Building Science Systems in Africa: Conceptual Foundations and Empirical Considerations

Edited by Rebecca Hanlin, Aschalew Demeke Tigabu and Gussai Sheikheldin

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Science Councils and Financing of Research, Development and Innovation in Africa

Julius Mugwagwa
Geoffrey Banda

Abstract

The African Union's Agenda 2063, supported by the Science, Technology and Innovation Strategy for Africa (STISA-2024), advocates for economic development that leverages the knowledge-based economy and especially the potential of STI in upgrading industrial activities. It is incontestable that research is fundamental for contextualized generation of new knowledge, adopting and adapting existing innovations and knowledge, and their application to Africa's economic and human developmental needs. African countries' innovation ecosystems that support the aforementioned goals, and the funding of research and STI through science granting councils (SGCs) and other actors, are critical. This chapter discusses three key issues on the funding of STI and research: first – how Africa has historically funded STI and the reasons behind adoption of certain approaches; second, the shortcomings of historical and current funding models; and third, innovative funding models from the continent and elsewhere that can be adopted to accelerate local research and innovation activities.

Adopting a historical and contemporary approach, the chapter explores how private and public actors across Africa can play a significant role and imbue resilience in financing research and innovation. The chapter also explores various strategies and measures research organizations use to align their activities with national development policies.

Introduction

Science, technology and innovation (STI) are undeniably key drivers of change (Cliff, 2010) and have been proffered as a key component of positively impacting African countries' economic growth, national and international competitiveness, as well as accelerating industrial development. The socio-technical imaginaries projected by policymakers revolve around new technology and innovation adoption leading to transitions in: economic and industrial structures; nature and form of employment; impact on people's livelihoods; and food and health security while protecting citizens from current and emerging technology and social risks. We adopt Jasanoff and Kim's (2015) description of socio-technical imaginaries as the notion or conceptualization of collectively held and projected visions of anticipated and wanted futures that are operationalized through STI ventures. Policymakers at national, regional and even continental levels shape these socio-technical imaginaries through policy and practice as well as operationalize them by allocating resources to their realization. Solving the wicked problem of realizing these socio-technical imaginaries hinges upon understanding the complexity of applying context-specific knowledge that applies social, applied and natural sciences, among other fields, to solve the economic and industrial development needs of African countries. We argue that research and innovation in these and other areas is critical in generating Africa-contextualized knowledge that supports evidence-based policy making, generates political legitimacy, acceptance of new technologies and innovations, while at the same time managing new risks that come as societies industrialize. Inevitably, this requires coordination and collaboration of activities by actors in academia, business, government and other sectors. SGCs as boundary-bridgers, boundary-brokers and collaborators (Cash, 2001; Pohl, et al., 2010; Guston, 1999) play a significant role in mediating and extending the research-policy interface and bringing together broader research-stakeholder interface (Schut, et al., 2013). Thus, SGCs do not only function as allocators of scarce resources, but they also have a performativity role which shapes and directs the research trajectory through guided identification of areas

that researchers and innovators should focus on. SGCs hence play a role in directing and shaping knowledge and innovation generation and subsequent diffusion. If there are symbiotic and synergistic relationships with other actors and agents which support translational and commercialization activities, it becomes possible to realize the projected socio-technical imaginaries of economic and industrial development. The various interactions, relationships, governance, regulation, support, funding and collaborations of the actors in the value chains and business models constitute the innovation ecosystem.

