Education and lifelong learning

5.5.7 Good governance, innovation policy, incentives, public expenditure and the development of infrastructure are all required to promote R&D activity, but will be collectively ineffective unless specific actions are taken to enhance human capacity, both in terms of the numbers of trained personnel and their skill sets. This needs to be addressed at all levels of the education system, including the concept of lifelong learning in the workplace. Education must remain one of the highest priorities for government expenditure.

5.6 Summary: Policies, incentives and investments.

5.6.1 Governments implement a wide array of policies, incentives and investments to promote R&D activities in their countries. The policy environment to promote R&D needs to be placed within a wider framework of policies designed to promote national economic and social development. Innovation strategies and policies need to interact with those on taxation, IPR, trade and mobility. The process to create an enabling environment for R&D investment in Africa will require governments to progressively address each of these policy issues.

5.6.2 Policy initiatives can be supported by targeted government expenditure. Direct investment in Ggovernment supported R&D may be implemented by government research institutes, HEIs and increasingly the private sector. This direct investment now needs to be to be augmented by investment to develop the human resources (education) and infrastructure required to promote R&D activity by the public and private sectors. Increasingly, this may involve Public-Private Partnerships.

5.6.3 These points are captured in the following recommendations:

Recommendation

8 Governments need to create a conducive environment for R&D activity. Government R&D expenditure should be linked to wider targets for national economic and social development. Policies will need to address issues of taxation, IPR, trade rules, the impacts of globalisation and should be designed to promote cooperation between the private and public sectors.

9 Direct government investment in R&D activities should continue to be an essential component of national innovation strategies.

10 Additional investment in education from primary through to higher education and life-long learning will be required to develop the human resources which will be essential to build national R&D capacity.

11 Governments need to work with the private sector to develop the infrastructure necessary to support growth in R&D activity.

6 Engaging the private sector in R&D

6.1 Introduction

6.1.1 Internationally, the private sector is responsible for funding and implementing the largest proportion of R&D activities. Within the OECD, the private sector on average funds 61.8 % of GERD and implements 67.7 % of activity. Similar data are virtually non-existent for Africa, but it is clear that private sector R&D activity is generally low. Some of the major opportunities and challenges for increasing national R&D activity will be to promote developments in the private sector.

6.1.2 The potential role that that the private sector can and should play in development was recognised internationally in 2002 through both the Monterrey Consensus (United Nations, 2002a) and the World Summit for Sustainable Development (The "Johannesburg Summit", United Nations, 2002b). The role of official development assistance to assist governments in developing countries to promote private investment for development has subsequently been discussed in detail (OECD, 2006b) and key messages from this analysis as presented as Box 8.

> "Vigorous and sustained economic growth, fuelled by investment and entrepreneurship, is needed for the private sector to create more jobs and increase incomes of the poor. In turn, this will generate the revenues that governments need to expand access to health, education and infrastructure services and so help improve productivity. But in many developing countries, investment rates are too low, productivity gains are insufficient, incentives for innovation are inadequate, returns on investment are not sufficiently predictable, and not enough secure, safe and adequately paid jobs are being created in the formal economy.
>
> Developing countries and their donor partners consequently need to do much more to address the market failures and structural impediments that are holding back productive investment (both domestic and foreign), and to do it better, for longer periods and in a more strategic way. ***Developing countries can help foster an investment climate that enables the private sector to flourish and fulfill its role as the main engine of growth. To do so, they can pursue macro-economic stability, improve the functioning of market-regulating institutions and strengthen procedures for contract enforcement and dispute settlement. Developing country governments can also improve the coherence of their policies in a range of areas – such as trade, tax, competition and investment promotion – that affect the volume of investment and its development impact.***"
>
> Source: Promoting private investment for development. The role of ODA (OECD, 2006b)

Box 8 Key messages to promote private investment for development.
(OECD, 2006b)

6.1.3 The structure of most African economies means that the private sector is often poorly developed. In this situation, it is likely that many companies will not yet be in a position where they are able to invest in R&D even with an attractive array of policies and incentives produced by governments. R&D activity is one of several investment options that a company may consider and as such decisions on R&D will be strongly influenced by the overall business environment, including the availability of trained staff and infrastructure.

