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The role of government in developing the biotechnology industry: a South African perspective

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Biotechnology has been identified as one of the key sectors for future economic growth in many countries, with South Africa being no exception. Consequently, the South African government introduced the National Biotechnology Strategy (NBS) in 2001 to modernise the government's biotechnology institutions and to develop the biotechnology industry, given a changing political and technical environment. An important product of the NBS was the establishment of biotechnology regional innovation centres (BRICs) in 2002, which aimed to develop and commercialise the biotechnology industry. The BRICs, however, were effectively replaced by the creation of the Technology Innovation Agency (TIA) in 2008, which also formed part of the 10-year plan of the Department of Science and Technology (DST). The TIA's aims are to develop South Africa's ability to convert local research and development (R&D) into commercial products and services. This paper will explore recent changes in the role of the South African government in its attempts to support and develop the biotechnology industry.

Introduction

Many countries have recognised the importance of biotechnology as a potential driver of economic growth in their economies (see, for instance, Poon and Liyanage, 2004). In addition, the biotechnology industry has been identified as having considerable potential to improve the quality of life and business efficiency in regions and nations (ITC, 2012). Given biotechnology's threefold potential for increasing economic growth, market dynamism and levels of innovation, it comes as no surprise that this highly scientific industry is viewed as a key instrument to advance economic development by researchers and policymakers around the world (Trippl and Todtling, 2007).

Consequently, the South African Department of Science and Technology (DST) introduced the National Biotechnology Strategy (NBS) in 2001 to modernise the government's biotechnology institutions and to develop the biotechnology industry given a changing political and technical environment. An important product of the NBS was the formation of biotechnology regional innovation centres (BRICs) in 2002 to develop and commercialise the biotechnology industry. The BRICs, however, were effectively replaced by the Technology Innovation Agency (TIA) in 2008, which also formed part of the DST's 10-year plan. The TIA's aims are to develop South Africa's biotechnology industry's ability to transfer local research

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and development (R & D) into commercial products and services. This paper places the South African biotechnology industry in historical context; it explores and highlights recent changes in the role of the South African government in the development of the biotechnology industry via BRICs and the TIA.

Defining the role of government in innovation systems

Few would disagree that an appropriate governance framework is important for sound public decision making in scientific and technological development, as well as for promoting innovation. Indeed, this is recognised by the South African government as the TIA notes that its main mandate is '… to support and enable technology innovation … to achieve socio-economic benefits and enhance South Africa's global competitiveness' (Technology Innovation Agency, 2012a, p.8; also see Technology Innovation Agency, 2011). An innovation system governance structure can be defined as the institutions, structures and procedures that government implements to promote innovation and the provision of incentives to agents within the biotechnology industry, as well as the rules and structures that govern the interaction amongst the different role-players (Hartwich *et al*., 2007). In other words, the governance framework for innovation systems reflects the institutions that policymakers have developed which are supposed to foster and stimulate the creation and dissemination of knowledge and technologies in a country or region (Hartwich and Jansen, 2007). Importantly, such hierarchies and programmes must consider stakeholder needs since any government intervention in the biotechnology industry is likely to fail if stakeholders are ignored.

Additionally, the level of centralisation of the governance framework for innovation systems also matters. In several countries, the governance of innovation systems is more centralised, with high levels of departmentalisation and political administration sectoralisation, as well as low levels of interaction, exchange and co-operation among various government departments and other government biotechnology institutions. However, evidence from developed countries reveals that a decentralised approach might be more effective. Some researchers argue that a governance framework for innovation systems should rely less on centralised control and reporting systems and more on flexible, decentralised management practices as the latter framework is more likely to incentivise biotechnology industry role-players (Hartwich *et al*., 2007). However, it should be noted that, no matter the level of centralisation/decentralisation, institutional leadership and political will are key for any governance framework to have a significant, positive impact. Broadly speaking, the South African government's biotechnology institutions used to be described as relatively decentralised, with an emphasis on regional rather than centralised, national structures. However, recent developments have seen a more centralised approach.

