6

South Africa

Mario Scerri

This chapter deals with the current role of the state in the evolution of the South African system of innovation. However, a 'snapshot' would not be adequate since we are dealing with dynamic systems in a constant state of flux. Hence there is a need to place the current relationship between state and innovation system within a historical context. In this chapter, the history covered starts with the 1996 White Paper on Science and Technology policy (hereafter referred to as the 'White Paper') as the focus of this analysis. This is done in full cognisance of the fact that the context for state policy and the forming of the post-apartheid system of innovation was strongly affected by the prior evolution of the South African national system of innovation (NSI) during the preceding periods of segregation and apartheid.

Although the broad definition of the NSI is adopted as the conceptual framework for this chapter, the length constraints impose a choice of the policies which will be specifically discussed. This choice is informed by a wider filter than just basic science and technology policies but it excludes the amalgamation of the broader human capital development policy arena which would include housing, health, social benefits, and other areas of basic needs provision.

Evolution of the Current Form of State

This section serves to set the historical context of the post-apartheid history of science, technology and innovation (STI), specifically focusing on the history of the relationship between state and market during the 20th century as the precursor of the changing relationship in the post-apartheid era. This then helps the understanding of the

nature of ruptures and continuities in the evolution of the South African NSI in the transition from apartheid to democracy.

The pre-democracy period

The role of the state in the evolution of the South African NSI since the turn of the 20th century and before the coming of democracy was, until the 1980s, marked by a strong element of intervention aimed at re-shaping the structure of most aspects of the South African economy. Briefly, this period can be divided into the pre-apartheid period of segregation and the apartheid era. Politically, the start of the 20th century was marked by the Anglo-Boer war and the formation of the Union of South Africa in 1910. The economy was based on the mining sector, most of which was British-owned, and the state intervened directly to ensure that the requirements of the mining sector, especially the supply of cheap black labour, were assured. The landmark piece of legislation in this regard was the 1913 Lands Act which expropriated over 90 per cent of African-owned agricultural land. This was partially due to the acknowledged fact that African peasantry was more productive than Afrikaner farmers with the consequence that African farmers were generating surpluses which were used to buy up white-owned farms. The other, less overt, reason for the Act was to ensure a supply of mine workers by displacing the larger portion of the rural black population from their primary source of income (see Bundy 1988).

After World War I, the state set up the Iron and Steel Corporation of South Africa (ISCOM) to address the openly recognised failure of the market to take up the incentive for the beneficiation of pig iron provided by plentiful supplies of ore on the one hand and the assured demand by the rapidly expanding rail system on the other. Through this and other initiatives, including the Electricity Supply Commission (ESKOM) and the Industrial Development Corporation (IDC), the state was instrumental in ushering in the manufacturing sector and the industrial diversification of the South African economy (Scerri 2009: chapter 3). These developments occurred within the context of a racially defined political economy which in this aspect was not markedly different from other colonised countries within the empire. Its distinguishing feature was rather the intra-white ethnic conflict with the polarisation between an Afrikaner government and a largely English-speaking capitalist class.

The establishment of apartheid, shortly after World War II marked the start of a programme of political, social and economic engineering that was to shunt the evolution of the South African system of innovation on to a path which became progressively regressive and, in its growing dissonance with the evolution of other systems in the post-colonial era, progressively anti-modern. The final entrenchment of the 'separate development' model of apartheid, wherein the black population was effectively excluded from the country's citizenry, had long-term devastating consequences on broad-based human capital formation which still poses the major constraint on the development of the post-apartheid system of innovation.[1] Ironically, however, the increasing political and economic isolation of South Africa during apartheid provided a strong incentive for the establishment of a strong military–industrial complex and the consequent development of a relatively formidable system of science and technology. The economic interventions of the state operated on three main fronts, all driven by the apartheid agenda.

The first was the creation of *bantustans* and homelands with separate administrative structures with varying degrees of autonomy. The model of 'separate development' required the development of employment bases in these homelands and extensive industrial incentive schemes, mostly in the form of employment subsidies which were established to promote industrial development in these *ersatz* political creations. Given the economic geography of apartheid, the *bantustans* and homelands could never have been economically viable and their industrial bases necessarily remained artificial economies, always dependent on transfers from the apartheid state.

The second intervention was driven by the need to integrate the capitalist sector and to 'de-ethnicise' white-owned capital. This required the inter-penetration of Afrikaner and English-speaking capital and was achieved through establishments, mergers and acquisitions.[2] This policy significantly reduced the (intra-white) ethnicity of capital and hence the state/market conflict which had been consistently evident during the segregationist period. While the patterns of concentration were changed, the degree of concentration of ownership and control was not, but this was not a major concern of the state.

The third major front of state intervention was in the form of price controls, supported by subsidies, particularly in staple foods and transport. The economies of the *bantustans* and homelands would never be able to absorb the populations allotted to them under apartheid and the majority of the oppressed lived as transient foreigners in 'white' South Africa, providing the bulk of the labour force. Apartheid economic geography placed this semi-permanent labour force in townships, denied residential rights in the urban centres and necessitated commuting long distances every day to work there. The main concern of the apartheid regime regarding this unique labour market system was that the inevitable political and civil unrest should not turn into outright revolution. There was a clear awareness that the supply of labour had to be assured through the price stability of the basic cost of living and the cost of transport required to bring workers to their places of employment and ferry them back to what essentially amounted to 'workers' dormitories'. During the 1980s, effectively the last decade of apartheid, the inherent wastefulness of the apartheid economy led to a widespread programme of privatisation of state organs which had formed the economic pillars of the system.

The post-apartheid era

Periodisation is necessarily arbitrary to some extent. This is especially true when the period under consideration is relatively short. The post-apartheid era effectively, though not constitutionally, started with the unbanning of the African National Congress (ANC) in 1990 and the start of negotiations towards a democratic state. The first democratic elections took place in 1994 and the first post-apartheid STI policy document was passed by Parliament in 1996. This chapter looks at the period of time since 1996 and the relation between state and market over this time span is roughly divided into three periods.

The first period started with the launch of the Growth, Employment and Redistribution: A Macroeconomic Strategy (GEAR) in 1996 (RSA 1996a) and lasted until the first review of the programme in 2001. South Africa's first democratic government had come into being in 1994, during the pinnacle of the hegemony of the Washington Consensus, a period during which market liberalisation was the only acceptable economic policy prescription worldwide. In the last few years of apartheid there had been a progressive

adoption of this economic ideology and the legitimacy of the new South Africa government and its consequent sudden entry into the global economy intensified this shift which was formalised as policy in GEAR. GEAR was an explicitly neoliberal macroeconomic programme which advocated liberalisation of markets in expectation of a 'trickle down' effect which would address the inherited inequalities of income, wealth and opportunities.[3] The role of the state was confined to the provision of basic needs, the maintenance of infrastructure and other aspects of the public goods provision function. The basis of this approach was that apartheid had been an allocative distortion which would not have been tolerated by a free market and that it therefore required the freeing up of market forces to correct for the 'distortion'.

The second period emerged with the review of GEAR and the growing sense of disillusionment with the performance of the programme and its capability to stimulate the structural transformation that was required for the development of the South African economy. The official review of the first four years of GEAR in 2001 found that, while macroeconomic stability, in terms of fiscal discipline, had been achieved, economic growth, investment and savings still fell below the GEAR targets. Moreover, net foreign direct investment had been consistently negative, education was falling behind the country's skills requirements, and unemployment and poverty had not been significantly addressed.

It was widely recognised that the persistent levels of unemployment were largely due to the failure to address the inherited shortage of human capital, within the context of an economic structure which has little absorptive capacity for low-skilled and unskilled labour.[4] The two complementary challenges were now to increase the employment of the low-skilled and the unskilled portion of the labour force while simultaneously increasing the overall skills level of the labour force. The recognition of the failure of GEAR in this area led to a series of initiatives, culminating in the Accelerated and Shared Growth Initiative for South Africa (AsgiSA) (RSA 2004) programme, which arose from the recognition of the need for an integrated state intervention on a number of complementary fronts in order to address the development challenges of the country. It was recognised that the shortage of skills was one of the major constraints to growth and this led to the launch of the Joint Initiative on Priority

Skills Acquisition (JIPSA) (RSA 2006b), which was formulated specifically to strengthen and coordinate a number of strategies designed to address the shortage of skills. However, although GEAR was revised in light of its failure to address the enduring high rate of unemployment, the remedial attempts were still marked by a high degree of fragmentation and a lack of coordination. This was due to the absence of an alternative comprehensive planning paradigm.

A possible third stage in the relationship between the state and market has its origin in the radical shift in the power base of the governing party that started with the election of its new national executive council at the end of 2007. This change ushered in the main labour union confederation and the South African Communist Party to the centre of the ideological base of the party, ostensibly displacing the market-friendly neoliberal ideology that had governed policy since 1994. The possibilities for this shift were further reinforced by the global financial crisis that led to a worldwide disillusionment with unregulated markets and again brought to the fore the central role of governments in the economic destinies of nation states. In 2010 the state issued the New Growth Path (NGP) policy document (RSA 2009) with the explicit opening statement that 'creating decent work, reducing inequality and defeating poverty can only happen through a new growth path founded on a restructuring of the South African economy to improve its performance in terms of labour absorption as well as the composition and rate of growth' (RSA 2009: 1).[5] However, in the intervening period since 2008 the rift between labour organisations and movements and the state has re-emerged with a growing perception that economic policy formulation is still caught up in the language of GEAR and that the financial crisis, with the strain that it is already imposing on the fiscus, may reinforce the original 'pragmatic' justification for fiscal caution with the consequent restraints on a state-led development programme. This period is now one of an open ideological contestation over the appropriate relationship between state and market in South Africa. The 2012 report of the Department of Science and Technology (DST) ministerial review committee (RSA 2012) was dismissive about the capacity of the approach adopted by the NGP document to address the developmental requirements of the South African NSI.[6]

Periodisation and Analysis of Institutions and Policies of the State Concerned with Innovation

The role of the state in the planning of the evolution of the South African NSI since the end of apartheid is marked by two divergent trends, both of which emerge from policy positions that were ratified by Parliament in 1996. In the case of the national science, technology and innovation policy there was a significant break with the old policy regime with the introduction of the 1996 White Paper on Science and Technology: Preparing for the 21st Century (RSA 1996b).[7] This marked the start of national STI policy formulation and implementation in the post-apartheid era. The White Paper was explicit in its adoption of the NSI concept as the informing planning framework for STI policy. The other trend was that of overall economic policy which affected the broadly defined national system of innovation. In this case there was a marked continuity with the shift towards neoliberalism during the late years of apartheid. There was therefore an essential disjuncture between an STI plan which effectively implied an interventionist approach and an overall economic planning context which required a reduction of state intervention. The result was a divergence between the two policy environments with a general isolation of STI planning from most of the other aspects of economic planning. This isolation of STI from other aspects of economic and social planning essentially reduced it to an exercise in the rationalisation of the various organs of an inefficient and wasteful public S&T apparatus that had been inherited from apartheid.

The state agency that was initially charged with designing and implementing the post-apartheid STI planning was the Department of Arts, Culture, Science and Technology (DACST), which was established in 1994. The initial placement of STI planning within a ministry which also included arts and culture at the inception of the new political economy provides some indication of the low priority assigned to STI planning at the time.

The democratic government's foundation document on STI planning was passed simultaneously with GEAR but was based in a radically different economic paradigm. When South Africa's 1996 White Paper on science and technology (S&T) policy was being

drafted, shortly after the end of apartheid, the national system of innovation was widely recognised to be disintegrating.[8] R&D expenditure was low by international standards and had been steadily decreasing over the previous seven years as the military–industrial complex of the apartheid regime was dismantled and the associated public R&D spending declined. South Africa exported manufactured goods which were intensive in physical capital and unskilled labour, and imported commodities which were intensive in technology and human capital (Scerri 1990, 2003). This was inevitable in an economy where the capacity for adding value to the abundant natural resources was fundamentally constrained by the human capital development consequences of the apartheid political economy. Moreover, the tariff system under apartheid had further served to reinforce these trade patterns.[9] By most definitions, the country's system of innovation was peripheral within the global framework.

The prime task of the White Paper was to define and establish national STI policy in line with the requirements of the newly democratic political economic system. The starting point of the White Paper was to a large extent based on the review of South Africa's NSI undertaken by the International Development Research Centre (IDRC) in 1993. The IDRC report concluded that not only had the science and technology policy been determined by the exigencies of apartheid but that it had also been badly coordinated.[10] These were therefore the two factors which needed to be addressed urgently — the reorientation of the national system of innovation to the requirements of the new political economy and the design of a coordinated national STI planning framework. However, even though the White Paper clearly envisaged STI planning as an integral part of national economic planning, the scope and the level at which DACST should have coordinating powers was determined by the overall economic planning context.[11]

The initial draft of the Reconstruction and Development Programme (RDP) (ANC 1994) preceding GEAR was a Keynesian economic plan, which placed the radical alteration of the living conditions of the majority of the population towards the top of its agenda. This was seen as the essential pre-requisite to provide the required preconditions to the long-term structural transformation of the South African economy. This transformation would be driven simultaneously on the demand side by the conventional

income multiplier effects of the enhanced quality of life of the broad population base, and on the supply side through the deepening and broadening of the technological capabilities pool, arising from an overall rapid improvement in the conditions of life of the population as a whole. However, in the three-year gap between the publication of the IDRC report and the submission of the White Paper, national economic planning shifted from the relatively interventionist position of the RDP to the neoliberal GEAR programme, which restricted the state to the role of a facilitator for market forces. Strategic intervention in the identification and promotion of potential growth sectors was largely abandoned and the market was placed at the centre of the economic coordinating mechanism. The consequence of this shift was the restriction of the coordinating role of DACST within the STI sector to a bureaucratic realignment of existing public sector STI specific institutions.

Within the context of the GEAR programme, STI policy could not interface with industrial, trade and labour policies, as well as education policy outside of the higher education sector both because of the restricted vision of the NSI and the generally neutral stance of the state towards the market.[12] Thus, for example, trade policy aimed at accelerating trade liberalisation (at a faster rate than the one proposed by the WTO) instead of trying to reverse the existing trade patterns, in spite of evidence against the wisdom of such a policy approach.[13] The White Paper had argued for a policy which maintained 'an appropriate balance between opening up the economy to global competitiveness and nurturing local initiatives' (RSA 1996b: 5), but the established neoliberal position drastically restricted the ability to pursue the 'nurturing local initiatives' side of the balance, and very rapidly exposed the national system of innovation inherited from apartheid, with its recognised structural weaknesses, to global competition without any provision for a transition period. The poverty of industrial policy was especially detrimental to the ability to design STI demand-side policies and this spilled over to most other areas of public sector programmes. So, for example, the innovation potential of housing programmes was totally excluded, thus foregoing a significant incentive for the development of indigenous technologies suited to the South African physical, social and economic environments.