6.1.4 These themes have been discussed as part of the enabling environment for R&D (Section 5.5). It is important to stress that tax incentives and government subsidies alone are unlikely to provide sufficient motivation for significant increases in private sector R&D.

6.1.5 Intellectual property rights (IPR) are one of the most important factors of policy and legislation that will influence private sector investment in R&D. Most private sector R&D activities tend to be conducted in-house (see Box 6, pg 17) which is partly a response to IPR. Even though in recent years the private sector in developed countries has sought to build links with universities, this still represents a small proportion of total activity and is happening in countries which already have strong IPR regimes.

6.2 The domestic private sector.

6.2.1 The needs of domestic private sector actors will vary depending on factors such as their size, business activity and potential availability of in-house R&D. Companies which are located solely within one country essentially have three choices in relation to innovation: (1) undertake their own R&D, (2) seek technology transfer from national R&D providers (e.g. government research institutes and universities) or (3) purchase technology from international sources. In many instances, the third option is chosen as being lowest risk, even though it probably has lower potential return on investment.

6.2.2 Within Africa, governments can adopt a number of policy initiatives that can provide incentives for companies to innovate and conduct their own R&D. In addition to providing favourable enabling conditions, governments can also look at the balance of activities between public and private sectors. For example, the shifting balance from public to private sector R&D provision in the United Kingdom (Figure 3) can partly be attributed to shifts in policy that opened up the marketplace for government R&D provision to the private sector and privatised some government research institutes. The European Commission has also opened research activities in their Framework Programme to SMEs, though they will only pay up to 50 % of total costs.

6.2.3 Asia provides examples of significant investment in R&D by the private sector. Korea has one of the highest proportions of business expenditure on R&D (nearly 80 %, Figure 3). China in the early 1990s had GERD of less than 1 % of GDP and the share performed by the business sector was around 40 % of total activity (Figure 4). Market liberalisation in the second half of the decade lead to increases in GERD and an emerging growing role for the private sector.

6.2.4 The following issues emerge as way to promote domestic investment in R&D:

- Governments need to invest to provide essential infrastructure and human resources (education).
- Governments need to invest in public research institutes and universities and provide specific support to promote technology transfer to the private sector.
- Exercises such as horizon scanning (foresight) are useful to ensure that government funded research has relevance to areas of potential economic (business) importance.
- Appropriate tax and other financial incentives can support R&D activity within a wider tax and policy framework that is conducive to general business investment.
- Opening up the market for provision of public funded research to the private sector.

6.3 Foreign companies and R&D investment

6.3.1 Inward investment in Africa is relatively low in most countries. Much of the investment coming into Africa is linked to infrastructure and technology such as ICT which have associated R&D requirements or for natural resource use (i.e. extractive industries). Unfortunately, much of this R&D is being provided from outside Africa. African governments should be looking at options to change this.

6.3.2 India and China provide an example as they are now able to attract foreign investment in R&D, including some international companies outsourcing R&D. Provision of appropriate infrastructure and well-trained graduates are seen as underlying this trend. Tax regimes, incentives and the lower cost base are important secondary factors, along with the potential for enhanced access to the growing economic power of these major emerging economies.

6.4 Summary: Engaging the private sector.

6.4.1 Africa differs from most of the developed world in that there are very low levels of private sector R&D activity. This is partly a result of overall low private sector activity in Africa, but also reflects poor infrastructure and low educational achievement.

6.4.2 Governments can take specific actions to encourage private sector investment in R&D. The development of appropriate infrastructure (including science parks) and investment in higher education can address structural issues. Once these are available, further incentives such as tax regimes and funding for technology transfer can be effective. Governments can also consider creating a more open marketplace for R&D allowing the private sector to bid for government contracts for R&D provision.

6.4.3 In the short-term, it will be difficult to encourage foreign private investment in R&D in Africa. Progress towards this objective will require action to enhance the climate for FDI in Africa, as well as those designed to address impediments to domestic R&D investment.