The South African biotechnology industry

Background

The Republic of South Africa is the most southern country on the African continent. The Republic is bordered by five other countries (Botswana, Namibia, Mozambique, Swaziland and Zimbabwe) while the Kingdom of Lesotho is an independent nation surrounded by South Africa. Over the past two decades, South

Africa has faced radical political changes. It has changed from a nation isolated because of political, international trade and other embargoes of the apartheid regime to an emerging world economy following the 1994 elections. During the apartheid political regime, local scientific and technological capacities were encouraged and developed in politically strategic sectors, such as the textile, mining and arms industries. These industries received much attention from government, while new, science-based industries, such as biotechnology and nanotechnology, received less government support (Motari *et al*., 2004; Akermann and Kermani, 2006a; Cloete *et al*., 2006; Gastrow, 2008).

However, South Africa already had highly developed institutions in medicine. One frequently used example of South Africa's excellence in medicine is the first human heart transplant performed by Christiaan Neethling Barnard at the Groote Schuur Hospital in Cape Town in 1967 (Akermann and Kermani, 2006a, 2006b; Al-Bader *et al*., 2009). Even that scientific feat did not prompt more support for biotechnology from the apartheid government. The apartheid government started to show an interest in biotechnology during the late 1980s, but the field attracted government attention only after 1994 (Gastrow, 2008).

In 2001, the DST launched the National Biotechnology Strategy (NBS), promoted as the key policy driver to build a biotechnology hub. One of the goals of the NBS was to encourage the development of biotechnology knowledge, skills, capacities and tools in South Africa (Gastrow, 2008). Consequently, between 2004 and 2007, government allocated R450 million for biotechnology development (Louet, 2006; Al-Bader *et al*., 2009). The NBS also benefited from an international review of management of biotechnology activities, concluding that:

- a dedicated agency was needed to champion biotechnology development in South Africa;
- such an agency would be required to manage relevant activities to ensure coherence between programmes;
- science and technology capabilities must be built and strengthened, specifically targeting human resource development;
- investment in the biotechnology industry must focus on commercial biotechnology products and processes locally and internationally (Wolson, 2005).

In response to these findings, the South African government aimed to encourage greater movement from research activities to commercialisation by encouraging public–private partnerships (PPPs) between local and international actors, and by creating biotechnology regional innovation centres (BRICs) (Cloete *et al*., 2006). Several other economic and legislative initiatives were also planned to stimulate biotechnology start-ups and investment. For instance, the 10-year plan (2008–2018) developed by the DST regards the biotechnology sector as a priority sector and has initiated programmes such as Farmer to Pharma [see Gastrow (2008) for more information] to promote the biotechnology industry. The government also enacted the Intellectual Property Rights from Publicly Financed Research and Development Act, 2008 to allow researchers to utilise intellectual property derived from publicly financed R & D. Another stated aim of this legislation is to create a national intellectual property management office, an intellectual property fund and also to make provision for the creation of technology transfer offices (TTOs) at universities and public research organisations (PROs) (Republic of South Africa, 2008a).

South African biotechnology institutions

Initially, the South African national biotechnology institutions, under the leadership of the Department of Science and Technology, could be sub-divided into two categories, namely, regional instruments and national instruments that include the National Bioinformatics Network (NBN), the National Innovation Centre for Plant Biotechnology (PlantBio), and the Public Understanding of Biotechnology Institute (PUB) as shown in Figure 1.

Regional instruments (BRICs) BRICs, together with two life sciences incubators called eGoliBio in Johannesburg and Acorn Technologies in Cape Town,[1] were created through the Godisa Trust in 2002.[2] The objective of the BRICs was to facilitate and support biotechnology innovation and commercialisation and some argue that these organisations have been the most important public tools in the development of private biotechnology activity (Al-Bader *et al*., 2009).