Supply-side STI policy was also restricted to direct R&D subsidies, in spite of the explicit acknowledgement in the White

Paper of the extensive use of fiscal incentives for R&D activities in industrialised economies, including high tax incentives. In the case of South Africa the only fiscal tool was to be direct subsidies on a matching grant basis. Consequently, within this constrained policy environment the recommendations in the White Paper were restricted to improving intra-governmental information flows, as well as improving links with the private sector. Moreover, the authority to coordinate S&T policy across the broad spectrum of the public service was allocated to the Ministers' Committee on Science and Technology which comprised all those ministers whose portfolios contained a significant S&T component. This was a weak coordinating mechanism and as a consequence STI initiatives have to a large extent been marked by a 'silo' mentality with each ministry and government department pursuing its own goals without much reference to an overall STI planning framework.

The White Paper also contained a specific proposal to develop an indigenous technology initiative, in collaboration with the Department of Trade and Industry, by addressing the technology requirements of small-, medium- and micro-scale enterprises. The state procurement policy was also intended to provide a demand-side stimulus to technology-intensive industries. This was an improvement on the previous promotion of all local industries regardless of their technological capabilities content.

The White Paper proposed a new coordinating mechanism for all government science, engineering and technology institutions which would be grouped as science councils and department-based institutes. Science Councils had been established in the 1980s to move public sector R&D institutions progressively towards private sector funding through contract work in order to increase funding beyond the state baseline funding scheme. However, the disadvantages of this system were the gaps between the R&D policies of individual councils and national development priorities and the tendency to crowd out private sector R&D performers through costing practices which did not cover full cost. The White Paper proposed that the fragmentation of research programmes could be reduced if Science Councils as well as department-based institutes would operate within a national goal framework with an increased level of coordination. The White Paper further proposed that department-based institutes should progressively shift to the Science Council category in order to escape the budget constraint of public funding,

primarily in order to allow the recruitment of qualified research personnel at competitive remuneration rates. While an institutional review process charged with the alignment of state R&D programmes with national objectives was established as the joint responsibility of DACST and the line department governing particular institutes, it was not going to be easy to enforce national priorities while increasing the dependence on private sector funding. Research and Technology Foresight Exercises were established to provide the guidelines for the investment of public S&T funds, specifically to identify 'potential technological trends and trajectories of significance to the social and economic development of South Africa' (IDRC 1993: 21). However, given the absence of fiscal R&D incentives and incentives emerging from related policy areas, the ability of the state to affect private R&D investment patterns was quite restricted.

The National Research Foundation (NRF) explicitly recognised the crucial role of human capital in the development process and it extended the definition of human capital to incorporate all aspects of human resource development, rather than restricting it to scientists and engineers. It set DACST with the task of introducing an S&T perspective into education programmes.[14] Quality control over the education sector was assured by the establishment of a National Qualifications Framework as the accreditation mechanism across the country. The role allotted to DACST was to develop curricula for pre-tertiary education levels and for adult training programmes. The NRF was set up to coordinate research funding in the tertiary education sector and to operate through four agency divisions — natural sciences and engineering, social sciences and humanities, health sciences, agricultural and environmental sciences. The NRF would also administer the National Facilities for Research.

The National Advisory Council on Innovation (NACI), a council of experts from diverse fields and sectors, representing various stakeholder bodies, was established as an advisory body for DACST. This council was designed to address some of the deficiencies of the previous Scientific Advisory Council identified in the IDRC report (IDRC 1993: 25–27) and, in contrast with the period of apartheid, the terms of reference and the areas covered by NACI were to be public knowledge.

The NRF supplanted the Foundation for Research Development as the national agency responsible for promoting and supporting basic and applied research as well as innovation. It funds knowledge

generation, the development of researchers, products and infrastructure. The NRF provides services and grants to support research and postgraduate research training. Funding from the NRF is largely directed towards academic research, the development of high-level human capital, and the national research facilities. The terms of reference of the NRF extend to all fields of the humanities, social and natural sciences, engineering, indigenous knowledge and technology. It has forged local and international strategic partnerships to promote research capacity development. The latest dramatic intervention in the shaping of the development of the higher end of the human capital chain is the South African Research Chairs Initiative (SARChI). This targeted approach towards human capital development has been designed as a medium- to long-term measure to enhance research capacity and its long-term reproduction in the higher education sector by drawing foreign expertise into South African universities with sufficient complementary funding to build lasting areas of excellence.

The main institutional instrument for the financing and control of specific R&D projects was the Innovation Fund, whose budget would derive from the reallocation of science funding across government ministries and departments. DACST would cooperate with the Department of Trade and Industry which administered the Support Programme for Industrial Innovation. The choice of projects to support was guided by the following three governing criteria:

- the needs of the previously disadvantaged (initially half of the funding was to be directed at such projects);
- large, long-term projects, in order to reverse the trend towards short planning horizons;
- strong links between innovation, diffusion and use, thus reducing endemic fragmentation and delivery bottlenecks.

While these priorities have remained reasonably constant since 1996, the capacity of S&T planning to address these priorities has improved since then.

In the case of the humanities, the Human Sciences Research Council (HSRC), which was established by the Human Sciences Research Act, No. 23 of 1968 is specifically charged with performing, coordinating and promoting research in social and human sciences. The HSRC has aligned its research structures and activities to major

development priorities and its current structure reflects this. Its main areas of activity are divided into cross-cutting units, research programmes and centres.

One of the cross-cutting units, 'Knowledge Systems', is charged with undertaking R&D and innovation surveys. The other focuses on policy analysis, capacity development and gender. The research programmes cover social development, focusing on the family, political structures, education, and health. The three centres cover: (*a*) poverty, employment and growth, (*b*) service delivery, and (*c*) education quality improvement.

On the whole, the strictures of the macroeconomic planning framework prevented the White Paper from addressing the fragmentation of the S&T planning framework. The definition of the perimeters of S&T planning was therefore not altered substantially from that during apartheid. What occurred was rather a refinement of the inherited structure within a democratic context. Effectively, the macroeconomic planning context restricted STI policy to managing the system of science and technology. Within this constraint the White Paper provided a sound plan for the overhaul of the institutional basis for the development of a sound S&T base. However, the lack of coordination with complementary policy contexts prevented the S&T policy from extending to an innovation policy that would radically alter the national system of innovation.

The second period of the post-apartheid era emerged in 2002 during the revisiting of the country's macroeconomic planning framework. The priority assigned to STI policy was significantly upgraded when DACST was split into two departments with a separate minister of science and technology and the Department of Science and Technology (DST) as the new agency for STI planning. This development came at a time when disillusionment with the performance of the GEAR programme led to a series of targeted initiatives towards the structural transformation of the South African economy.

The new policy statement on STI policy (RSA 2002a) allocated a significantly extended coordinating role over various aspects of STI for the DST. Several STI functions which were located in other ministries and departments have since then been located within the DST. The most notable was the transfer of the Council for Scientific and Industrial Research (CSIR) from the Department

of Trade and Industry to the DST in 2005. However, the planning context of the DST is still largely limited to science and technology planning, to the exclusion of some of the more crucial determinants of innovation. Thus, for example, human resource development was largely the domain of the Department of Education (DoE) which, in 2009, was split into the Department of Higher Education and Training (DHET) and the Department of Basic Education. The influence of the DST over the funding of higher education has grown considerably over the past few years. However, the splitting up of the DoE has introduced a possible disjuncture in the national stream of human capital development. The DST and the DHET now collaborate to an unprecedented degree that marks a significant shift in human resource development policy. However, the influence of DST over primary and secondary education policy formulation and implementation, or in overall skills development, is still limited, apart from the relationship between the DST and the Department of Labour (DoL) which was established through the National Skills Development Strategy which commenced in 2001. Overall, the role of the DST is still defined by the generally neutral intervention stance of the implicitly neoliberal economic policy environment that still dominates development planning in South Africa. In this role it acts as a facilitator for the mobilisation of R&D resources but was, until the publication of its 10-year plan in 2007, prevented from designing and implementing strategic intervention initiatives and 'picking winners'. Again, this vague policy mission of the DST reflected the still hesitant and fragmented state of economic planning following the implicit loss of faith in GEAR.

Innovation policy and the development of structures for its implementation have developed rapidly since 1996. In the first five years after the White Paper the disjuncture between the conceptual framework of STI policy and the neoliberal grounding of the overall macroeconomic plan severely inhibited the ambit of the innovation policy. Since 2002 and the reassessment of GEAR there has been a progressive narrowing of the gap between innovation policy and economic policy, and this has generated a rapid institutional development that goes substantially beyond the science and technology sphere.

Specificities of the System of Innovation in South Africa and Its Relationship with the State

Using a biological metaphor, national systems of innovation may be usefully identified on the basis of their viability, defined in terms of their capacity for reproduction, growth and evolution (Scerri 2009: 37). The ability to reproduce a given system is seen as the minimum requirement for the survival of the system, but long-term viability also requires that systems are capable of growing along their current trajectories and, even more importantly, evolve either to adapt to changing environmental conditions or to lead changes in the knowledge environment. The three aspects are of course strongly interrelated, especially when different time horizons are considered.

We can assess the viability of a system of innovation at various levels of inclusion or aggregation, depending on the particular definition that is adopted. The two definitions that we will look at are the system of science and technology and the broader system of innovation. This distinction is important because we may obtain significantly different assessments at the two levels. A healthy and viable system of innovation does not necessarily require a sophisticated system of science and technology for its long-term survival. On the other hand there are numerous examples of strong systems of science and technology which are set against a backdrop of a severely underdeveloped national system of innovation. In such cases the national system of innovation resembles the enclave economy model, with pockets of excellence in a sea of poverty. Such systems are more sustainable than ever due to the integration of markets with globalisation. In such cases the links between the local high technology enclaves and the global market are closer than those with the rest of the NSI. There is, however, always a latent instability in this type of NSI with its enduring inequalities of incomes and life chances. In the broader version of the concept, the NSI which evolved under apartheid constituted such a system and it is its enduring legacy which forms the formidable obstacle to the needed developmental transition in the current South African economy.

Major features of the national, regional and local production and innovation structures

The economic history of South Africa is intimately tied to its rich endowments of a wide range of mineral resources and in most

aspects the development of secondary and tertiary sectors can best be understood within the analytical framework of the minerals–energy complex. Even with the increasing diversification of the South African economy away from the primary sector it can still be shown (Fine and Rustomjee 1996) that the South African economy can be seen as resource-based, even if several times removed. The performance of the South African economy since democracy has not fulfilled the set of objectives set out in the first macroeconomic plan.

Macroeconomic indicators for South Africa are presented in Annexure A to this chapter. The annual growth rate of real GDP in South Africa moved along an upward trend between 1999 and 2007. However, as can be seen from Figure A6.1, this growth rate dipped considerably after 2007, in line with global economic changes, becoming negative in 2009, though it showed a sharp recovery in 2010. GDP per capita shows a similar trend over the same period, as can be seen from Figure A6.2. However, the significance of this growth rate for economic development or the transformation of the South African system of innovation has to be qualified by two important provisos. In the first place, unemployment has not been significantly addressed and remains extremely high. Figure A6.3 in Annexure A, shows that the rate of unemployment, estimated to include discouraged job seekers who no longer register with the DoL was running at slightly below 40 per cent by 2006. Second, the enduring income and wealth inequalities means that the relative material conditions of life and the life prospects of a significant portion of the South African population have not improved over time. This is reflected in the Gini-coefficient depicted in Figure A6.4. These two variables provide an indication of the lack of fundamental transformation in the South African economy in the enduring phenomenon of jobless growth. This concern with enduring structural unemployment is the current overwhelming focus of macroeconomic planning in South Africa.

The sectoral structure of the South African economy is shown in Table A6.1, in terms of the composition of GDP. Again, we need to note that while the economy has diversified considerably over its history of industrialisation since the inter-war period, with the secondary and tertiary sectors attaining increasing prominence, the linkages to the primary sector are still a defining feature of the South African system of innovation. This can be seen through a look at the composition of South African exports as depicted in Figure A6.5.

The other salient feature of the South African economy, which is discussed in more detail in a subsequent section, is the high degree of regional unevenness of economic performance. As argued further on, this is to a large extent the heritage of apartheid economic geography and the failure to redress its effects significantly in the post-apartheid era.[15] Table A6.2 in the annexure provides a snapshot of the divergence in the economic structures of the nine provincial economies which were established after apartheid. The composition of these nine provinces varies substantially in terms of the inclusion of the former four 'white' provinces established under apartheid and the various *bantustans* and homelands.[16] The previous 'white' provinces had grown organically on the basis of comparative, and the emerging competitive, advantage. The *bantustans* and homelands, on the other hand, were *ersatz* creations designed to justify the apartheid model of equitable separate development. None of these had an inherent rationale for autonomous economic integrity and survived as supposedly independent administrative structures on the basis of streams of transfers from the apartheid state.

We can briefly note at this stage that those provinces which are economically sound are the ones which are the least reliant on the primary sector. This is especially notable in the case of Gauteng, where, in spite of its rich mineral resources and a well-established mining sector, the primary sector contributes a negligible proportion to its Gross Geographic Product. On the other hand, those provinces whose economic performance on several fronts is well below the national average are heavily reliant on the primary sector. In general there is a strong correspondence between the inclusion of those provinces defined as 'white' under apartheid and economic performance.

System of science and technology

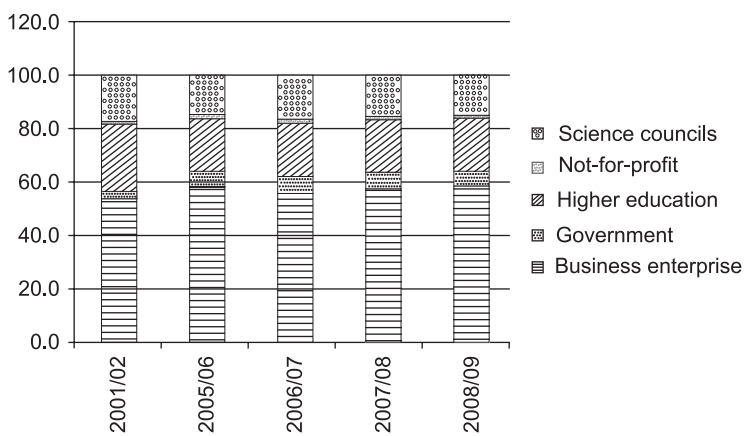
The South African system of science and technology has been substantially reformed since 1994 and the role of the state in this reform is quite evident. The three main indicators that are used to assess this are: (*a*) R&D expenditure and activity, (*b*) R&D human capital development, and (*c*) the convergence patterns of public R&D spending.

R&D Activity

Table 6.1 summarises the basic R&D indicators for South Africa over an 18-year period. It shows that R&D intensity (as a percentage of GDP) grew steadily between 2001 and 2007 but dropped slightly every year since then. R&D intensity had dropped to a low of 0.69 per cent of GDP in 1997–1998 due to the vacuum caused by the drop in defence-related research since the demise of apartheid, but has picked up steadily since. If we decompose national R&D expenditure, some interesting patterns and trends emerge.