6.4.4 The recommendations provided in the previous sections have addressed many of the issues of relevance to the private sector. The following addition recommendations are suggested as being of specific relevance to the private sector

Recommendations

12 Governments should provide funding and other incentives to promote technology transfer from government and university R&D to the private sector.

13 Governments should consider opening up the market for provision of public funded research to the private sector.

7 Conclusions

7.1.1 The target for African nations to allocate public spending for R&D of 1 % of GDP adopted by the 1st AMCOST meeting is ambitious, but is comparable to similar targets in developed countries. Only one country in the OECD currently allocates this level of expenditure, this illustrates the scale of the challenge, specifically when it is recognised that Africa's current expenditure on R&D by both the public and private sectors is considerably lower than other regions of the world.

7.1.2 This review of international arrangements for national financing of R&D has provided a number of recommendations that would help African nations to develop their own strategies to increase their R&D activity. It is suggested that the target for public expenditure on R&D needs to be placed within a wider framework relating to national Gross Expenditure on Research and Development (GERD). This would recognise the very important role of the private sector in funding and implementing R&D. Additionally, whilst this review recognises the value of the long-term target of 1 % of GDP for public expenditure, it suggests that it may be helpful to augment this with realistic medium-term targets for GERD.

7.1.3 R&D activity should be fully integrated within plans for national social and economic development and this can be assisted through the provision of national science and innovation strategies. These strategies could consider the range of stakeholders in the public and private sectors that act to fund, provide and benefit from R&D activities. For example, within the public sector, departments of agriculture, defence, environment, energy, finance, higher education and transport can all be major R&D funders and clients in addition to any department with responsibility for science.

7.1.4 Governments need to develop and implement policies that create a conducive environment for R&D activity. Placing R&D within the concept of innovation and linking this to wider targets for economic and social development can be helpful. Within most African nations, this would best be done by linking investment plans for R&D (or innovation strategies) into national poverty reduction strategy papers.

7.1.5 In most OECD countries, the private sector is the largest source of R&D activity. African nations need to promote R&D activity by the private sector. There are many examples of incentives and policies, such a R&D tax provision, IPR legislation and publicly funded technology transfer discussed further in this report. It is noted, however, that these incentives and investments can only be effective if governments also act to provide a stable business environment, essential infrastructure and improved education.

7.1.6 The public and private sectors are seen to have complementary roles in promoting S&T and increasingly these groups work together. Governments have a role to create suitable enabling environments that promote such collaboration and associated technology transfer. Universities are becoming more active in building links with industry throughout the world.

7.1.7 Investing in education systems is one of the most important prerequisites to improve economic development in Africa. Plans to enhance R&D activity in Africa must be linked with those to revitalise education, especially higher education. Universities around the world are playing a vital role in driving innovation, through provision of R&D and meeting the demand for trained staff. The new role for higher education is clearly seen in this report, through the trend of increase R&D activities by HEIs in most OECD countries and the knowledge-driven economic development in the Asia countries of China, India, Korea and Malaysia included in this study.

7.1.8 The target for public expenditure of 1 % of GDP is achievable in Africa, but this can only happen if R&D (and S&T) moves out of any remaining academic silos and is placed within the wider context of a growing productive economy. Governments have important roles in providing guidance and direct investment, both of which must remain an integral part of national strategies to support R&D. Additionally, achieving the target will also require the public and private sector to work together to promote both R&D and to provide the wider enabling conditions including infrastructure.

7.1.9 The conclusions and recommendations contained within this report have been designed to be of a generic nature recognising the great diversity of social, educational and economic contexts within the continent. It is intentional that they are not prescriptive, but instead are intended to provide a framework for stakeholders in each country to design specific approaches or strategies that fit on top of existing institutional, legislative and policy frameworks. This report was designed to support the implementation of the AU-NEPAD Science and Technology Consolidated Plan of Action (CPA). The CPA itself has specific policy related programmes that will assist African nations to move towards the 1 % target.

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