The developmental challenges for Africa present the typical definition of the wicked problem. The wicked problem has characteristics of such magnitude of complexity – implying a problem that cannot be resolved easily but entails multiple resolutions (Rittel and Webber, 1973; Struik and Kuyper, 2017; Waddock, 2013). We acknowledge that economic and industrial development futures for African countries will face the typical wicked problem. For example, by solving the economic growth challenge through industrialization – which leverages application of new and existing technologies – there is a risk of environmental damage, which raises new risks for citizens. Thus, solving the development problem can create a sustainability, environmental and health challenge for the continent. As one problem is resolved, a new one arises which needs to be resolved, and the sequence is repeated, hence the need for local generation of knowledge, technologies and innovations that address the local issues in a timely manner. We argue that this realization calls for greater emphasis on enhancing local science systems and funding researchers and innovators. The wicked problem is extended to competition for resources for research and innovation against other social and economic development imperatives that need immediate political action. Focusing specifically on research and innovation, there is further intersectoral resource competition across diverse areas such as engineering, social sciences, health, natural sciences and other humanities. We argue that research and innovation require sustainable and innovative funding models and investments by the public, private, public-private-partnerships and charities, as well as other actors.

However, 37 years after adopting the Lagos Plan of Action, and despite consistent acknowledgement of the importance of research and innovation in the continent's economic and industrial development and improved productivity (Mugwagwa et al., 2018), numerous African countries have not met the heads of states' commitment to allocate at least 1 per cent of gross domestic product (GDP) to research and

development (R&D). Only Kenya allocated 0.8 per cent and Mali and South Africa – with 0.7 per cent of GDP – have come near the goal (UIS, 2016). Africa's low domestic investments in research and innovation in particular, and in STI broadly worsened after the 2008 global financial crisis and the subsequent 2008–2012 global recession which caused reduced budgetary allocations to R&D globally. The same situation prevailed in developed economies; for example, the EU's target to raise overall R&D investment to 3 per cent of GDP by 2010 was shifted to 2020 after the 2010 deadline was missed (UIS, 2016). The 3 per cent target was an ambitious goal as the UIS data tool shows. To date, only six countries worldwide (three in the EU: Denmark, Finland and Sweden) have managed to surpass the 3 per cent target. The leaders are Japan at 3.6 per cent, Israel at 4.1 per cent, South Korea at 4.3 per cent, while Austria, Germany and Switzerland hover around the 3 per cent target, as does the United States (UIS, 2016). In response to these challenges, countries have experimented with various approaches, institutional reforms, models and mechanisms for funding and financing research and innovation that have delivered good results. For instance, in the USA, the Small Business Innovation Research Program (SBIR) – a pre-commercial procurement scheme – was introduced in 1982 and it mandates the use of 2.5 per cent of the federal R&D budgets from all government departments and agencies with large R&D budgets to contract R&D services from SMEs (SBIR, 2020). Similarly, the Malaysian government established the Cradle Fund, a unit of the Ministry of Finance that supports the creation of an ecosystem to promote a strong and innovative business growth environment for technology entrepreneurs in Malaysia (Cradle, 2020). Africa can learn lessons from some of these programmes.

It is thus imperative that Africa also explores new approaches, sources, tools, and institutional arrangements to improve the funding of research and innovation. Ozor (2015) and World Bank (2008) argue that, to increase funding and financing opportunities for research and innovation under the current global financial crises and national cutbacks in R&D budgets, new approaches and considerations must be made. A key policy hook for increased investment in research and innovation are the Sustainable Development Goals (SDGs), which advocate for promoting research in all fields and full research capacity in all countries by 2030. Our recent work on new approaches for funding research and innovation in Africa (Mugwagwa and Banda, 2019) revealed that countries were deploying specific instruments as tools to translate R&D funding policy formulation into implementation. The possibilities span

direct funding by government, of research (whether for government labs, universities, private actors, etc.), or private R&D (through, for example, grants or procurement), to non-financial instruments such as network-based policies, and information brokerage between different actors. Many nations have tried to include a considerable component of tax incentives for private R&D, though this is currently weak in Africa, apart from South Africa.