Figure 6.1 shows that the share of government R&D financing (government plus science councils) remained stable at approximately 20 per cent over the period. In fact most of the increase in R&D intensity was due to public financing. The proportion of financing contributed by business dropped correspondingly for 2005. The one worrying trend is the downward trend in the share of R&D performed in the higher education sector, which dropped from 25 per cent to 19 per cent from 2001 to 2009.

Figure 6.1: *Expenditure Breakdown of GERD by Sector, 1997–2009 (percentage)*



Source: Calculated from RSA (2012: 196, Table 1).

In the 2008–2009 National Survey of Research and Experimental Development (RSA 2011) it emerged that the largest component (87.4 per cent) of government R&D expenditure (government and Science Councils) was spent in natural sciences, technology and

Table 6.1: *Summary of NSI Indicators*

	1991/92	1993/94	1997/98	2002/02	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09
Gross Domestic Expenditure on R&D (GERD) (Rand Billions)	3	3	4	8	10	12	14	17	19	21
% GERD*	1.04	0.75	0.69	0.76	0.81	0.87	0.92	0.95	0.93	0.92
Total R&D Personnel (FTE) (1000s)				34	25	30	29	31	31	31
Total Researchers (FTE) (1000s)				9	14	18	17	19	19	19
Total Researchers per 1,000 Total Employment (FTE)				1.9	1.2	1.6	1.5	1.5	1.5	1.4
Total R&D Personnel per 1,000 Total Employment (FTE)				7.3	2.2	2.6	2.4	2.5	2.4	2.2
% Civil GERD**				0.7	0.7	0.8	0.9	0.9	0.9	0.9
Total Researchers*** (1000s)				19	31	37	39	40	40	40
% Women Researchers****				35	38	38	39	40	40	40

Source: Maharajh (2011: 244).
Note: All figures have been rounded off to the nearest positive integer level to show the trends in stark contrast.
* As a percentage of GDP.
** As a percentage of GERD.
*** Headcount.
**** Expressed as a percentage of Total Researchers.

engineering compared to 86.4 per cent in the 2003–2004 survey (RSA 2005b). The major recipients of government R&D for 2008–2009 were agricultural sciences (17.6 per cent), medical and health sciences (15.8 per cent), and earth sciences (14.3 per cent). In the case of Science Councils the main recipients were engineering sciences (27.5 per cent), medical and health sciences (14.3 per cent) and agricultural sciences (14.1 per cent).

The spread of R&D expenditure among national departments, provincial departments, government research institutes and museums changed dramatically over the period 2003–2004 to 2008–2009, as can be seen in Table 6.2.

Table 6.2: *Breakdown of Government R&D Expenditure (percentage)*

Performer	*Year*	
	2003/2004	2008/2009
National Departments	40.8	25.2
Provincial Departments	18.7	20.4
Research Institutes	33.3	50.8
Museums	7.2	3.6

Source: RSA (2005b, 2011).

The public sector's share of total R&D expenditure is also evident in state-owned enterprises which account for 20 per cent of business enterprise R&D (RSA 2012: 203). Taking this into account, the share of the public sector in total R&D amounts to around 32 per cent as compared with an almost 47 per cent share by the private business sector. For 2008–2009, approximately 6 per cent of all R&D personnel were employed in the government sector, as compared with 44 per cent and 37 per cent for the higher education and the business sectors, respectively (RSA 2012: 35).

The other two aspects of the NSI which are strongly related to the system of science and technology are the production of the higher end researchers, in the form of scientists, engineers and technologists, and the regional convergence in S&T development.

Human R&D Capital Development

The human capital constraint inherited from apartheid was clearly identified in the National Research and Development Strategy:

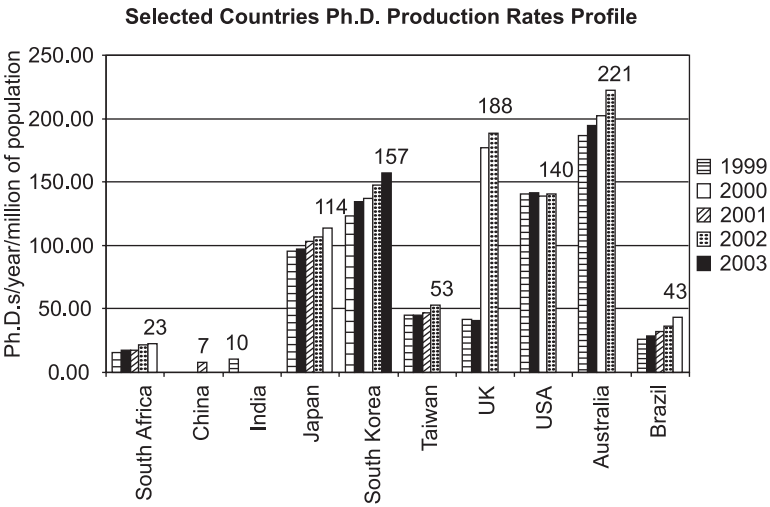
> Our human resources in science and technology are not being adequately developed and renewed; we have an aging and shrinking scientific population. The key indicators show that black and women scientists, technologists and engineers are not entering the academic ranks and that the key research infrastructure is composed of people who will soon retire. In 1990, the percentage of scientific publications produced by researchers 50 years of age and older was 18% (one in five), but by 1998 this figure had increased, alarmingly, to 45% (one in two). Over the same period the percentage of publications by black scientists rose only very slightly, from 3.5% to 8% (less than one in ten). Participation by women has not changed over the 1990s, with publication output being about 10% of the total. Currently, there is less than one researcher for every thousand members of the workforce, as compared with five in Australia and ten in Japan. Given that 'technology walks on two legs', the 'frozen demographics' prevalent in our National System of Innovation represents a critical state of affairs (RSA 2002a: 21).

However, this statement refers solely to the S&T population in South Africa, thus implicitly restricting the focus of STI strategy to the system of science and technology. In this area South African statistics paint a poor picture of the country's STI capacity, as may be seen in the following two figures.

Figure 6.2 compares Ph.D. production rates across selected developed and developing economies. Compared to developing countries such as Taiwan, Brazil, China, and India, South Africa's production rates are not all that poor. The 10-year innovation plan estimates that 'to build a knowledge-based economy positioned between developed and developing countries, South Africa will need to increase its PhD production rate by a factor of about five over the next 10–20 years' (RSA 2007b: 34) which has formidable implications for re-building a tertiary education system that while growing, is not nearly growing fast enough to make the attainment of the stated requirement feasible.

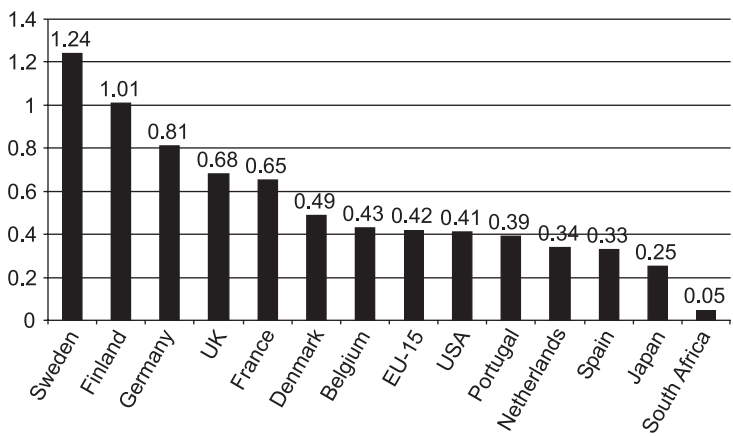
Figure 6.3 compares the number of Ph.D.s relative to the population in South Africa with those of selected developed economies. As the figure shows, the South African production of Ph.D.s per 1,000, is far below that of leading knowledge economies.

Figure 6.2: *International Comparisons of Ph.D. Production Rates*



Source: RSA (2007b).

Figure 6.3: *Number of Ph.D.s per 1,000 of the Population*



Source: RSA (2007b).

The human capital requirements of the South African national system of innovation, at least at the higher end of the human capital spectrum are well-recognised by the government in its stated goals in the DST's 10-year innovation plan. These goals are listed in Table 6.3.

Table 6.3: *Human Capital and Knowledge Generation*

	By 2018 South Africa will have:
Human Capital Development Actions and Outcomes	➢ 210 research chairs at universities and research institutions across the country by 2010 and 500 by 2018 (58 were in place in 2006)
	➢ About 6,000 Ph.D.s produced per year in all SET disciplines by 2018
	➢ About 3 000 SET Ph.D.s/doctorates produced per year by 2018
	➢ An optimal ratio of technicians to researchers
	➢ A 2.5 per cent global share of research publications (2006: 0.5 per cent)
	➢ 2,100 Patent Cooperation Treaty international applications originating in South Africa (2004: 418)
	➢ About 24,000 patent applications at the South African Patent Office (2002: 4721).

Source: Ten-year innovation plan (RSA 2007b).

However, the challenge to achieve the stated higher education targets is quite formidable. The DST document talks about a 'human capital pipeline' from postgraduate students to recognised researchers. In the case of scientists, engineers and technologists the output of Ph.D.s would have to increase fivefold from the 2005 base in order to achieve the set target. The reforms that are planned to try to achieve this target mainly have to do with improving the incentives mechanism for academic careers. However, the sphere of influence of the DST is limited to higher education while the bottleneck in the production of accredited researchers is most stringent at the primary and secondary school levels. This is a much greater challenge, given that the matriculation pass rate has been declining since 2003 and is less than that of 2002. When combined with the quality of the education of South African pupils as indicated in their performance on internationally comparable tests (see Annexure D), this indicates a severe inter-generational constraint on the achievement of the targets set in the DST 10-year innovation plan.

The difficulty in the way of achieving these goals is easily evident in the demographics of the R&D community, as depicted in Annexure B. This is further reinforced when looking at the trends in HEI enrolments as presented in Annexure C. These indicate that enrolments have reached a plateau which is significantly lower than the requirements for the South African NSI.

This bottleneck in the production of researchers is due to reasons which are both supply side and demand side. In terms of the supply into the university system the poor quality of the South African school system (see Figure D6.1 in Annexure D to this chapter) has had a knock on effect on universities in the form of dropout rates of up to 50 per cent and a reduction in the number of undergraduates with sufficiently high exit scores to enter graduate programmes. On the demand side, there is little perceived incentive for students to enter into doctoral programmes. On the one hand, the total opportunity costs of a doctorate are generally seen as much too high, given the private sector labour market conditions for the masters qualification level. On the other hand, the returns from a university career both in terms of remuneration and of the conditions of work, are not seen as being sufficiently high to warrant the cost of a Ph.D.

The national systems of innovation

The core determinants of the three aspects of the long-term viability are human capital development, regional convergence processes and an equitable distribution of income, wealth and life chances. Human capital is the *sine qua non* pre-requisite for the indigenous technological capabilities of an innovation system. Given the appropriate institutional context, it defines the main source of the wealth of nations in the global knowledge and learning economy. When we approach the analysis of NSIs from the broader perspective we need to be circumspect in the easy adoption of the concept of human capital. Its orthodox definition is firmly set within a neoclassical theoretical context which places it alongside other types of capital as primarily instrumental in production and as a source of returns for its owner. Within the broad definition of the NSI, this usage is inappropriate in its limitations and ideological implications (see Bowles and Gintis 1975). In this chapter human capital is rather defined along the lines of human capability, *a la* Sen's (1999) definition.

The other essential pre-requisite for the formation of a viable national system of innovation is a stable (multi)nation state where all parts of the economy are seen to be developing. Enduring regional imbalances in economic performance threaten the stability of the political economy and the integrity of the NSI. Finally, extreme inequalities in income, wealth and life prospects, with their implications for human capital development and social and political

stability, can have dire consequences for the long-term viability of the NSI.

In the case of South Africa, the analysis of these three sets of determinants indicates that there is still an urgent need to address the fundamental flaws of the apartheid national system of innovation. Simultaneously, they indicate those areas which would, if addressed in a coherent integrated fashion, go a long way towards creating the required rupture with history that should have marked the dawn of the new democratic political economy of South Africa. These are now areas that are recognised by the state as of major concern.

Human Capital

The performance of South African pupils in standard literacy and numeracy tests compared with a range of developed and developing economies is extremely poor (see Figure D6.1 in Annexure D). This is of greater concern than the output of the higher education sector, because of the inter-generational implications for the future human capital base in South Africa. In terms of education and training the indications are that South Africa is struggling to reproduce its human capital base.

From a systems perspective we need to extend the concept of human capital beyond training and education. Human capital formation occurs in a broader context than that of schools, technical colleges and universities. From a broad economic perspective human capital is a public good whose availability is crucial to the economic well-being and development prospects of the nation. In this sense it has large externalities in that the returns on it cannot be entirely appropriated by any single agency but only by the whole of society. Moreover, human capital formation is a fundamentally dynamic process, subject to accelerating obsolescence rates, and if its rate falls below specific thresholds it will be impossible to achieve its sustainable reproduction and development, with the returns on it mainly being private with little or no spillovers to the economy at large.

Within systems of innovation, human capital is probably the single most important factor for success. Hence it constitutes the crucial channel for an economy's investment efforts. It is, however, a particularly long-term investment with an average of 18 to 22 years from birth to the 'production' of a skilled participant in the economy. This factor, when combined with the heavy externalities content, automatically implies that the main responsibility for human capital

development lies with the state. It also implies that the family unit, however that is defined, which provides the basic framework for human capital development, has to be protected from instability in order to ensure an uninterrupted stream of investment.

In the case of South Africa the impact of apartheid, and the long pre-democratic history before that, on the family unit was prolonged and devastating, with forced removals, institutionalised and widespread migrant labour, job reservation and separate education effectively degrading the country's broad-based stock of human capital. In South Africa the family is generally extended, often trans-generationally and increasingly impoverished of parents due to the HIV/AIDS pandemic. It is marked by an inherited and now structurally entrenched system of migrant labour with absent men, fathers and husbands as well as absent women, wives and mothers. In the rural areas extended families are often headed by grandparents. In urban areas the prevalence of single-parent families is increasing and, against the backdrop of abject poverty, this is seriously prejudicial to human capital development. Moreover, the average family unit is much too vulnerable to a volatile employment environment to allow for long-term planning. In these conditions the loss of employment has disastrous effects on human capital formation, often interrupting or delaying education streams. Third, a family structure that is typically constantly under attack by the conditions of endemic poverty is always threatened with disintegration. The impermanence of the family structure has a highly adverse effect on the socialisation of children and on the proper internalisation of a society's values which is the ground in which formal education takes root. While it forms the foundation of the human capital formation process which is required for sustainable development, it is also the most vulnerable component of human capital. The brunt of the responsibility for a country's human capital formation thus lies fundamentally with the state. In the post-apartheid South Africa business operates within the context of a labour market that is still very much an apartheid construct, with a widespread scarcity of skills among the labour force and a poor institutional infrastructure for human capital formation. In this regard it is the family, as the bedrock institution, that is the damaged link in the human capital formation chain. Hence the focus of national policy should be on the redressing of past institutionalised generalised disintegration of the family's ability to fulfil its human capital formation function.