At the outset, there were three biotechnology innovation centres, specifically the Cape Biotechnology Initiative in the Western Cape, the East Coast Biotechnology Consortium (EcoBio, operating under the trade name of LIFElab) in Kwazulu Natal, and the Biotechnology Partnership for Africa's Development (BioPAD) in Gauteng province (see Table 1). The BRIC institutions had different areas of interest: Cape Biotechnology and LIFElab focused on human health biotechnology research and development, while BioPAD concentrated on several areas, including biotechnology research and development in the agriculture, mining and environmental fields. It is important to note, however, that the BRICs now operate under the auspices of the TIA (Technology Innovation Agency, 2012a).

The Cape Biotechnology Initiative was incorporated as a company in 2002 (Pouris, 2008) to invest in the development of a biotechnology economy by focusing on five selected areas: (i) nutraceuticals from biotechnology processes; (ii) drug delivery; (iii) point of care diagnostics; (iv) combination and conjugate vaccines; and (v) high throughput bio-prospecting (DST, 2006). LIFElab was incorporated as a trust in 2002 (Pouris, 2008). Its main aims are to promote economic growth in the biotechnology sector and to improve the quality of life in the East coast region. LIFElab also provides venture capital to projects that advance biotechnology growth in bioprocessing and research into infectious diseases, such as malaria, HIV/AIDS and TB (DST, 2006).

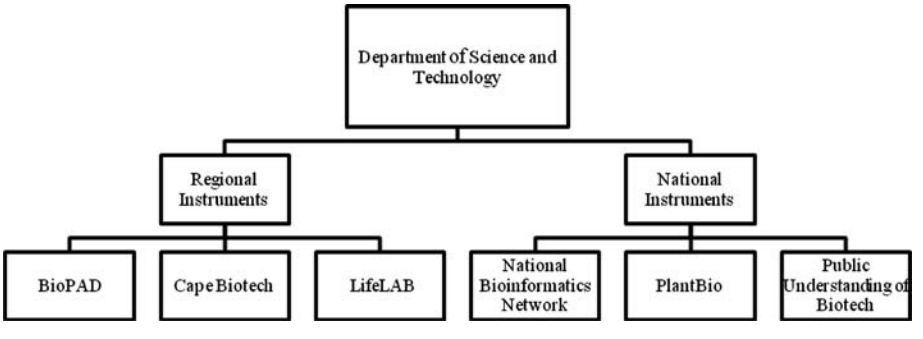

Figure 1. The South African government's biotechnology landscape prior to the establishment of the TIA

Table 1. Biotechnology regional innovation centres (BRICs) in South Africa

BRICs	Location	Aims
Cape Biotech	Black River Business Park, Cape Town	Industry development and capacity creation, distribution and managing government funds by investing in projects with potential in human health
LIFElab	East coast region	The two primary programme areas are human health and bioprocessing
BioPAD	The Innovation Hub Science Park, Pretoria	To promote industrial sector growth via process and product development; to improve mining competitiveness; to rehabilitate damaged environments or to prevent adverse environmental effects through the use of biotechnology

Source: Akermann and Kermani (2006a).

With funds from DST, BioPAD was created in 2002 as a national innovation and support centre. For control purposes, these funds are administered by a trust. The overriding goal of BioPAD is to develop biotechnology companies and stimulate economic growth by acquiring equity in companies in exchange for financial assistance (Pouris, 2008). BioPAD's investments focus on areas related to animal health, human health, as well as the industrial, mining and environmental biotechnology fields. By the end of 2006, the centre's investment in research projects approached R200 million.

National instruments Prior to the establishment of the TIA, three national instruments were used to promote and develop the biotechnology industry. The National Bioinformatics Network (NBN), located in Cape Town, was incorporated as a trust. NBN was established to assist in the development of human resources, computing skills and facilities, networking, teaching, training and laboratory facilities within the bioinformatics field (Pouris, 2008). The NBN was dissolved in 2008, in part because of lack of funding. PlantBio was established in 2004 and was also incorporated as a trust (Pouris, 2008). PlantBio focuses on an array of areas, such as food security and poverty alleviation, *in vitro* propagation, marker assisted and conventional breeding, biocontrol and biofertilisation, as well as plant transformation (DST, 2006). PlantBio has been absorbed as part of the TIA.