Undoubtedly, scientific knowledge and technological innovation, among other forms of innovation such as institutional, organizational and social innovation are essential for supporting economic development, fostering social wellbeing while at the same time protecting the environment, and mitigating the effects of anthropogenic climate change. Throughout history, different types of innovations have been important forces behind both positive and negative industrial development trends. As the opportunities ushered in by STI continue to expand – riding on new frontiers in research especially in the life sciences – there is a global shift to clean growth, population mobility and aging society, and a rise in artificial intelligence and data revolution, among others. This entails dynamic changes and complexity in the practice of scientific research, and equally in the funding and governance of research and innovation at different levels. Africans are forced to play in this arena and have to grapple with late comer industrialization where stringent environmental and social standards have been imposed.

These dynamic changes call for new forms of collaboration not only among the key players around STI, namely research funders and research actors such as academia, industry, business, government and private non-profit entities, but also other players outside these sectors. This collaboration will be vital for galvanizing sectors and disciplines across economies, to obtain the best practice of science research ecosystems, funding and governance. Already, increased funding of science, research and innovation by some governments is placing a high premium on increased collaboration. For example, the UK government has committed to increase funding of R&D from roughly £9.5bn in 2016/17 to about £12.5bn in 2021/22, on the back of Grand Challenges which seek collaboration across disciplines; between universities, research and innovation bodies and businesses; and internationally. To foster these collaborations through leveraging and bringing together existing institutional capacities, the UK Research and Innovation (UKRI) was recently established as an organization mandated to spearhead mechanisms to "support the Research Councils to collectively make up

more than the sum of their parts," and develop a "smoother pathway to more applied research" (Nurse Review, 2015). Under UKRI, a Strategic Priorities Fund has been established to support multidisciplinary and interdisciplinary programmes, while an Industrial Challenge Fund has been established to bring together the UK's world leading research with business. Enhancement of integrative roles is indeed a core function of key agencies in research and innovation systems worldwide.

Through an ambitious effort ushered in by the African Union's Agenda 2063, African countries have responded to the realization that individually and collectively they will not be able to sustain current levels of economic performance and achieve SDGs without developing and implementing bold policies and programmes for STI (AAS, 2018). The African Union (AU), regional economic communities (RECs) and regional institutions such as the African Development Bank (AfDB), as well as international organizations such as the World Bank and United Nations agencies, have developed strategies and programmes to advance STI for Africa's sustainable development (AAS, 2018). At continental level, the AU launched the STISA 2024 as one of the key strategies supporting Agenda 2063. Specifically focusing on health security, the AU developed the Africa Health Strategy (AHS) 2016–2030 whose focus is developing agile knowledge, technology and innovation systems that are African-driven and address the high disease burden through targeted and systematic health systems strengthening, supported by scaled-up health interventions, inter-sectoral action and empowered communities. A key component of the Health Strategy is strategic investment in research and innovation for improved access to medical health technologies. Consequently, through the African Union Development Agency-New Partnership for Development (AUDA-NEPAD), AU developed the Health Research and Innovation Strategy for Africa 2018–2030 (HRISA 2018–2030) which was recently adopted at the AU Specialized Technical Committee on Health, Population and Drug Control of April, 2015. Aware of the importance of research and innovation funding, HRISA (2018–2030) identified one of the key seven priority interventions as "Promoting Sustained Investments and Financing Mechanisms on Research, Development and Innovation for Health".

At national level, many countries have adopted or are developing policies, strategies and implementation programmes for STI. The scientific community, through institutions such as the African Academy of Sciences (AAS), programmes such as Developing

Excellence in Leadership, Training and Science Initiative for African Scientists (DELTAS) funded by DFID and Wellcome Foundation, national academies and SGCs, have launched various programmes for promoting STI for development (Mugwagwa and Banda, 2018). Against this backdrop of an active and broad agenda for STI in Africa and drawing from recent work of the African Science Granting Council Initiative (SGCI) on new approaches for funding research in Africa, this chapter takes a historical, contemporary and forward-looking approach to explore ways through which African countries can innovatively increase and sustain funding and capabilities for STI. Among the key arguments for this chapter is that there are important lessons to draw from historical and current funding models and approaches to ensure better effectiveness and alignment of STI with national development agendas.