The main policy implication of these arguments is the fusion of policy ends and means. The increasing well-being of the family unit is both a robust measure of the objective of development policy and the main mechanism towards the achievement of the objective. The acceptance of this proposition will require a fundamental re-prioritisation of the various development policy measures. It will also enable the development of an integrated policy framework in that various sectoral policies will be assessed in terms of their estimated contribution towards the establishment of a programme of human capital investment that is sound, broad-based and sustainable.

On a broad-based level, a sustained programme of human capital formation will have two effects on the system of innovation. In the first place, there is the supply-side push in terms of enhanced inputs into the system of innovation which expands the ability of a nation to absorb, adapt and create new knowledge. Second, a broad-based enhancement of human capital implies an expansion of the internal market, with the consequent income multiplier effects especially on those goods which have higher technology content, since these usually exhibit high income elasticities of demand.

Poverty and Income Inequality

Broad-based human capital development can be severely constrained by endemic high levels of poverty and income inequality. The two are strongly related since income inequality over inter-generational periods leads to persistent poverty traps which translate into a class-determined divergence of streams of human capital formation.

Income inequality in South Africa, as measured by the Gini-coefficient, has remained persistently high in South Africa (see Figure A6.4 in Annexure A).

Inequality between races has declined, while inequality within race groups has grown. In 1993, 61 per cent of inequality was between race groups; however, by 2006 inequality between race groups had declined to 40 per cent. Over the same period, inequality within race groups has become much more prominent (RSA 2007a: 22). These trends continued through to 2008 (RSA 2010).

These divergent trends indicate that the South African economy may be slowly moving from one where the basis of inequality is defined by race to one defined by class. Be that as it may, poverty remains endemic in South Africa. An indicator of the trend of poverty is the behaviour of the Human Development Index over

time, depicted in Figure A6.5 in Annexure A. South Africa's HDI is 0.597, which gives the country a rank of 110 out of 169 countries. This is above the average of sub-Saharan Africa which stands at 0.389 but below the world average of 0.624 (UNDP 2011). Although there is a shallow upward trend in the HDI between 2005 and 2010, its consistent low level is a worrying indicator of enduring poverty, which when combined with growing income inequality holds out poor prospects for human capital development in South Africa. The mitigating factors making for a degree of poverty since 2005 are provided by the alleviation in incomes from increased transfers such as social grants and employment in expanded public works programmes. On the other hand, the increasing loss of jobs in the wake of the financial crisis will dampen, if not reverse, the possible redress of poverty and inequality. The other factor that may change the trend of the Human Development Index is the reform in the public health sector, with an invigorated HIV/AIDS strategy that will significantly alter the impact of the pandemic on the life expectancy component of the Human Development Index.

Both the poverty levels and the unequal income distribution have been alleviated somewhat in recent years through increasing social grants (old age pensions, disability compensation and child support) and expanded public works programmes. These are not sufficient, however, to alter the structure of an economy that is still tied into the generally low-skilled factor market. Low labour productivity forms the basis for the claim that South African wages are uncompetitive and the only way out of this bind is the enhancement of the human capital base. Allowing market forces to bring wage levels down would be fundamentally counterproductive and force the economy permanently into a low skills trap.

Regional Convergence

The economic geography of apartheid has not been adequately addressed by the post-apartheid re-drawing of provinces and municipalities (see Scerri 2010). In fact, the post-apartheid economic geography is one which is characterised by enduring, and sometimes increasingly divergent, development paths across the country.

Indicators of the quality of human capital in the provinces, as an indication of the capacity of the system of innovation again show large disparities across provinces. There are marked disparities in the Human Development Index across the nine provinces (Scerri 2010).

Provincial disparities are also starkly evident in the area of education (ibid.), with two provinces (Gauteng and the Western Cape) showing significantly higher achievements than national averages in terms of the percentage of their populations with some secondary education, matriculation level and tertiary education. In the absence of effective intervention, these trends have become cumulative and path dependent. Vast regional disparities in terms of most of the indicators of a healthy innovation system have thus emerged. If we were to apply the concept of the local system of innovation, we would then have to ask which provinces actually do constitute a provincial system of innovation. The answer is strongly correlated with the original constitution of the provinces. Where a specific post-apartheid province most closely corresponds to the industrial heartland of one of the four 'white' provinces under apartheid, there are strong indications of a healthy and viable provincial system of innovation. In the case of those provinces which contain a large component of the homelands and *bantustans* created under apartheid, the indications are strong that the statutory definition of a province does not correspond to a provincial system of innovation.

This divergence is further reinforced by the internal migration patterns among provinces (ibid.), with only two provinces (Gauteng and the Western Cape) showing net immigration in 2001. Moreover, the comparison between 1996 and 2001 shows an increased reinforcement of this pattern as the North West province and Mpumalanga moved from positive to negative net migration figures and even the Western Cape showing a drop in its (positive) net migration. These net migration patterns tend to reinforce regional divergence because of the effect on human capital. We usually assume that those who migrate in search of a better life tend to be the more skilled and enterprising members of communities. If this assumption holds, the shift in human capital from poor to richer provinces would be more than proportional vis-à-vis the simple migration figures.

Unlike national systems of innovation, provincial systems do not exist simply by virtue of their legal definition. Intra-state legal entities are not sovereign polities and their status is subject to legal redefinitions. Simultaneously, from our perspective the rationale for the existence of sub-national legal/economic constructs, such as provinces, should be assessed on the basis of whether specific provinces actually constitute provincial systems of innovation. The

information which has been provided in this section indicates that a number of provinces in South Africa do not constitute, and possibly cannot constitute, provincial systems of innovation.

Generally those provinces which are made up of the economic heartlands of the previous 'white' provinces under apartheid do constitute viable sub-national systems of innovation. These systems evolved on the basis of comparative advantage and on that basis developed formidable sets of competitive advantage with the ongoing support of the state. Path dependency ensured that their viability tended to be reinforced over time. These provinces are Gauteng, the Western Cape, Kwa-Zulu Natal, and the Free State.

The composition of the other five provinces is more closely aligned with the artificial economies created under apartheid to lend some semblance of legitimacy to the grand model of separate development. These various *bantustans* and homelands were never, and could never, be economically viable without extensive, complex and enduring transfers from the apartheid government. In the post-apartheid era, it is difficult to imagine that they could ever be viable given their history. Their formation was the result of an essentially flawed process of negotiation in the short negotiation period before the country's first democratic elections and there is sufficient argument that the provincial map of South Africa should be revisited.

Explicit and Implicit State Policy Towards Science, Technology and Innovation

Explicit state policy regarding science, technology and innovation covers those policies which directly refer to the system of science and technology and define the role of the state in this regard. In the case of post-apartheid South Africa, there are three core documents which are landmarks in the evolution of state STI policy. These are the 1996 White Paper on Science and Technology, the 2002 National Research and Development Strategy and the 2007 Ten Year Innovation Plan. All these policies were the product of the government agency in charge of STI planning (first DACST and then DST).

The second set of policies, which we have termed implicit, are those which are not officially seen to belong in the sphere of STI planning but which nevertheless have an impact on the evolution of

the NSI, as defined in the broader sense. The implicit policies that have been considered more relevant are those that refer to industrial policy, education and local development. The link between industrial and STI policy should be obvious, but in the case of South Africa this development and the cementing of this link really began with the review of GEAR in 2001. The rationale for the inclusion of education policy is obvious because of its impact on human capital development. This is dealt with in the section on policies affecting human capital development, further on. In the case of local development, we have seen that the high degree of unevenness is threatening the integrity and durability of the South African system of innovation in all but the legal definition. Given the divergence in regional rates of development and growth within the country, we could well end up with permanently entrenched enclave economies with two provinces on a high growth path, two others on a faltering growth trajectory and the remaining five progressively denuded of their development potential. Policies on local development are addressed further on in this section of the chapter.

STI specific policies

The White Paper

The 1996 White Paper was caught in a policy contradiction that arose from the incompatibility between its explicit choice of the NSI approach as its conceptual framework and the imperative to align its policy prescriptions with the broader neoliberal macroeconomic policy framework. The outcome of this conflict was a compromise between a broad coordinating vision for STI policy and the effective limitation of STI policy to science and technology initiatives. The specific terms of reference for DACST as set out in the White Paper were as follows (RSA 1996b: 33):

- to promote coherence and consistency in the government's approach to stimulating South Africa's national system of innovation in general, and in its commitment to the support of science, engineering and technology development in particular;
- to promote and coordinate interdepartmental and government-wide initiatives relating to the support of innovation and technology diffusion;
- to direct the preparation of a government-wide Science Budget, in order to permit ministers to assess relative spending

priorities on a multi-year basis, across the full spectrum of government's activities in support of innovation;
- to design and present to ministers a comprehensive system for the management of government science, engineering and technology institutions, in order to ensure that their roles within the national system of innovation are clearly defined, that they have clearly defined and understood objectives, and that they undertake their mandate with efficiency, economy and effectiveness;
- to ensure that the management system referred to above includes adequate arrangements for evaluation of performance against international best practice, and that output measures are in place to indicate the nature of the contribution being made by government SETIs (science, engineering, technology, and innovation organisations) to South Africa's development;
- to manage the process of evaluation and review created within the management system described here and to recommend to ministers any actions necessary as a result of assessments carried out;
- to represent the government in formal international, inter-governmental negotiations dealing with science, engineering and technology and with the promotion of innovation;
- to provide a link between government and the activities of the National Advisory Council on Innovation;
- to commission or conduct any policy research necessary to the fulfilment of the responsibilities set out above.

Apart from the first item on this list, the White Paper focused entirely on science and technology policy. This is quite common in ministries or departments of science and technologies across most countries. However, it is the broader policy context within which such functions are set that determines whether S&T policy translates into STI policy. The neoliberal policy framework of GEAR grievously impeded this transformation.

The National Research and Development Strategy (NRDS)

The 2002 National Research and Development Strategy (NRDS) document, which was drafted around the time of the review of the GEAR macroeconomic plan, identified some key systemic fault lines within the national system of innovation that needed to be

addressed. It is worth quoting the listing of the text in full:

1. *The termination of key technology missions (such as military dominance in the subcontinent and energy self-sufficiency) by the previous government between 1990 and 1994.* This resulted in a drop in national R&D spending from 1.1 per cent in 1990 to 0.7 per cent of Gross Domestic Product (GDP) in 1994.[17] This reduction happened at a time when the National System of Innovation needed to expand to cope with the needs of 40 million people as opposed to a mere 5–6 million.
2. *Strategic considerations, from human, economic and security perspectives.* Adequate responses to new diseases and to old forms of new diseases, whether these diseases affect humans or animals, need to be informed by local research programmes. From a security perspective, even being a smart buyer of rapidly developing technology rather than a developer requires a critical mass of local scientists doing research in relevant areas. The S&T capacity of the country is running as fast as it can, but is still losing ground.
3. *Human resources.* Our human resources for science and technology are not being adequately renewed. An overwhelmingly white, male and aging scientific population is not being replaced by younger groupings more representative of our demographics.
4. *A complex set of factors driven largely by globalisation has resulted in reduced levels of both investment and performance by the South African private sector in R&D.* This could result in a loss of local control of the developing knowledge base that underpins the success of our most competitive companies.
5. *Inadequate intellectual property legislation and infrastructure.* New developments in biotechnology have increased our vulnerability with respect to the exploitation of our biodiversity, and inventions and innovations from publicly financed research is not effectively protected and managed.
6. *Fragmented governance structures* (RSA 2002a: 15–16, numbering added). Although research institutions have been reviewed and key performance indicators put in place, the roles of different departments in governance and in setting output targets for government research institutions is [sic] not clear or synergistic. From a budget perspective there is no holistic view of science and technology spending by government.

The key to this analysis lies in point 6, the fragmentation of relevant government structures, and the ensuing policy direction was driven by the recognised need to address the coordination failure. Since 2003 the DST has dramatically increased its funding for the biotechnology sectors, marking a shift to a strategic 'picking winners' intervention. Enhanced tax incentives for R&D expenditure were introduced in 2006. Overall, S&T policy has now acquired a sustained focus and direction that are supported by an increased budget and human resource complement. Its coordination role was redefined and has been significantly enhanced since 2002 (Kahn 2008). The NRDS (RSA 2002a) set itself the following three main objectives:

(a) Measures to enhance innovation

- The need to address the 'innovation chasm', i.e., the gap between innovation and diffusion: to this end the Foundation for Technological (FTI) was planned to create technology missions and to address the innovation chasm.
- A specific recognition of the need to develop social sciences to understand the workings of the South African NSI.
- A review and coordination of innovation funding instruments.
- The current formulation of missions is:
  - Poverty reduction (focus on demonstration and diffusion of technologies to impact quality of life and enhance delivery)
  - Key technology platforms (focus on knowledge-intensive new industries):
    - National Biotechnology Strategy
    - ICT
  - Advanced Manufacturing with linkages to the Integrated Manufacturing Strategy (see RSA 2002b)
  - Leveraging resource-based industries and developing new knowledge-based industries from them (mobilising the power of existing sectors). This amounts to the 'knowledge beneficiation' of a historically resource-based economy
- Science and technology for poverty reduction oriented towards enhancing basic skills provision: this recognises the critical role of broad-based pre-university education in the development of the human capital base of the NSI.
- Two technology platforms, ICT and biotechnology, are assigned a development priority.

- † Access to technology for SMMEs (small, medium and micro enterprises) and BBEE (Broad Based Economic Empowerment) enterprises; again this is linked to the Integrated Manufacturing Strategy.
- † An integrated approach to the development of the agricultural sector with respect to areas of R&D (indigenous knowledge, biotechnology, earth observation, and aspects like logistics) and between national and provincial R&D programmes.

(b) SET human resources and transformation

The document identifies potential and actual areas where South Africa has a scientific competitive strength. Astronomy, human palaeontology, biodiversity, Antarctic research, geology, geomagnetism, and space science are areas of competence which arose from geographic attributes. Other areas of evident knowledge advantage include indigenous knowledge, deep mining technology, medical research, microsatellite engineering, encryption technology, and fluorine technology.

However, the main concern is the faltering education system which has been unable to provide the required flow of qualified students for higher education, especially in SET areas. The NRDS advocates programmes aimed at raising matriculation pass rates and the number of pupils taking science and mathematics.[18]

(c) An effective government science and technology system and infrastructure

The NRDS identified the excessive fragmentation of R&D activity, spread across state-owned corporations, Science Councils (performers and funding agencies), universities and domain-specific research organisations/capacities within the public sector with separate budgets and reporting systems as a major impediment to building a coherent S&T planning framework. The NRDS states categorically that '(t)he size, shape and content of the system of government-owned and funded science and technology institutions and programmes must be aligned with the economic and social development strategies of government' (RSA 2002a: 62).