An initiative started in 2003 by the South African Agency for Science and Technology Advancement (SAASTA) is the Public Understanding of Biotechnology (PUB) programme. SAASTA, an arm of the National Research Foundation (NRF), was chosen by the DST (which funded the project) as an implementing agency. PUB was established to endorse and proclaim the potential of biotechnology as a contributor to economic development. In addition, PUB is also seen as a possible forum for deliberation on current and potential future applications of biotechnology (Public Understanding of Biotechnology, 2012). Interestingly, PUB is operating under the auspices of the DST and has not been absorbed by the TIA. All of these institutions were intended to play a vital role in stimulating and commercialising biotechnology by supplying finance, business infrastructure and advice. Above all, they were supposed to assist biotechnology firms to grow and eventually become settled, established firms.

Establishing the Technology Innovation Agency and its key contributions

The TIA Act was enacted in 2008 (Republic of South Africa, 2008b) and the creation of the TIA was planned to coincide with the inauguration of the DST's 10-year plan (Tektique, 2012). In the main, the TIA is involved in several fields, namely industrial biotechnology, agriculture, health, mining, energy, advanced manufacturing technologies, and information and communication technologies (Technology Innovation Agency, 2012a) and is a single public agency that was formed from a merger of seven DST-funded organisations – Tshumisano, LIFElab, BioPAD, PlantBio, Cape Biotechnology, the Innovation Fund and AMTS (Advanced Manufacturing Technology Strategy) (Msomi, 2009; Technology Innovation Agency, 2012a). The TIA has a central and a regional component. The TIA central component's functions are to: (i) develop national strategy; (ii) plan oversight and governance (including risk management); (iii) provide regional support and coordinate all TIA functions; and (iv) approve funding and manage an executive investment portfolio (see Figure 2).

On the other hand, the TIA regional component focuses on strategy execution and implementation in the various provinces. It is responsible for corporate strategy execution, developing regional partnerships and other linkages, developing technology nurseries, acting as the main client interface and for providing advisory services. Another important function of the TIA regional component is to identify and assess opportunities, which are then referred to the TIA central component for funding. Lastly, the TIA regional component also manages funded projects (Msomi, 2009).

Together with private sector partners, the TIA aims to improve the country's ability to transform local research and development (R & D) into successful, commercial products and services (Naidoo, 2009). In addition, the agency provides services, such as innovation financing, which incorporates several stages of funding over the life cycle of a start-up biotechnology firm for the development of commercially-viable, technology-based goods and services; technology development, including technical and advisory services; promotion of domestic and foreign investment linkages; technological and enterprise expertise and capacity-building; and institutional and human capital development. The TIA's income for the 2011/12 year was R504 million, significantly less than the income for the 2010/11 financial year, which was more than R606 million (Technology Innovation Agency, 2011, 2012a).

The key objectives and functions of the TIA are to create a platform to connect the formal knowledge base (R & D) and the real economy (commercialisation of R

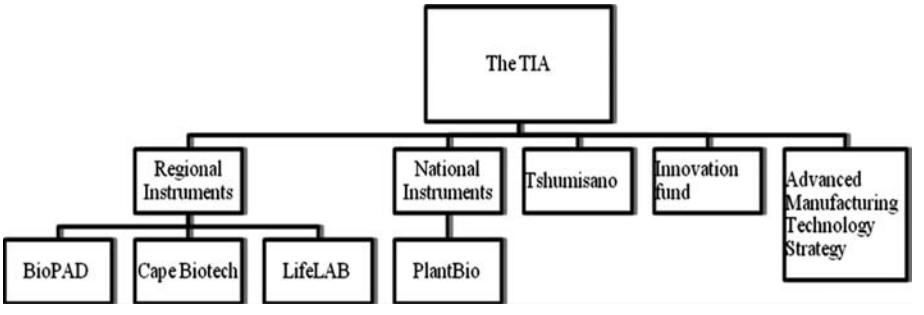

Figure 2. The seven integrated institutions of the TIA

& D into goods and services); encourage the development of technology-based products and services; encourage the development of both public and private technology-based enterprises; grow a large technology base for the South African economy; offer an intellectual property protection support platform; encourage investment – including through facilitating venture capital and foreign direct investment (FDI) in R & D; and to develop human capital for the biotechnology industry and innovation fields (Naidoo, 2009).