Historical and current funding African research mechanisms

Funding models for research and innovation are largely driven by national competitiveness and hence geared towards economic development and industrial transformation, and these are closely linked to a nation's capacity to educate, innovate, and build (Juma, 2016). In Europe, for example, the innovation principle is argued to be a critical driver of "societal prosperity and… [to be] indispensable for sustainable development and economic growth" (ERF, 2015). With African countries having signed up to SDGs, how innovation is conceptualized and operationalized requires research, especially for localization of industry and economic development strategies that are in line with SDGs.

Historical funding mechanisms

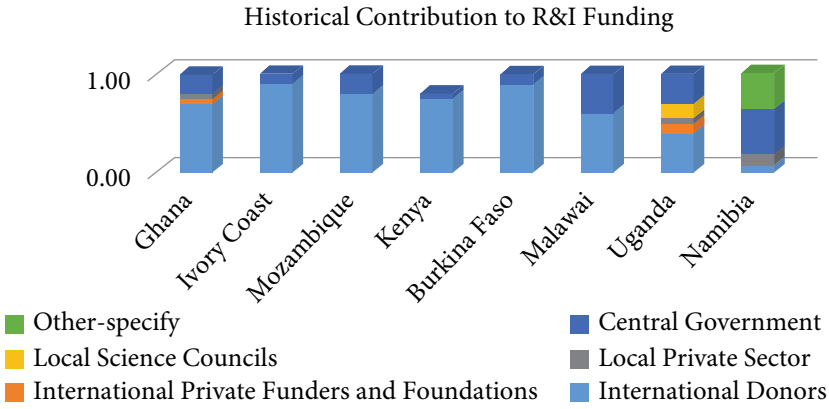
Funding research, technology and innovation for many African countries is challenging on many fronts given the impact of colonial history on industry structure, knowledge and innovation generation and appropriation locally. Colonies were set up as the periphery to supply goods to the centre, and the centre generated the innovations and knowledge that were adopted in the periphery; hence the historical low priority and scant allocation of funds to research, technology and innovation. This historical genesis informed strategies for industry structure and development, and as a result there was no purposive effort to promote grassroots technologies and innovations that would be

translated locally into commercial goods and services, with the potential for export, except for agriculture.

Agriculture was prioritized for funding compared with engineering and life sciences. Focusing on Zimbabwe, Donovan (1995), for example, highlights that prior to independence, agricultural research was under the responsibility of the Ministry of Agriculture, and in the 1970s the Agricultural Research Council was established to supplement state research. Funding for agricultural research and extension services, a key component of innovation diffusion was availed by the state. With the advent of independence in Zimbabwe, funding for agricultural research fell from 10.8 per cent before 1980 to 7.9 per cent of government expenditure on agriculture in the 1980s (Donovan (1995). However, because of the commercial farming sector, commodity research funded by producer associations increased (Jansen and Rukova, 1992). The story is similar for Malawi and South Africa where funding agricultural research and innovation was the preserve and responsibility of the state. However, in Malawi and Zimbabwe, aid agencies and donor funds played an important role in supporting agricultural research, development and training programmes targeted at small holder farmers (Donovan, 1995). The commercial sector also funded agricultural R&D. For example, commercial farmers formed a Maize Breeders Association in 1919 in modern day Zimbabwe to improve maize varieties grown in the country, building on earlier work to establish research stations in the country (Rusike and Donovan, 1995). Of importance in the funding for agricultural research was how the state linked basic and applied sciences with translational activities, which led to the local development of crop breeds adapted to local climatic conditions.

As argued earlier, colonies were destinations for manufactured goods and consequently other technologies were not prioritized for local development and translation. Data on financing research, technology and innovation in sub-Saharan Africa (SSA) dating back to the 1900s is scant. In a separate project we sought to establish sources of funds for research in the last five years (Mugwagwa and Banda, 2018). We found that historically, international donors provided up to 60 per cent, 70 per cent, 75 per cent, 80 per cent and 90 per cent of research funding in Malawi, Ghana, Kenya, Mozambique and Burkina Faso respectively in the 1990s and 2000s. International and local private sector funding played an insignificant role in funding research, technology and innovation (see Figure 5.1).