(d) Private sector interventions

A number of new incentive and restructuring schemes were introduced by the NRDS to stimulate and facilitate private sector

R&D. These included:

- Tax incentives for R&D
- Provincial innovation initiatives, such as incubators to be run by the proposed Foundation for Technological Innovation
- Dedicated funding for global technology sourcing aimed at small and medium firms complemented by information drives to expose local firms to new sources of technology
- Venture capital in the form of seed and early-stage venture capital for high-technology businesses, in conjunction with the DTI

The Ten-Year Innovation Plan

The most recent statement on the shape and direction of S&T policy was laid out in the DST's 10-year plan (RSA 2007b). This plan articulates a firm commitment to move S&T planning more specifically towards innovation and to shift the base of the economy from natural resources to the knowledge economy. It specifically defines an 'innovation chasm' in the national system of innovation, i.e., a failure of R&D, especially state-sponsored R&D, to translate into outcomes which have a significant economic return. The main constraints on the path to the knowledge-based system of innovation are identified as:

- human capital development
- low R&D levels and intensities
- a poor knowledge infrastructure, and
- sub-optimal levels of ancillary functions, such as finance, that impede the flow from R&D to innovation.

The plan provides for priority areas for R&D support on the basis of the contribution of these areas to the transformation and development of the national system of innovation. The explicit vision for the South African National System of Innovation by 2018 includes:

- Being among the global top 10 in terms of the pharmaceutical, nutraceutical, flavour, fragrance, and bio-pesticide industries
- Deploying satellites that provide a range of scientific, security and specialised services for the government, the public and the private sector
- Achieving a 25 per cent share of the global fuel cell market with novel platinum group metal (PGM) catalysts
- Development of a fuel cell programme for transport and domestic use

- Initial capability in the production of hydrogen by water splitting
- Being a world leader in climate science and the response to climate change
- Having met the 2014 Millennium Development Goals to halve poverty

(RSA 2007b: 5)

This represents a decisive shift away from neutral intervention towards the type of strategic role of what Kahn (2008: 153) calls 'the mission-oriented push of the three decades of the apartheid wars in Angola, Mozambique and the then Rhodesia'. Within the context of the post-apartheid innovation system this strategic intervention should, if sustained, provide the required transformation of the system of science and technology into a system of innovation. This shift to 'picking winners' also takes cognisance of the main requirements for the success of state-supported R&D projects. These are:

- the need to achieve critical R&D mass (lumpiness of R&D capital),
- a systems approach with due regard for the required complementarities with skills development, physical capital investment and services, and
- the long-term nature of such R&D programmes which takes into account the depreciation of knowledge.

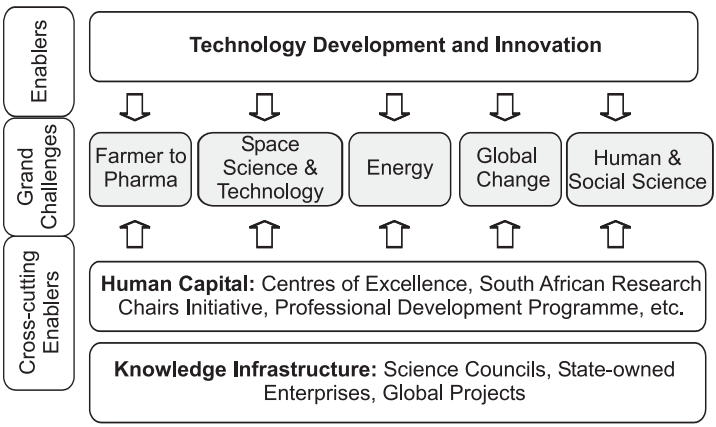
The 10-year plan identifies five 'great challenges' which demand a multi-disciplinary approach for their attainment and which 'are designed to stimulate multidisciplinary thinking and to challenge our country's researchers to tackle existing questions, create new disciplines and develop new technologies'. The grand challenges, listed here, provide a clear indication of the envisaged expertise requirements:

- The *Farmer to Pharma* value chain to strengthen the bio-economy
- Space science and technology
- Energy security
- Global change science with a focus on climate change
- Human and social dynamics

Human capital at the high end of the spectrum, and the institutions that are directly charged with its production, form the core foundations, or enablers. Progress in all these areas is seen as

based on the three foundations of innovation, human capital and knowledge infrastructure. Figure 6.4 illustrates the interconnections between these foundations and the grand challenge programmes. There is also an acceptance that international collaboration in innovation needs to be promoted.

Figure 6.4: *Grand Challenges and Enablers of the Ten-year Plan*



Source: RSA (2007b: 11).

The 10-year plan also seeks to address the fragmentation of funding mechanisms for STI by forming a separate entity, the Technology Innovation Agency (TIA) as a specialised agency which incorporates, among others, the Innovation Fund and the Biotechnology Regional Innovation Centres. The TIA was established in 2008 (RSA 2008a) and its main brief is to enhance market opportunities in partnership with industry and state research institutions. The TIA's broad objectives are listed as follows (RSA 2007b: 32):

- Act as a technological agency that will provide funding and complementary services to bridge the gap between the formal knowledge base and the real economy
- Stimulate development of technology-based services and products
- Support development of technology-based enterprises — both public and private
- Provide an intellectual property support platform

- Stimulate investment (venture capital, foreign direct investment, etc.). Facilitate the development of human capital for innovation.

This new public entity is specifically designed to stimulate and intensify innovation in order to develop technological innovations and interventions and create the appropriate environment for commercialisation. The TIA is expected to serve the development of technology-based products and services, by the public and private sector technology-based enterprises. The conceptualisation of TIA has been criticised from a number of perspectives (see Masilela [2008] for a comprehensive assessment of the TIA bill). Van Zyl (2011) is unambiguous about the implementation failure of the TIA to date.[19]

The 10-year plan marks a decisive shift in the policy stance towards the development of the South African system of innovation. While there is still a degree of disjuncture between STI planning and other policy areas, shifts in related policies also indicate a broad-based move towards a programme of targeted state intervention in the development process. However, there is still an evident gap between intent and implementation, as obvious in the case of the TIA.

Broader policy framework

As discussed earlier, the overall policy framework in which the new democratic South African system of innovation was born was the neoliberal programme contained in the GEAR document. This is still the overall policy document and even though there is a widespread loss of confidence in the validity of the underlying paradigm, it still sets the policy language. Any initiatives to address specific problems on any front through direct intervention are isolated and fragmented, and lack the required alternative paradigmatic context. Within the GEAR framework, performance shortcomings are seen purely as delivery failures due to an under-qualified and inept civil service at the provincial and municipal levels. While this is true, a neoliberal approach to planning will still be inappropriate to address the structural transformation which is needed to alter the evolutionary path of the NSI to one which is more appropriate to the requirements of a democratic political economy.

However, as mentioned earlier, there is now a widespread shift towards a more interventionist approach. This is reflected in a number of areas and we briefly outline relevant policies in industrial policy,

before proceeding to policies affecting human capital development and local development further on in this section.

Industrial Policy

The Microeconomic Reform Strategy and the Integrated Manufacturing Strategy (RSA 2002b) are explicit in their recognition of the failure of the state to engineer the required structural transformation of the South African economy:

> The Microeconomic Reform Strategy seeks to affect positively six key performance areas, namely, growth, competitiveness, employment, small business development, black economic empowerment, and geographic spread of economic activity. Government has recognised that weaknesses in addressing these issues arise, in part, from a failure to integrate government policies and programmes adequately (RSA 2002b: 27).

The main initiatives which were adopted in the strategy addressed the promotion of Black Economic Empowerment (later changed to Broad-Based Black Economic Empowerment), small business development, an alignment of policies and strategies towards employment creation and the integration of the various levels of national and local government to foster a more evenly spread growth and development process.

The Accelerated and Shared Growth Initiative for South Africa (RSA 2004) programme set out the following overarching objectives:

- Reduce the unemployment rate from 30 per cent to 15 per cent by 2014.
- Reduce poverty from one-third to one-sixth of the population by 2014.
- Increase the annual GDP growth rate from the then average of 3 per cent to 4.5 per cent per year for the period 2005 to 2009 and to 6 per cent for the period 2010 to 2014. This target should create a sustainable annual growth rate of 6 per cent.

The binding constraints to the achievement of the growth rate required to reduce poverty significantly were identified as:

- currency volatility,
- an inefficient national logistics system whose infrastructure lacked the required capacity for growth,

- the shortage of skilled labour,
- market concentration, monopoly power and barriers to entry,
- limited new investment opportunities,
- a regulatory environment which was not appropriate for the SME sector; labour law was identified as one of the constraints,
- shortcomings in state organisation, capacity and management.

In order to address goals in light of the constraints broad policies were developed with regard to macroeconomic management, the development of infrastructure, sectoral and industrial strategies, skills and education, the Second Economy (referring to the economy 'inhabited' by the majority of the population which bore all the symptoms of severe underdevelopment), and public administration.

National Integration of the NSI

The landmark policy document on local development is the 2006 National Framework on Local Economic Development. This policy statement is unusual in that it explicitly specifies its underlying theoretical foundation. This is identified as 'new institutionalism' which is defined as follows:

> New Institutionalism breaks down the distinction between economy and society, showing how economic decision-making and action is shaped by the shared values, norms, beliefs, meanings, and rules and procedures, of the formal and informal institutions of society. The normative agenda of the New Institutionalism is to develop shared meaning and values, and to strengthen the networks of social interaction. This has also been variously described as building *social capital* or developing *social cohesion* (RSA 2006a: 7).

The various characteristics that are identified as the indicators of successful and sustainable local development include a combination of causes and effects. They can be grouped into the following broad categories (Scerri 2009):

- **Human capital** which is defined in terms of a population that is skilled, problem solving and innovative. The long-term development of human capital is set in a context of guaranteed safety nets. This is further reinforced by a sound environmental policy which provides for the aesthetic component of social life.

- **Institutional networks** which include sound governance in terms of innovative, transparent and fully accountable local authorities, and complex sets of private sector relationships which lead to an optimal utilisation of local assets. Assets in this case are defined to include the natural, physical, financial, human, and social capital of local economies. The availability of a sound physical and social infrastructure significantly lowers the incidence of transactions cost in the local economy. This lowering of transaction costs is further enhanced by sound institutional networks. One of the effects of a vibrant provincial system of innovation would be a complex economic structure with a wide diversity of production sectors. In such a context the larger portion of the income earned by the provincial population would be spent in the province. This would feed into the virtuous cycle of tax revenue generation, leading to better infrastructure with feedback effects to local consumption.
- **Linkages across municipal, provincial, national, continental, and global systems** provide an immediate access to the population and the economy to cutting edge information and global finance. These linkages also reinforce the competitive advantage of local economies and their ability to access the full set of development incentives offered by the national government and global institutions.

The main constraints on the achievement of an even process of local development are the familiar ones of low levels of human capital, inefficient and corrupt local public management, and the poor quality of infrastructure. On top of that there is the low level of integration resulting in weak links to other local systems of innovation. The corresponding strategy areas are governance and delivery, the proper assessment of local comparative and competitive advantage in order to target intervention with support schemes for business and business infrastructure development, and the development of community investment programmes.

Human Capital Development

In line with the discussion throughout this chapter, the broad definition of human capital is adopted in this document. This covers more than education; it also includes those aspects which determine the conditions for the long-term nature of human capital

development. While human capital development is a supply-side policy, in the sense that it enhances the technological capabilities of the NSI, it also has demand-side effects in that a generally improving quality of life implies an increasing demand for the products of innovation.

The review of the performance of the South African economy during the first five years of GEAR brought in an urgent drive to address human capital development in a comprehensive manner. This drive was articulated in the 2001 Human Resource Development Strategy for South Africa (RSA 2001) document which addressed the crippling shortfall of human capital in a holistic manner. The document which focuses primarily on education and training is remarkable in that it lays the foundation for the proposed initiatives in the broader terms of human development. The goals (RSA 2001: 10) are specified as:

- To improve the Human Development Index: an improved basic social infrastructure is critical for a productive workforce and a successful economy
- To reduce disparities in wealth and poverty and develop a more inclusive society (measured by the Gini-coefficient)
- To improve international confidence and investor perceptions of the economy (measured by South Africa's position in the international Competitiveness League)

Although there is a conflation of causes and effects in the grouping together of these three goals, this statement of intent signals a decisive shift in the placing of human development as a strategy for development as well as the objective of development. The strategic objectives of human resource development were listed as:

- a solid basic foundation, consisting of early childhood development, general education at school, and adult education and training;
- securing a supply of skills, especially scarce skills, within the Further and Higher Education and training bands of the National Qualifications Framework (NQF), which anticipate and respond to specific skill needs in society, through state and private sector participation in lifelong learning;
- an articulated demand for skills, generated by the needs of the public and private sectors, including those required for social development opportunities, and the development of small business and;

- a vibrant research and innovation sector which supports industrial and employment growth policies. (RSA 2001: 11)

The 2004 AsgiSA document identified a number of medium- and long-term interventions to address the skills shortage. These covered the improvement of public schooling, especially in mathematics and science, investment in priority areas in tertiary education and the development of work-based training programmes and scarce skills initiatives. This led to the establishment of a joint council in government to strengthen and coordinate the activities to address the skills shortage. The urgent need for skills, which are a necessary input for AsgiSA programmes, led to the idea of creating a short- to medium-term troubleshooting approach towards skills challenges. This gave rise to the Joint Initiative on Priority Skills Acquisition (RSA 2006b), which was designed to address the acquisition of scarce and priority skills. JIPSA adopted a three-point strategy:

1. Five high-profile priority skills areas were identified for immediate attention:
   a. high-level, world-class engineering and planning skills for the 'network industries' — transport, communications, water, energy
   b. city, urban and regional planning and engineering skills
   c. artisanal and technical skills, with priority attention to infrastructure development, housing and energy, and in other areas identified as being in strong demand in the labour market
   d. management and planning skills in education and health
   e. Mathematics, Science and language competence in public schooling.
2. JIPSA launched a systematic process of discussion with key 'project owners' and role-players regarding the skills required to underpin AsgiSA projects and to increase labour absorption. This led to concrete proposals for priority skills initiatives in the fields of tourism, ICT, BPO, and biofuels. During the reporting period, JIPSA focused on engaging the project owners in the tourism, ICT and BPO sectors.
3. A limited number of focused analyses and consultations were initiated to address perceived constraints and inefficiencies in the current frameworks and institutional arrangements

for skills delivery. The following issues are receiving priority attention:

a. analysis of the problem of unemployed graduates
b. strengthening of the labour market and skills information system
c. the National Qualifications Framework Review and quality assurance mechanisms
d. analysis of artisan training capacity.

Inter-NSI Integration (Scale Issues)

It is widely agreed (see Muchie et al. 2003) that the development of the South African NSI cannot be considered in isolation from the rest of Africa. In the new world economic order of economic blocs, there is a dire need to create an African (or a sub-Saharan African) system of innovation. A number of customs unions exist in Africa and the one that is immediately relevant to South Africa is the Southern African Development Community (SADC).