The TIA considers itself an organisation that is addressing market failure and aims to connect various role-players and to establish institutional linkages along the innovation value chain. Consequently, the TIA concentrates its financial and non-financial support in the gap between role-players, the so-called 'innovation chasm' (Msomi, 2009). The South African innovation chasm is composed of three distinct components: a funding support gap for innovation and product development; a cultural gap between developed countries and developing countries; and a capacity gap in human capital for innovation (Naidoo, 2009). If the TIA is successful in bridging the South African innovation chasm, the country could see a substantial improvement in the development of the biotechnology industry. One area of concern is that the new TIA structure may be too centralised (Hartwich *et al*., 2007). However, an in-depth study would be required to determine whether the TIA is really more centralised than previous structures.

The current state of the biotechnology sector in South Africa

Compared with developed countries, the biotechnology industry in South Africa is still small and underdeveloped. According to the *National Biotechnology Audit* (DST, 2008), there are 78 'active' biotechnology companies in the country, of which 38 are 'core' biotechnology companies.[3] A core biotechnology company's

Table 2. Core and biotechnology active companies in South Africa

Characteristics	Core biotechnology companies	Active biotechnology companies
Number of companies	38	78
Location	Gauteng 43%, Western Cape 30%, KwaZulu-Natal 19%, rest of SA 8%	Gauteng 43% Western Cape 26%, KwaZulu-Natal 12%, rest of SA 19%
Spin-offs	Companies: 16 (from universities: 44%, from government: 31%)	Companies: 25 (from universities: 28%, from government: 36%)
Foreign owned	Companies: 5	Companies: 12
Number of employees (2006)	765	72,844
Products	559	1542
Profits (2006)	R520 million	R767 million
R & D expenditure	R76 million	–
Fund raised (2003–2006)	R216 million	–
Major funding sources	BRICs: 36%; innovation fund: 19%	–

Source: DST (2008).

Table 3. TIA investments in health biotechnology

iThemba Pharmaceuticals (Pty) Ltd	A research based drug discovery company located in Modderfontein. The company's mission is to champion world-class drug discovery and development of new treatments for infectious diseases such as HIV/Aids, malaria and tuberculosis
DISA Vascular (Pty) Ltd	A medical devices company that specialises in vascular technology for the treatment of coronary artery disease. The company has been developing stents for the international market since its inception in 1999
African Clinical Research Organisation (SOC) Ltd (ACRO)	ACRO is the first South African, full-service, contract research organisation to provide a range of clinical trial management and monitoring services to help clients develop interventions and negotiate the path from conception and discovery through to the clinic and market
Altis Biologics (Pty) Ltd	Altis Biologics is a regenerative medicine development company focused on developing and bringing to market new biomaterials and regenerative biological products with a particular emphasis on orthopaedic and dental tissue regeneration. Altis Biologics is a start-up biotechnology company that uses animal tissue to fabricate biocompatible bone graft replacements for use in human skeletal reconstruction
Southern Access Technologies	A start-up biotechnology enterprise that is currently developing a heart valve deployment device which will allow insertion of new synthetic heart valves by using a catheter without need for open heart surgery
Endogrowth	Endogrowth was supported with an investment through the idea development fund for the development of a prototype laparoscopic device used to grab and remove tissue during laparoscopic surgery
Other TIA investments	Two new health technology products were developed with TIA funding Geoaxon's Kuduwave Audiometer was developed and given regulatory approval. This product enables hearing tests to be performed without the use of soundproof booths which increases access to hearing tests, especially in rural areas Custommed Orthopaedics completed an implant guidance system for use in shoulder and hip replacement surgery. Plans are underway to launch the product in southern Africa and Australia TIA continues to co-fund a feasibility study on Tenofovir Gel Microbicide for the prevention of HIV infection in women. TIA is providing R1 million for the study, and the remaining R9 million will be funded by the IDC and Cipla Medpro. The study is scheduled to take 12 months, resulting in a detailed business plan and budget for the registration, manufacture and distribution of the gel