Figure 1: Historical Sources of Research and Innovation Funding (Beyond 5 Years Ago)



Source: Mugwagwa and Banda (2018)

International donors have historically been the main funders of research (see Figure 5.1) owing to the colonial history described above and the general persuasion that African countries were recipients and consumers of innovation, hence the lack of state and local private investment in research and innovation in areas outside agriculture. Unless there is strategic investment in research and innovation as demonstrated by South Africa and Kenya, which have national research foundations and government departments that support innovation, international donors will continue to play a significant role especially in life sciences. For example, the DELTAS programme underwritten by DFID and Wellcome Foundation supports emerging and senior scientists in African countries in health research, with 40 million pounds availed to support five-year research projects. These funds were used to support, for example, the West African Centre for Cell and Biology of Infectious Pathogens (WACCBIP, 2019) centre for infection and immunology at the University of Ghana where emerging African scientists are working, for example, on identifying candidates for a malaria vaccine. WACCBIP was established in 2013 as one of the centres of excellence funded by the World Bank (with USD8 million), and they have attracted funds from the African Academy of Sciences (AAS), and Alliance for Accelerating Excellence in Science in Africa (AESA) – an initiative in AAS and AUDA, Wellcome Trust and UK aid, among others. In interviews with scientists, they lamented the lack of direct government support for research, technology development and innovation and they reported

constant anxiety on the issue of sustainability with international funding especially with the financial crisis that began in 2008 and other economic challenges in the donor countries. It is evident from the foregoing that historically, some dynamic factors and actors have shaped the funding (sources and uses) of research and innovation in African countries.

Current funding mechanisms

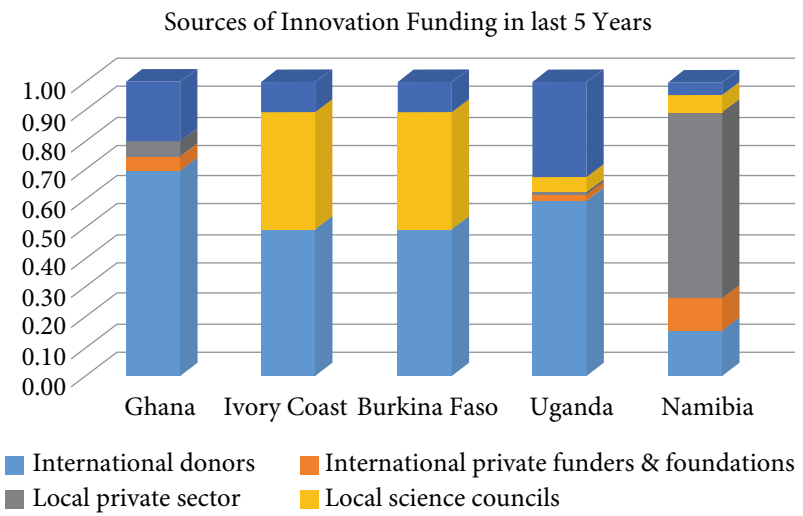
Over the years, there have been shifts in what donors, central government, science councils and other players will fund. In Ghana, the central government funding budget for research is spread as follows: 80 per cent – salaries, 10 per cent – research and 10 per cent – research infrastructure; whereas international donors support is at 70 per cent for research activities and 30 per cent for research infrastructure. The private sector on the other hand funds research activities at 100 per cent; and international private funders also cover 100 per cent for research activities (Mugwagwa and Banda, 2018). We found that although government funding may not be at the magnitude required to support large scale technology development and innovation, government programmes are an important source of funding by virtue of funding salaries and administrative functions for researchers. The second most important source of funds was multinational and bilateral donors followed by SGCs, local private sector and local NGOs. We found that government and SGCs are assuming a prominent role in funding of research and innovation.