The 2007 SADC Protocol on Science Technology and Innovation is a legally binding document aimed at regulating collaborative initiatives within the framework of the SADC Regional Indicative Strategic Development Plan (RISDP) and Africa's Science and Technology Consolidated Plan of Action. The overall aims of the protocol are to:

- Establish institutional mechanisms in order to strengthen regional cooperation on and coordination of science, technology and innovation,
- Institute management and coordination structures, with clearly defined functions, which will facilitate the implementation of regional STI programmes,
- Promote the development and harmonisation of science, technology and innovation policies in the region,
- Pool resources for scientific research, technological development within the region,
- Demystify science, technology and innovation by promoting public understanding and awareness of and meaningful participation in these disciplines, and
- Work towards the elimination of restrictions that restrict the free movement of scientists, technologist and engineers for the purposes of education, research and participation in joint STI programmes.[20]

This agreement is set within the broader 2003 NEPAD (New Partnership for African Development) STI cooperation framework. The structure of the NEPAD Science and Technology programme

covers governance structures, priority S&T areas with key outputs in each area, business and implementation plans and human capital development.[21] The governance structure is composed of a ministerial council, a steering committee of relevant director general-level officials, the NEPAD secretariat, as well as regional coordinators. The priority S&T areas have been grouped into the following programme clusters:

- biodiversity, biotechnology and indigenous knowledge
- energy, water and desertification
- material sciences, manufacturing, laser, and post-harvest technologies
- ICT and space science and technology
- mathematical sciences

The key outputs in each area are specified as:

- Research outputs targeted at addressing social and economic problems in Africa
- Technology hubs/incubators to nurture new innovations
- Human resource development
- Stemming of the brain drain
- Strengthening of institutional capacity

The programme of action requires that business plans be formulated in each NEPAD region for each cluster, which is to be consolidated into a single overall consolidated plan. The implementation mechanism includes the establishment of centres of excellence in each region for each programme and the development of continent-wide networks to maximise economies of scale and scope in R&D programmes.

Regional integration across sub-Saharan Africa is relevant at yet another level. The entry of South Africa in the BRICS grouping is at first sight odd, given the small size of its economy, in terms of population, GDP and all other macroeconomic variables, relative to those of the other countries in the group. Its presence alongside considerably larger economies can only be understood in terms of its being an African economy with the most diversified and complex NSI in the sub-Saharan region. Implicitly, South Africa brings the rest of the region into the BRICS grouping. This proposition, however, can only be valid if premised on an evident degree of regional economic integration. Alternatively, South Africa's continued effective 'membership' in BRICS can only be sustainable on the basis of a progressive transition from a national to a regional system of innovation across sub-Saharan Africa.

Outcomes of State Policy and State Institutions on the NSI

The assessment of any single policy is not easy given the large amount of determinants which may influence outcomes. These determinants consist of other state policies and state performance, as well as factors exogenous to the state planning arena, whether local, or global. Thus the identification of clear lines of causality is rarely simple. In the case of the South African system of innovation, the search for causalities is further complicated by the short time span of the relevant period. The South African political economy changed fundamentally in 1994, but most of the policies which are relevant today originated in 2002. This is far too short a time to assess the effects of policies which have been, or should have been, designed to fundamentally alter the structure of the NSI in its broadest sense.

Within the confines of S&T policy design and implementation, the DST has certainly extended its coordinating role considerably since its transformation from DACST in 2002. In the short span of time since then it has moved much closer to placing its activities within the NSI conceptual framework, as articulated in the 1996 White Paper. The 2007 10-year innovation plan following on the 2002 National R&D Strategy document sets out the agenda for the next stage in the strategic path of the DST. While it is much too soon to discern any results, the restructuring of the Ministry of Science and Technology is already following the recommendations of the 2007 plan.

On the broader canvas, the most worrisome failure of policy is on the education and training front. It is widely acknowledged that the performance of public education from primary schooling to the tertiary education level has failed to produce the sufficiently educated labour force that is required for the country's development process. It is also widely acknowledged that the National Skills Development Strategy and the Human Resources Development Strategy working through the Sector Education and Training Authorities have also generally failed to increase at any significant level the skills base of the economy. The AsgiSA and JIPSA programmes, drafted largely as another response to the continuing failure to address the country's human capital constraints are still too young to enable an assessment of their effects. The DST has been actively trying to redress the lack of research capacity in universities and the SARChI programme, has,

in its short lifetime, been a highly successful means for addressing the low reproduction rates of researchers.

In the case of local development, the 2006 National Framework for Local Economic Development document (RSA 2006a) marks a decided break in the approach to regional imbalances in the development process. It is obviously much too soon to assess the impact of this policy initiative on the highly distorted economic geography of South Africa. However, the current provincial map will continue to place a severe constraint on the roll out of the new local economic development policy framework.

Most of the STI cooperation initiatives within the context of the SADC and NEPAD are still bogged down by bureaucratic inefficiencies in a structure which is top heavy and wasteful of funds. There is little beyond statements of intent specifying areas of cooperation in STI among member countries of the AU (as articulated in NEPAD 2006) and the SADC. One of the more promising initiatives within NEPAD is the development of common STI indicators for the region which would allow intra-Africa comparability.

Conclusions and Recommendations Targeting Improvements in the NSI with Specific Emphasis on the Role of the State

The South African system of innovation which forms the object of this study can be seen as a very young one. The advent of democracy in 1994 marked a decisive shift in the legal underpinnings of the system. There are, however, strong reservations as to whether political change was sufficient to engender a corresponding transformation of the NSI. There are strong arguments, which have been briefly outlined in this chapter, that the fact that the first macroeconomic plan for the new democracy was a neoliberal one meant that there was a continuation, and indeed an unprecedented legitimacy, of the economic structure which developed under apartheid. The review of the performance of the South African economy led to a revision, albeit a fragmented one, of the role of the state in the structural transformation of the South African economy. From this perspective, therefore, the origin of the post-apartheid system of innovation, in terms of state policy aimed at engineering the required break from the economic structure

carried over from apartheid, should be defined as from the earlier part of the 21st century. This makes the new South African system of innovation quite young.

There are two main constraints on the development of the post-apartheid NSI that were carried over from the apartheid economy. They are the depletion of broad-based human capital and the regional unevenness that grew from the economic geography of apartheid. State policy within the framework of the GEAR macroeconomic plan was severely restricted to a market facilitation role and the provision of public goods, including education. The expectation was that the liberalisation of markets would stimulate a burst of growth whose benefits would trickle down to the general public and progressively raise the quality of life. It was never clear how this policy would redress the degeneration of the human capital base under apartheid and the review of the first five years of GEAR made it clear that unemployment, poverty, income inequality and education and training had not improved. It was also acknowledged that the enduring levels of market concentration and the associated barriers to entry had proved to be an insurmountable obstacle to the redistribution of wealth through Broad-Based Black Economic Empowerment. The negotiated settlement on the definition of provinces also tied in the economy to one of the more debilitating aspects of apartheid. The high level of the unevenness of development among provinces has become highly path dependent and has formed the basis for a distorted NSI.

It is now clear that the South African state has taken upon itself the role of the leader of the reshaping of the NSI, even though it may not be stating it in quite those terms. Certainly, the DST has shifted to a targeted intervention policy and has adopted the role of a leader in R&D financing and activity. There are a number of recommendations which would enhance the effects of state policy on the development of the South African system of innovation that we list here:

1. The coordinating role of the DST over all state STI programmes and initiatives has to be strengthened to eradicate the 'silo' planning with its endemic wastefulness of opportunities and its potential for contradictory policies.
2. The DST has to redefine the 'human capital pipeline' to include all education and training programmes. From this stance it should be an active partner with the Departments

of Education and Labour so as to bring in an overall coordinating structure in education. It should also liaise with the Department of Public Works in its expanded public works programme so as to ensure that the training component generates more of an impact on human capital development than a simple soaking up of unemployment.

3. An indigenous STI component should be built into all government construction and infrastructural programmes. The specific economic and environmental conditions in South Africa offer ample scope for the development of local technologies and an STI requirement in the public tendering processes would constitute a significant demand-led stimulus to local innovation. Insofar as the South African economic and environmental conditions are replicated across a substantial portion of sub-Saharan Africa, there are substantial potential economies of scale for the long-term development of local appropriate technologies. The constitutional commitment for the provision of basic needs, in terms of housing, clean water, energy, communications, health, and education offers a potential for a state-led demand stimulus for innovation that should be substantially stronger and certainly longer lasting than that provided by military expenditure under apartheid.
4. The identification of the S&T areas listed as the 'grand challenges' in the 10-year innovation plan (RSA 2007b) provides a clear signal of a concerted and targeted supply-side STI stimulus programme. Again, this could be substantially complemented by demand-side incentives which would assure the long-term viability of STI initiatives.
5. The provincial map of South Africa has to be revisited in order to eradicate the fundamental historically determined differences in development potential. This redrawing should reduce the number of provinces to a maximum of five and should ensure that those sub-national artificial economies previously designated as *bantustans* or homelands be merged with the historically advantaged sub-national entities within the parameters of viable provincial systems of innovation. The DST can play a crucial role in this reformation through its new mandate to deploy STI planning at the provincial level. The redrawing of the provincial map could actually

ensure that the provincial strategy of the STI generates the maximum returns.

6. The urgent addressing of poverty should be placed at the core of development policy as a strategic tool as well as an objective of development. This, when combined with recommendation (3) should also provide a huge boost to the purchasing power of the internal market. In the current environment of the global financial crisis this would imply a strongly expansionary fiscal policy. The 2001 Human Resource Development Strategy did just that and developed 25 indicators as a means to achieve a comprehensive improvement in the human capital base of the South African economy. This endeavour was, however, bedevilled by poor implementation and faulty monitoring mechanisms. The solution to this failure lies not so much in the articulation of the original vision as in the reform of its implementation.

The shunting of the evolutionary path of the South African system of innovation on to an alternative development track cannot be approached in a piecemeal incremental manner, given the distortions generated during apartheid economic history. It requires a considerable programme of structural development on a broad front and it is the state that has to take on this role with conviction in a concerted and coordinated effort.

The weaknesses and threats identified by the OECD review of innovation policy in South Africa (OECD 2007: 13–17) consist almost entirely of shortcomings of the various determinants of human capital and human capabilities availability and development, as well as inappropriate state STI policy implementation. In the case of the latter factor, poor coordination of STI policy across government ministries and departments is cited as a main source of the implementation failure. In the case of human capital formation requirements the report focuses almost exclusively on the higher education sector. Among the several recommendations, the report drew attention to the requirement that a broad approach to innovation should be adopted, wherein the innovation capabilities are fostered and enhanced across the economy (OECD 2007: 19). The report also notes (ibid.: 80–81) that the knowledge base of the South African economy had not shifted significantly away from a resource-based economy.

The landmark 2012 report of the DST Ministerial Review Committee on the STI landscape in South Africa (RSA 2012) marks a watershed in the state's appraisal of its performance in developing an NSI appropriate to the structural transformation of the South African economy. The review committee accepts the assessment of the 2007 OECD report and elaborates on the shortcomings of the current role of the state in the evolution of the South African system of innovation. The identified problem areas can be summarised as follows (RSA 2012: 10):

- An enduring strong reliance on a resource- and commodity-based economy
- Poor public sector coordination of the planning and implementation of the NSI
- Business was insufficiently involved in building the NSI, at the levels of both large and small firms
- Lack of understanding of the broader definition of the NSI
- Human capital constraints at the higher end of the skills spectrum
- Inadequate capacity for the STI measurement
- Enduring poverty and exclusion

In Section 6.1 of the report of the Ministerial Committee the conceptualisation of the NSI is addressed directly with two broad alternatives on its coordinating form considered — loose or tight coordination (RSA 2012: 96–97). The report offers a 'tripartite' coordination model with a central policy-making core and a coordination structure setting the context within which the 'NSI performing agents', covering the public and private sectors and civil society, operate (RSA 2012: 98–99). The path dependence of an uncoordinated NSI in South Africa is explicitly recognised in the report.[22] The report offers a wide range of recommendations (41 in all) covering the governance of the NSI, business and social innovation, human capital and the knowledge infrastructure, monitoring and evaluation, and the financing of the NSI. The more specific and significant recommendations include:

- With respect to governance, the main recommendation is for a single coordinating body (a National Council on Research and Innovation) established and located in the Office of the President and overseen by the Deputy President. A unitary R&I vote is also proposed to ensure better coordination of the public funding of R&I.

- With respect to the business innovation environment, recommendations are made to strengthen existing funding and coordination mechanisms, such as the Technology and Human Resources for Industry Programme (linking industry, HEIs and the state in innovation projects), as well as establishing funding mechanisms specifically designed to enable the access of small- and medium-sized enterprises to technology and scientific knowledge.
- Human capacity development is assigned a high priority as a major obstacle in the development of the NSI. However, the specific recommendations in the report focus on post-schooling education with an envisaged large expansion in technical colleges, curricula revisions at HEIs and measures to ensure a higher rate of reproduction of young academics. The placement of social innovation as a separate vaguely specified category, along with the scant attention to the pre-matriculation school sector does however place limits on the eventual efficacy of human capacity development policy as recommended in the report.
- Monitoring, evaluation and learning enhancement, expansion and centralisation covering system-mapping, analysis, building, steerage, evaluation, learning, and foresight exercises. The proposals should lead to an enhanced coordination and collation of reports from the various state agencies in the NSI.
- In the case of the financing of the NSI, it is proposed that R&I funding for the HEI sector should be significantly increased, that current business R&I-oriented incentive schemes should be enhanced, and that incentives for innovation-intensive foreign direct investment should be put in place.

The report of the Ministerial Review Committee marks a watershed in the evolution of the role of the state in the South African system of innovation. Its candid assessment of the failure of the state to transform the NSI on a number of crucial fronts, along with an explicit acceptance of the path-dependent nature of an unplanned NSI, sets the basis for a new and more appropriate coordination regime of the system. The recognition of the statutory limits to the ability of the DST, in isolation, to alter the shape of the NSI and the proposed elevation of the required coordination role to a supra-ministerial level augurs well for the development of a more coherent innovation strategy. This also opens up the policy formulation space

for core areas, especially in the case of human capabilities formation, which are still only partially addressed in the report.