Source: Authors' own construction based on TIA (2012a, 2012b).

major economic activity is within the biotechnology field and uses a minimum of one biotechnology-related technique, whereas an active company either manufactures and sells biotechnology products or performs R & D in the biotechnology

Table 4. TIA investments in agricultural biotechnology

Nguni Cattle	Develops embryo transfer technology for the removal of an embryo from a cow of superior genetics in order to transplant the embryo into the reproductive tract of a cow of average genetics
X Sterile Insect Technique (Pty) Ltd	The company uses an environmentally friendly technology to provide control of false codling moth in citrus, pomegranates and various deciduous varieties. This technology has significantly reduced the use of toxic organophosphates and some other insecticides that were commonly used to control these insects
Biogold/Citrogold (Pty) Ltd	The company forms part of an international network of companies that specialises in the development and management of intellectual property in horticultural products. Additionally, the company offers a one-stop platform for innovators in horticultural research to the commercialisation of their new products. Citrogold is the South African arm of the operation

Source: Authors' own construction based on TIA (2012b).

field. Active firms employ more people than core firms: the total number of employees in the former is more than 72,800 compared with only 765 people employed in the latter. The revenues of active firms reached R767.6 million in 2006, up from R624.4 million in 2004. In contrast, the turnover for core firms was R520 million in 2006 (see Table 2).

The TIA has also invested in several companies, organisations and technology platforms. Principally, the TIA invests in companies and organisations that are involved in health, agricultural and industrial biotechnology, and most of the technologies in question are close-to-market technologies. Table 3 shows the investments by the TIA in companies that develop health biotechnology, whereas Tables 4 and 5 show similar investments in the agricultural biotechnology and industrial biotechnology fields, respectively. The tables also provide a brief overview of some of the companies' activities.

As can be seen in Tables 3–5, the TIA has invested in several biotechnology organisations and companies. Note, however, that the success of these investments has not been evaluated in this paper. The TIA has been actively investing in several technology platforms as a means of developing the biotechnology industry in South Africa. Table 6 shows some of the investments the TIA has made in this area.

Discussion and concluding remarks

Countries around the world have developed programmes and incentives to foster the development of biotechnology, an industry identified as a potential driver of economic growth. As a result, the argument for governments to become involved in the biotechnology industry by developing strategic plans, promoting and developing the biotechnology industry has grown stronger over time. In particular, governments can assist the development of the biotechnology industry by investing directly in, and providing investment incentives for, technical, physical and knowledge infrastructure, by fostering collaborations between various stakeholders to strengthen innovative capacities.

Table 5. TIA investments in industrial biotechnology

Food and Cosmetic Technologies cc (FaCT)	The company is based in KwaZulu Natal and is actively involved in the application of technologically advanced nutraceutical ingredients and food products that will meet the nutritional needs of consumers. One of the products that has been developed by the company is the low glycemic index sugar (a sugar blend with a lower glucose level than standard sugar) that would lead to a natural and safe alternative to existing products available for diabetics and health-conscious consumers
Nguni Juice cc	Nguni Juice commercialises value added products from indigenous fruits and plants. The company is involved in developing a proprietary process for the processing of a beneficial wild fruit from indigenous southern African trees to produce a variety of unique caffeine-free natural energy drinks high in a variety of vitamins, minerals and essential amino acids
Enzyme Technologies (Pty) Ltd	The company was established to use waste from the stems of the pineapple. The main aim of the company is to produce a high quality and high activity stem bromelain with a long shelf-life that will make it a market leader in its field
Fermentation Technologies and Innovation (Pty) Ltd (FermTech)	FermTech strives to be a leading biotechnology company focused on the development and production of biosimilars. The company has developed proprietary fermentation and protein purification technologies, as well as the necessary expertise and human capital for the company to be recognised as a leading manufacturer of high-value low-volume recombinant biological products in the African continent
Quorus Biotechnology	A start-up company focusing on increasing the production of high-value compounds to meet increased demand in the flavourant market

Source: Authors' own construction based on TIA (2012a, 2012b).