Figure 5.2 representing funding in the last five years, shows remarkable difference from Figure 5.1 on traditional sources of funds. Ivory Coast and Burkina Faso show the significant role played by SGCs while Namibia reported a large role played by the private sector. International donors still play a large role in funding research and innovation in the countries that we surveyed (Mugwagwa and Banda, 2018). Respondents in the study preferred local funding models based on the need to ensure sustainability. However, the different countries reported that research and innovation was ranked low and some of the drivers included inadequacy of funding, difficulties in complying with funding requirements, lack of timely availability of funds, lack of national strategies and governance of research.

Despite the shift in funding sources, the greatest challenge for many SSA countries is supporting translation activities. Funding basic and applied research is a low-hanging fruit; the difficult investment is in supporting

translation activities and especially the handover from technology development and proofing to scaling up and commercialization. South Africa has made strides in creating an environment where research and innovation funded by the state in universities is supported by later stage concept proofing by institutions such as the Council for Scientific and Industrial Research (CSIR) – a national research organization established in 1945. The CSIR is funded through the Department of Science and Technology (at 30 per cent) and the balance of funding is generated from contract research activities, royalties, and licenses on intellectual property. The CSIR covers diverse industrial sectors such as Smart Mobility, Next Generation Health, Agriculture and Food, Manufacturing, Chemicals, Defense and Security, Mining, and other sectors relevant to the technological development of the country. The CSIR works closely with universities and local industry, for example, on trialing vaccine candidates. Of importance is the strategic development of an innovation ecosystem that at least spans the value chain of a technology.

Figure 5.2: Sources of Innovation Funding in the Last 5 Years



Source: Mugwagwa and Banda (2018)

Box 5.1. Diversity of research and innovation funding instruments

Government Role	Exploring	Framing & piloting	Scaling & mainstreaming	Sustaining & nurturing
Visionary	**Foresight & brokerage** Undertake or commission scoping research, host events, broker meetings	**Agenda setting** Develop policy strategy for resource allocation	**Informing and coaching** Providing how-to support via e.g. start-up hubs, innovation district services	**Science diplomacy** Engage within international networks to showcase capacity and attract inward investment
Customer	**Green papers** Commission research on emerging R&D	**Standards** Establish norms that stimulate new use of knowledge	**Procurement (new tech)** Selectively purchase early stage technologies	**Procurement (desired tech)** Support desirable yet mature technology markets
Innovation broker	**Test beds** Provide closed regulatory 'sandboxes' for safe experimentation	**Platforms and clusters** Connect researchers and users in localized networks, with virtual labs, etc.	**Public Private Partnerships** Arrange cooperative agreements with private sector	**Impact rewards** Reward impact toward desired outcomes with savings, capital investment, etc.
Funder	**Direct funding** Funding of primary research	**Direct finance** Stimulate new thinking to drive future opportunities	**Grants and subsidies** Incentivize behaviour change, such as inter-firm R&D collaborations	**Public service investment** Scale up through wider provision of infrastructure and public services
Regulator	**Self-regulation** Encourage voluntary codes	**Governance** Promote ethical standards, transparency and accountability rules	**Value protection** Safeguard intellectual property	**Compliance** Penalize uncooperative practices

Our data suggest that in addition to SGCs the state also has a performativity function that manifests in various roles (see Box 5.1); with the state as the visionary, customer, provider, funder and regulator. As the key developer of futures and socio-technical imaginaries the state sets the agenda and develops policy and science diplomacy that progresses the realization of the desired futures. In this role, the state can promote foresight and brokerage through undertaking commissioning and scoping of research and this is a function where SGCs collaborate with the state in the identification of the research theme focus for the short, medium and long term. The state, working with SGCs, can act as the consumer of knowledge, technologies and innovations through use of green papers, and commissioning of path-breaking R&D for areas where market failures cause inertia. In addition, the state can use procurement as an active industrial policy tool that forms and shapes markets by promoting state institutions to purchase new technologies from emerging enterprises.