Notes

1. The term 'black' is here used in the way that liberation movements used it as representing all the disenfranchised populations regardless of race or ethnicity.
2. This is documented in detail in Fine and Rustomjee (1996: chapter 7).
3. See Adelzadeh (1996) for an orthodox economic critique of GEAR.
4. The employment of low-skilled labour in South Africa has no significant effect on the long-term prospects for human capital development. As Altman (2006: 6) puts it: 'There is evidence to show that the wages of low skill and semi-skill formal sector workers is stagnant or falling and that these jobs are becoming increasingly precarious in character. This is consistent with the path of industrial development, which has increasingly leaned to the outsourcing, the real expansion of services, and of the informal sector.'
5. See Maharajh (2011: chapter 9) and Nattrass (2011) for a review and discussion of the contradictions in the NGP document.
6. '[T]he New Growth Path document . . . says little about innovation, R&D and technology, instead being content, with one exception, to repeat the indicators of the Ten-Year Innovation Plan. This is insufficient to build a prosperous state whatever its design may be, and would position South Africa outside mainstream thought on the importance of innovation' (RSA 2012: 123).
7. The 1996 White Paper was the second of the two official national STI policy documents in the history of South Africa. The first was legislated in 1916, as part of the move to formalise S&T planning across the British Empire during World War I (Scerri 2009).
8. '[W]e have in place an ailing national system of innovation. It is fragmented and is neither coordinated within itself nor within national goals; innovation capacity is not being built but is being eroded; national investment in R&D is not increasing relative to GDP, but falling' (RSA 1996b: 46).
9. Lall (1993) argued that the tariff system under apartheid was perverted in that it protected mature industries with limited potential for technological advance while exposing emerging industries with a high technology potential to international competition. From this perspective, trade liberalisation would have removed the distortion effects of tariffs. However, the rapid removal of protection for labour-

intensive low-skilled industries such as textiles and clothing caused the collapse of specific sectors and an increase in unemployment. Of course the more appropriate policy would have been to re-draw the tariff regime on the basis of some version of the 'infant industry' argument.

10. '[I]ndividual institutions trying to adapt are doing so in a policy vacuum at the highest levels of the present South African government. It may be that in the past, during the days of the National Party government's "Total Strategy", there was strong coordination and shared purpose among the institutions of the white dominated state. *If that was the case then*, we found no evidence of it being the case now . . . (r)ather, we saw a series of institutions, each trying to define for itself a role in a "new" South Africa' (IDRC 1993: 5).
    'There are no articulated economic or social goals towards which various institutions could apply their efforts . . . as a consequence of the policy vacuum, resource allocations are essentially frozen, subject only to minor variations approved by officials within a system which is non-consultative and non-transparent, even to other high-level government officials' (IDRC 1993: 22–23, emphasis added).
11. The White Paper was clear on the need to integrate S&T policy within the overall national planning framework. Governments of the industrialised countries recognised, at the beginning of the 1980s, that one of the challenges of promoting technological innovation was in devising means to ensure that government actions across all fields — in trade, education, labour laws, environmental protection, to name but a few — be taken with due consideration of how these actions would affect the climate for innovation. (RSA 1996b: 22)
12. 'Section five of the Document (GEAR), on "Trade, Industrial and Small Enterprise Policies", is thin on what the proposed trade policies, industrial policy and small enterprises are to be. On trade, the proposals appear to do away with any policies, as fast as possible. Some small enterprise policies are listed and there is a complete absence of any proposal for an industrial policy or strategy' (Adelzadeh 1996: 81, parentheses added).
    The formulation in labour policy was caught up in the dual trap of low skills and high unemployment. In the absence of an overall policy which placed human capital development as a top priority in economic planning, labour market liberalisation became the only apparently logical tool to address unemployment.
13. 'The evidence to support the proposition that import liberalization is automatically good for growth is weak — almost as weak as the opposite proposition that protectionism is good for growth' (UNDP 2005: 119).

14. 'The government intends to create the following outputs related to human resource development:
    - A human resource development investment strategy which would be an integrated and affordable five-year HRD plan.
    - A training strategy which details sectoral investment programmes for the National Training Strategy, with a priority on immediate investment strategies.
    - Restructuring education through improving the quality of education within the prevailing fiscal constraints with the priority on skills for employment, growth and democracy and a plan for effective backlog provision.
    - Social partnerships in human resource development with specific reference to partnerships with the private sector on education, health and training. This also proposes a training investment target of five per cent of the salary bill' (RSA 1996b: 71).
15. Under apartheid, four 'independent' *bantustans* were created along ethnic lines. These were Transkei (Xhosa), declared independent on 26 October 1976, Bophuthatswana (Tswana), declared independent on 6 December 1977, Venda (Venda), declared independent on 13 September 1979, and Ciskei (also Xhosa), declared independent on 4 December 1981. The other six homelands — Gazankulu (Tsonga [Shangaan]), KaNgwane (Swazi), KwaNdebele (Ndebele), KwaZulu (Zulu), Lebowa (Northern Sotho or Pedi) and QwaQwa (Southern Sotho) — were assigned partial administrative autonomy.
16. These were the Cape, Natal, the Orange Free State, and the Transvaal.
17. However, the ratio of gross expenditure on R&D relative to the GDP has been rising steadily since 1997–98 and is comparable to that of Poland, Portugal and Hungary (Kahn and Blankley 2006).
18. 'This issue has become so pressing that it will be necessary to increase "out-of-school" programmes to support mathematics, science and computer education. A number of pilot programmes, run by dedicated volunteers in many cases, have shown excellent results. In addition, specific consideration should be given to incentivising schools to produce more black and more female Mathematics and Science matriculants at the higher grade. For example, private schools that successfully produce higher-grade Mathematics and Science matriculants from designated groups could be retrospectively paid the equivalent of the education subsidy' (RSA 2002a: 55).
19. 'So far the effect of TIA on the innovation landscape has not been apparent. On the contrary, quite a number of funding initiatives incorporated into the TIA have been abruptly ended, leaving research institutions responsible for personnel and running costs and in some cases even resulting in the loss of highly skilled personnel. In addition,

the payments of many research contracts are in arrears, leaving institutions liable for payments to subcontractors and international collaboration partners. Apart from the financial implications, this situation has serious international reputational risks for the South African innovation system' (van Zyl 2011).

20. See http://www.dst.gov.za/media-room/press-releases/sadc-ministers-sign-protocol-to-improve-science-and-technology-cooperation/?searchterm=SADC%20protocol%20on%20STI (accessed 2 December 2011).
21. See http://www.dst.gov.za/other/icr/products?submen=1#flagship (accessed 2 December 2011).
22. 'Where innovation has been left free to proceed along trajectories defined by historical precedent, it becomes a dynamic that inadvertently has the effect of deepening inequalities and imbalances, rather than ameliorating them' (RSA 2012: 110).

References

Adelzadeh, A., 1996. 'From the RDP to GEAR: The Gradual Embracing of Neoliberalism in Economic Policy', *Transformation*, 31(4): 66–95.

African National Congress (ANC), 1994. *Reconstruction and Development Programme*. Johannesburg: Umyanyano Publication.

Altman, M., 2006. 'Low Wage Work in South Africa', Paper presented to IZA/World Bank Conference on Employment & Development Berlin, Germany, 25–27 May, Human Resources Development Council, Cape Town.

Barnard, G., 2009. 'Realising South Africa's Employment Potential', Working Paper no. ECO/WKP (2009)3, Economics Department, Organisation for Economic Co-operation and Development.

Bowles, S. and H. Gintis, 1975. 'The Problem with Human Capital Theory — A Marxian Critique', *American Economic Review*, 65(2): 74–82.

Bundy, C., 1988. *The Rise and Fall of African Peasantry*. London: Currey.

Centre for Science, Technology and Innovation Indicators (CeSTII), 2005. *Main Results of the South African Innovation Survey 2005 (Covering the Period 2002–2004)*. Pretoria: Department of Science and Technology.

Fine, B. and Z. Rustomjee, 1996. *The Political Economy of South Africa: From Minerals-Energy Complex to Industrialisation*. Johannesburg: University of the Witwatersrand Press.

International Development Research Centre (IDRC), 1993. *Towards a Science and Technology Policy for a Democratic South Africa*. Ottawa: International Development Research Centre.

Kahn, M., 2008. 'Science and Technology Policy', in A. Kraak and K. Press (eds), 2008. *Education, Employment and Skills in South Africa*. Cape Town: Human Resources Development Council, 134–60.

Kahn, M. and W. Blankley, 2006. 'The State of Research and Experimental Development: Moving to a Higher Gear', in S. Buhlungu, J. Daniel, R. Southhall, and J. Lutchman (eds), *State of the Nation: South Africa 2005–2006*. Cape Town: Human Resources Development Council, 270–98.

Lall, S., 1993. 'What Will Make South Africa Internationally Competitive?', in P. Baker, A. Boraine and W. Krafchik (eds), *South Africa and the World Economy in the 1990s*. Washington DC: Brookings Institution, 50–70.

Maharajh, R., 2011. 'Innovating beyond Racial Capitalism', Ph.D. Dissertation, Lund University.

Maharajh, R. and T. Pogue, 2006. 'A Representation to the African Peer Review Mechanism on Assessment of South Africa's Socio-Economic Development', African Peer Review Mechanism (APRM) National Secretariat and Institute for Economic Research on Innovation, Tshwane University of Technology, Pretoria.

———, 2008. 'South African Science, Technology and Industry Scoreboard 2008', *Cooperation Framework on Innovation Systems between Finland and South (COFISA)*, Department of Science and Technology, Tshwane University of Technology, Pretoria.

———, 2009. 'Transforming South Africa's National System of Innovation for Accelerated and Shared Growth and Development', Country Report for Comparative BRICS Study, Rede de Pesquisa em Sistemas e Arranjos Produtivos e Inovativos Locais (RedeSist) and International Development Research Centre (IDRC), Rio de Janeiro.

Masilela, T., 2008. 'Governance Challenges: Considerations in Structuring Agencies to Support Innovation', Faculty Seminar Paper, Faculty of Economics and Finance, Tshwane University of Technology, Pretoria.

Muchie, M., P. Gammeltoft and B.-Å. Lundvall (eds), 2003. *Putting Africa First: The Making of African Innovation Systems*. Aalborg: Aalborg University Press.

Nattrass, N., 2011. 'The New Growth Path: Game Changing Vision or Cop-out?' *South African Journal of Science*, 107(3/4): 1–8.

New Partnership for Africa's Development (NEPAD), 2006. *Africa's Science and Technology Consolidated Plan of Action*. Midrand: New Partnership for Africa's Development (NEPAD) Office of Science and Technology.

Organisation for Economic Cooperation and Development (OECD), 2007. *OECD Reviews of Innovation Policy: South Africa*. Paris: Organisation for Economic Cooperation and Development.

Republic of South Africa (RSA), 1996a. *Growth, Employment and Redistribution: A Macroeconomic Strategy*. Pretoria: Department of Finance, Republic of South Africa.

Republic of South Africa (RSA), 1996b. *White Paper on Science and Technology: Preparing for the 21st Century*. Pretoria: Department of Arts, Culture, Science and Technology, Republic of South Africa.

———, 2000. *Towards a National Skills Development Strategy: Skills for Productive Citizenship for All*. Pretoria: Department of Labour, Republic of South Africa.

———, 2001. *Human Resource Development Strategy for South Africa*. Pretoria: Department of Education and Department of Labour, Republic of South Africa.

———, 2002a. *South Africa's National Research and Development Strategy*. Pretoria: Department of Science and Technology, Republic of South Africa.

———, 2002b. *Accelerating Growth and Development: The Contribution of an Integrated Manufacturing Strategy*. Pretoria: Department of Trade and Industry, Republic of South Africa.

———, 2003. *Towards a Ten Year Review: Synthesis Report on Implementation of Government Programmes*. Cape Town; Pretoria: Office of the Presidency, Republic of South Africa.

———, 2004. *Accelerated and Shared Growth Initiative for South Africa-AsgiSA*. Cape Town; Pretoria: Office of the Presidency, Republic of South Africa.

———, 2005a. *National Skills Development Strategy, 1 April 2005–31 March 2010*. Pretoria: Department of Labour, Republic of South Africa.

———, 2005b. *National Survey of Research & Development 2003/2004*. Pretoria: Department of Science and Technology, Republic of South Africa.

———, 2006a. *National Framework for Local Economic Development (LED) in South Africa (2006–2011)*. Pretoria: Department of Provincial and Local Government, Republic of South Africa.

———, 2006b. *Joint Initiative on Priority Skills Acquisition — JIPSA*. Cape Town; Pretoria: Office of the Presidency, Republic of South Africa.

———, 2007a. *Development Indicators — Mid-term Review*. Cape Town; Pretoria: Office of the Presidency, Republic of South Africa.

———, 2007b. *Innovation towards a Knowledge-based Economy Ten-Year Plan for South Africa (2008–2018)*. Pretoria: Department of Science and Technology, Republic of South Africa.

———, 2008a. *National Survey of Research and Experimental Development (R&D) 2006/2007*. Pretoria: Department of Science and Technology, Republic of South Africa.

———, 2008b. *Towards a Fifteen Year Review*. Cape Town; Pretoria: Office of the Presidency, Republic of South Africa.

———, 2009. 'The New Growth Path: The Framework', South Africa Government Online. http://www.info.gov.za/view/DownloadFileAction?id=135748 (accessed 2 December 2011).

Republic of South Africa (RSA), 2010. *Development Indicators — Mid-term Review*. Cape Town; Pretoria: Office of the Presidency, Republic of South Africa.

———, 2011. *National Survey of Research & Experimental Development: Main Results 2008/2009*. Pretoria: Department of Science and Technology, Republic of South Africa.

———, 2012. *Department of Science and Technology Ministerial Review Committee on the Science, Technology and Innovation Landscape in South Africa (Final Report)*. Pretoria: Department of Science and Technology, Republic of South Africa.

Scerri, M., 1990. 'R&D and the International Competitiveness of the South African Manufacturing Sector', *South African Journal of Economics*, 58(4): 341–56.

———, 2003. 'The Competitiveness of the Southern African Customs Union within the Context of the Indian Ocean Rim', in G. Campbell (ed.), *The Indian Ocean Rim: Southern Africa and Regional Co-operation*. London; New York: Routledge-Curzon, 123–42.

———, 2009. *The Evolution of the South African System of Innovation since 1916*. Cambridge: Cambridge Scholars Publishing.

———, 2010. 'Provincial Systems of Innovation and Globalisation in South Africa', in B. Dallago and C. Guglielmetti (eds), *Local Economies and Global Competitiveness*. New York: Palgrave Macmillan, 75–94.

Sen, A., 1999. *Development as Freedom*. New York: Anchor Books.

United Nations Development Programme (UNDP), 2005. *Human Development Report 2005*. New York: United Nations Development Programme.

———, 2009. *Human Development Report 2009*. New York: Palgrave Macmillan.

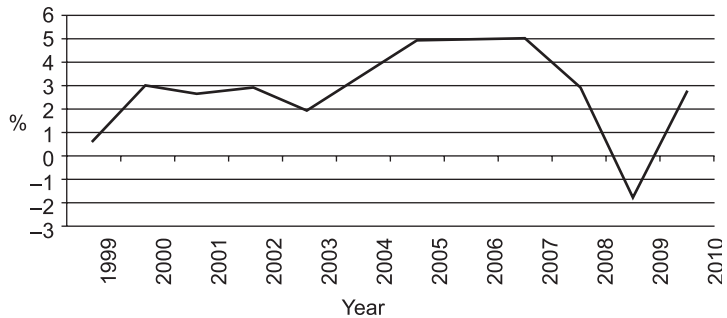
———, 2011. 'Human Development Indicators', Human Development Report Office, United Nations Development Programme. http://hdrstats.undp.org/en/countries/profiles/ZAF.html (accessed 2 December 2011).