There is little doubt that the South African national system of innovation has developed a substantial repository of local and international knowledge. Unfortunately, this knowledge is evident mainly in academia and has not been translated into viable products and services. There are several constraints. These include poor access to adequate financing (and particularly seed and first-stage financing), market inefficiencies, a relatively weak and uncoordinated intellectual property rights framework, as well as weak institutional coordination and alignment within the national system of innovation (Naidoo, 2009).

As a result of the above-mentioned constraints, government has decided to integrate interim support institutions, such as BioPAD and PlantBio, into the TIA. The government has also made a sizeable financial investment in the TIA. However, it is not clear at this stage whether the investment will be sufficient to allow South Africa to compete with other emerging markets in the biotechnology field. Few will dispute that the South African government has taken steps in the right direction and that more is currently being done to promote the development of the South African biotechnology industry than ever before.

Table 6. TIA technology platform investments

Platform title	Platform description
Bioprocessing platform	The bioprocessing platform promotes economic growth in the biotechnology sector by providing enabling resources in product development, infrastructural and technical support. The platform provides an environment which promotes the development of capacity in industrial biotechnology, as well as the development of new products and services
Institute for Diagnostics Research (IDR)	IDR has developed two unique monoclonal antibodies for use against malarial pfLDH that can be marketed to customers. The antibodies were tested in-house on an ELISA and immunochromatographic tests. Both antibodies recognised the recombinant LDH protein as well as the native antigens in malaria-positive samples obtained from the University of Pretoria and the Gambia. IDR has successfully established small to medium scale *in vitro* production of mAbs
National genomics platform	Provides high-throughput sequencing services
Biosafety platform	Coordinates, facilitates and conducts risk assessments for biotechnological products
Centre for Proteomic and Genomic Research (CPGR)	Provides services in the fields of genomic and proteomic research. TIA invested R9.1 million in CPGR, situated in Cape Town. CPGR works with higher education institutions and industry clients, such as Sasol, Protechnic (South African national defence force) and GlaxoSmithKline
Drug Discovery and Development Centre (H3-D)	Provides services in the field of drug discovery through access to resources. TIA and the medicines for malaria venture concluded a 50% co-funding agreement of the H3-D platform at the University of Cape Town, totalling R2.5 million per year over four years for drug discovery and development. The platform undertakes collaborative research with iThemba Pharmaceuticals and other universities in malaria and tuberculosis
Metagenomics platform	Aims to develop human capital and to produce products from extreme environments for commercial exploitation using modern genetic and microbiological technologies. The TIA-funded metagenomics platform (valued at R2.5 million) at the University of Free State offers bioremediation services to the mining industry to assist in the treatment of acid mine drainage
Bioprospecting platform	The main aim of this platform is to determine the effectiveness of the compound to inhibit/impede HIV replication in the laboratory as well as to determine its safety using different experimental models
Metabolomics platform	Aims to develop relevant animal models to study changes in metabolism under different states and bioinformatics analysis tools for metabolomics
WDDAP commercialisation	Conducts research in the area of rate-modulated drug delivery product design, development and evaluation, with particular focus on the development of innovative polymeric devices capable of controlling the rate of drug delivery, sustaining the duration of therapy and/or targeting delivery of a drug to a specific organ or tissues, while maintaining blood concentrations within therapeutic limits

Source: Authors' own construction based on TIA (2012a, 2012b).

Notes

1. Acorn Technologies merged with Cape Biotechnology in 2009.
2. Now known as SEDA, the Small Enterprise Development Agency.
3. The data presented here are from the latest, audited and publicly available survey. DST completed another survey in 2011, but the results from the 2011 survey are still not publicly available.

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