Van Zyl, A., 2011. 'Innovation in South Africa — The Role of the Technology Innovation Agency', *South African Journal of Science*, 107(1/2).

Annexure

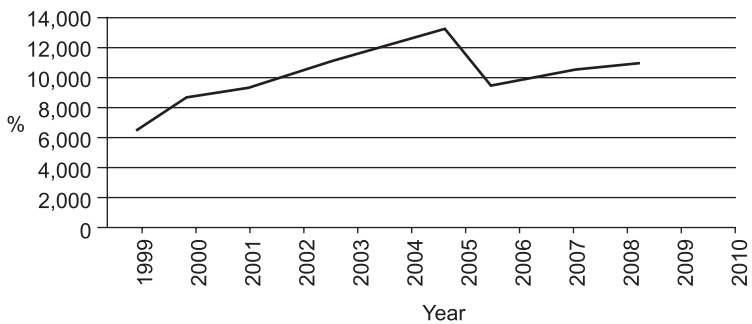
Annexure A: Selected Macroeconomic Indicators for South Africa

Figure A6.1: *Real South African GDP Growth Rate*



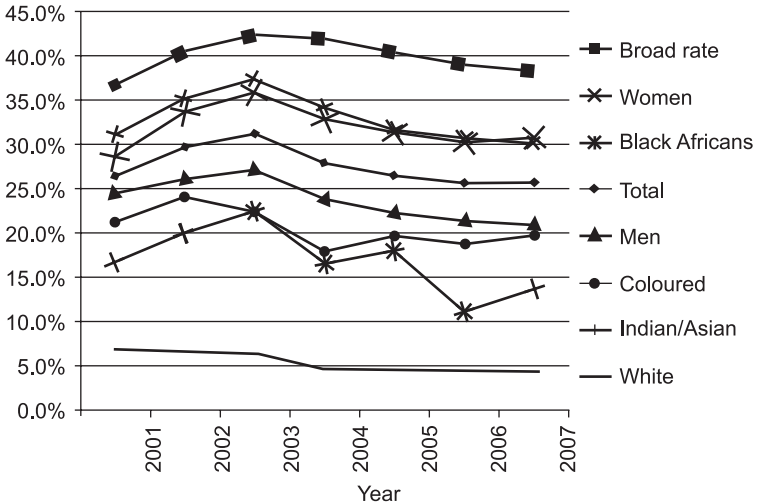
Source: Maharajh (2011: 244), http://www.indexmundi.com/g/g.aspx?c=sf&v=66 (accessed 2 December 2011).

Figure A62: *South African GDP Per Capita (PPP US$)*



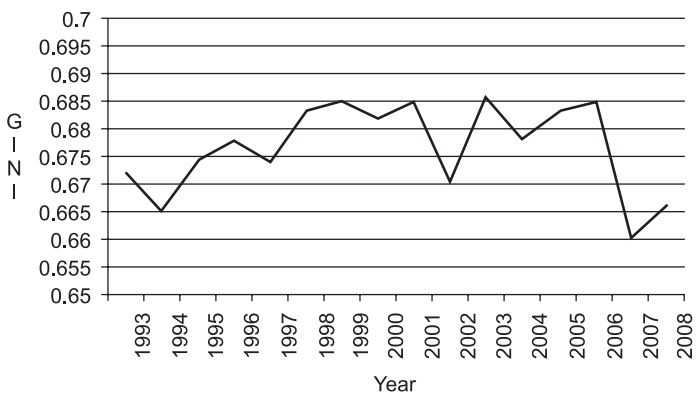
Source: RSA, 2005b and RSA, 2011, http://www.indexmundi.com/g/g.aspx?c=sf&v=67 (accessed 2 December 2011).

Figure A6.3: *South African Unemployment Rates (2001–2007)*



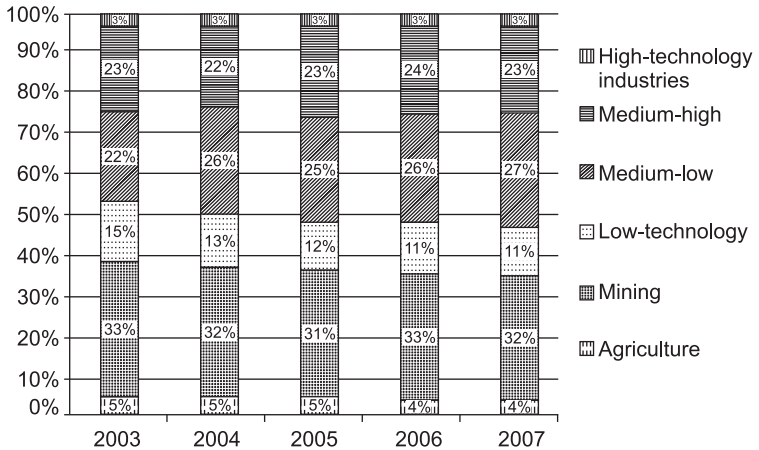
Source: Maharajh and Pogue (2008: 33).

Figure A6.4: *Income Inequality in South Africa: Gini-coefficient*



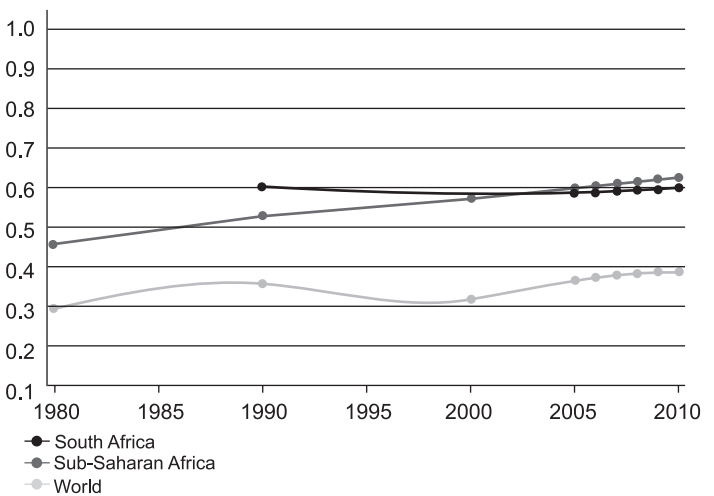
Source: RSA (2010).

Figure A6.5: *Composition of Exports, 2003–2007*



Source: Maharajh and Pogue (2008:18).

Figure A6.6: *Comparative HDI Trends*



Source: UNDP (2011).

Table A6.1: *Composition of South African GDP by Sector*

Industry	*Relative Size 2010 (per cent)*
Agriculture, forestry and fishing	2.2
Mining and quarrying	5.5
Manufacturing	15.3
Electricity, gas and water	1.9
Construction	3.2
Wholesale and retail trade, hotels and restaurants	11.9
Transport, storage and communication	9.1
Finance, real estate and business services	21.0
General government services	13.7
Personal services	5.6
Total value added	89.4
Taxes less subsidies on products	10.6
GDP at market prices	100.0

Source: Statistics South Africa — Statistical Release P0411 (Table D).

Table A6.2: *Percentage contribution to South African Industrial Output by Sector and Province (2010)*

Industrial Sector	*Province*								
	W. Cape	North West	Mpumalanga	Limpopo	KZN	Free State	Gauteng	E. Cape	N. Cape
Primary industries	3.7	32.7	26.4	29.7	5.7	19.6	3.8	1.9	32.2
Mining and quarrying	0.2	30.7	23.6	27.2	1.9	13.6	3.4	0.4	26.2
Secondary industries	19.9	9.2	21.2	8.3	23.1	14.9	22.4	17.1	7.3
Manufacturing	13.0	4.9	12.6	2.6	16.8	9.4	15.0	12.6	2.3
Tertiary industries	67.1	48.6	43.0	52.6	62.0	58.0	64.4	71.5	51.0
Wholesale and retail trade; hotels and restaurants	15.7	10.3	9.7	10.3	13.6	11.4	13.2	13.7	10.8

(*Cont.*)

(*Cont.*)

Industrial Sector	*Province*								
	W. Cape	North West	Mpumalanga	Limpopo	KZN	Free State	Gauteng	E. Cape	N. Cape
Finance, real estate and business services	27.8	11.9	11.4	14.3	17.7	14.7	23.0	18.9	12.5
Community, social and other personal services	5.5	7.9	5.4	4.8	6.1	11.6	4.5	10.8	8.8
General government services	10.0	11.7	10.0	17.1	13.3	14.0	16.5	21.0	12.3

Source: Statistics South Africa — Statistical Release P04411 (Table I).

Annexure B: Selected Human Capital Indicators

Figure B6.1: *Demographics of Research Personnel*

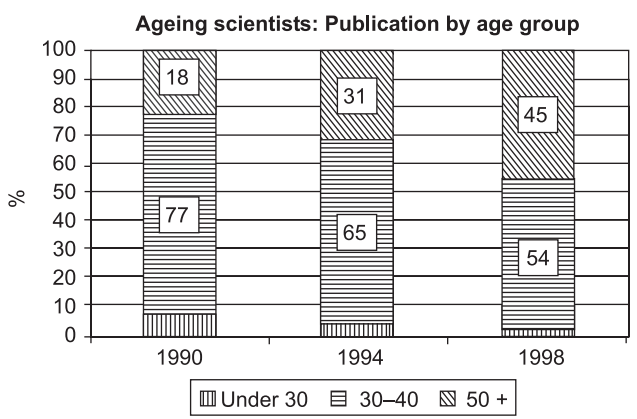
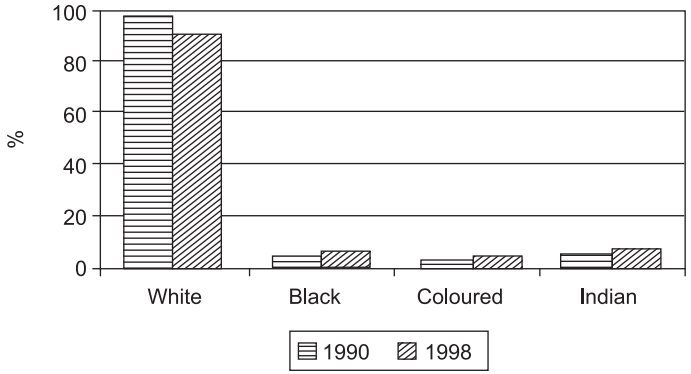


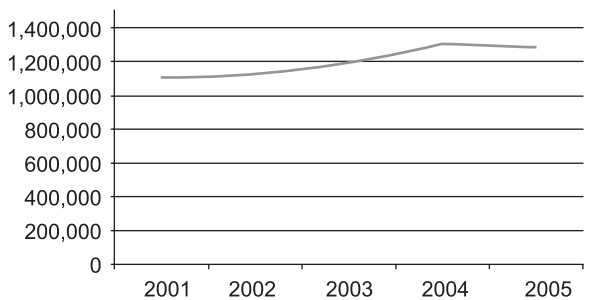
Figure B6.2: *Scientific Publication by Race*



Source: RSA (2002a: 53).

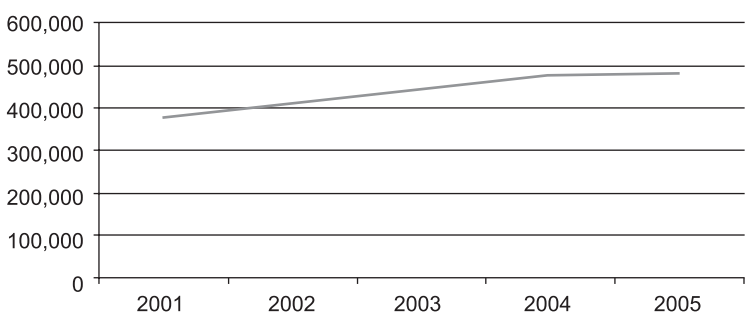
Annexure C: HEI Enrolments

Figure C6.1: *Total HEI Enrolments in South Africa*



Source: Maharajh and Pogue (2008: 56).

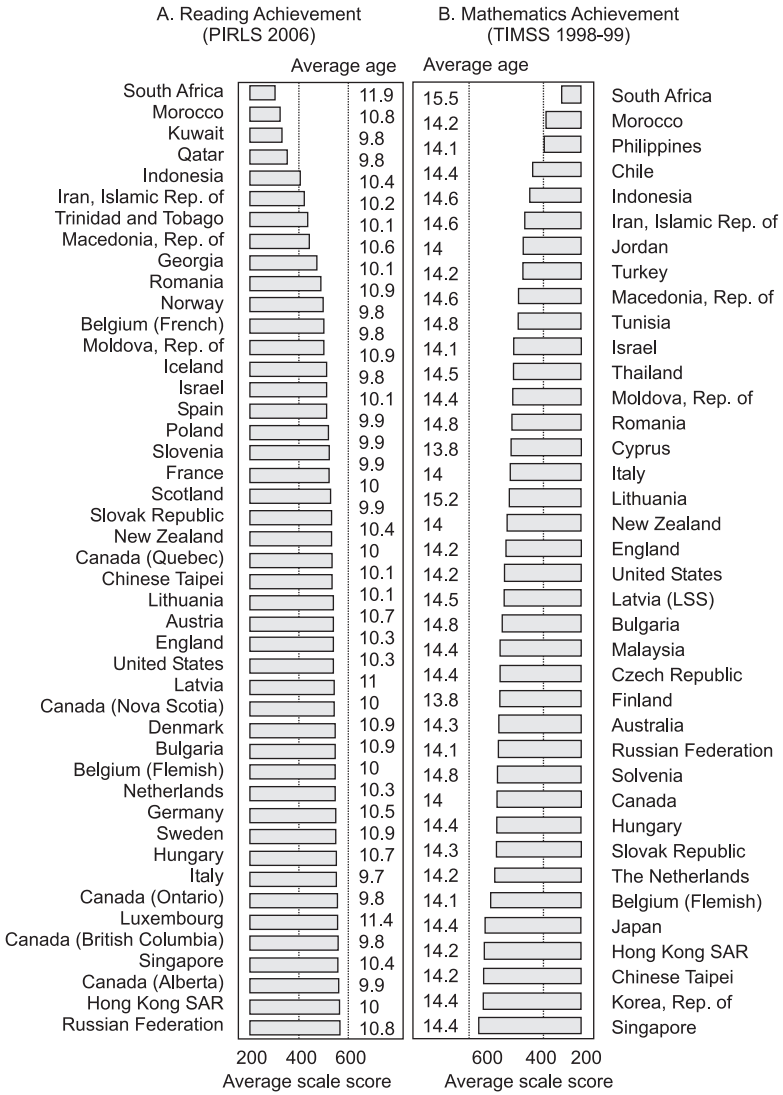
Figure C6.2: *Contact HEI Enrolments in South Africa*



Source: Maharajh and Pogue (2008: 56).

Annexure D

Figure D6.1: *International Tests of Scholastic Achievement*



Source: International Association for the Evaluation of Educational Achievement (IEA), Progress in International Reading Literacy Study (PIRLS) 2006 and IEA, Trends in International Mathematics and Science Study (TIMSS), 1998–99, in Barnard (2009).