The third function for the state is as an innovation broker, providing institutional and infrastructural frameworks and spaces for testing new technologies and innovations supported in the early stages of development by SGCs. This function as argued earlier calls for collaborative working arrangements between policymakers and SGCs to forecast new technologies in the pipeline and horizon scanning for the challenges of nascent value chains, business models and emerging or non-existent markets. SGCs usually work with industry through industry-academia collaborative grants, with the state providing regulatory and technology sandboxes for safe trial of innovative technologies. Where market failure is a significant impediment, the state can use public-private partnership to avail the material and financial resources to promote a technology or innovation where there is no incentive for the private sector to go it alone. In addition, SGCs in conjunction with the state – based on forecast research and innovation themes – can pull innovations through impact investment.

The fourth function of the state which links directly to the primary remit of SGCs is funding of research and innovation through grants managed by SGCs or an innovation institution usually managed by the state or quasi-state leadership. The state could also use R&D subsidies as market-signalling mechanisms to promote research and innovation. In addition, the state can invest in publicly-funded infrastructure that forms the backbone for basic and applied research, as well as downstream de-risking of proof of concept stage by providing be-spoke infrastructure

where innovators can trial their new technologies and innovations. This is attractive for innovators as first, it de-risks the early stages for them and signals to the market and funders the potential of the technology and innovation; and second, the entrepreneurs who are resource-poor can delay investment in infrastructure and allocate scarce resources to progressing commercialization of their technologies and innovations.

The fifth function for the state is that of a regulator, providing governance systems to assure the public of the quality, safety and efficacy of new innovations while mitigating any risks that may arise. A key challenge with especially radical or disruptive innovations is their impact on business models, value chains and markets, and sometimes they need new and unprecedented governance systems. SGCs play a key role in shaping the direction of research themes for emerging technologies, and as argued earlier, if research themes are identified locally and funding to SGCs is also local it becomes easier to align the strategic thrusts of the state, SGCs, researchers, innovators and regulators. The state does not only form and shape markets but through intellectual property protection, also protects the investment of researchers and innovation to allow them to recoup their investments through patents.

Lessons and way forward for effective and efficient science funding in Africa

That the place of STI on the national, regional and continental policy agendas in SSA has become markedly more prominent in recent years is not only reflected through initiatives such as STISA-2024 (AUC, 2014), but also through policy and institutional developments at various levels. It is also increasingly clear that financing research and innovation for sustained economic growth and industrial development in Africa requires a joined-up thinking of the knowledge and innovation generation, translational activities and commercialization continuum. Funding only one aspect of this value chain will not optimize the benefits that innovation gives to economic growth.

Given the pervasive nature of research and innovation, and the potential multiple entry points for funds and impact thereof, good and effective funding approaches are not only those that result in increased capabilities and productivity for the targeted sectors, but also those that demonstrate more encompassing value for money from outputs resulting from deployment of such approaches. Although assessing direct impact is important, so too are the more complex issues such as influence on system-wide decision making, human and institutional

capacity, relationships, access to knowledge and the context in which research and innovation outputs can be applied (Mugwagwa et al., 2018). For example, many African countries face immense problems of large numbers of unemployed youths. Young people (15 to 24 years) constitute about 37 per cent of the working age population, but account for more than 60 per cent of all unemployed people in Africa (AfDB et al, 2013). Effective research and innovation funding approaches therefore should result in mutually reinforcing and complementary investments in R&D and innovation by both private and public sectors. This will in turn result in multiple impacts from small entrepreneurial initiatives to growth in high technology industries with the concomitant employment of millions of workers.

As alluded to earlier, the importance of research and innovation is increasing in most African countries, as demonstrated by institutional and policy provisions for STI which have been instituted in the last few years. A key issue for Africa though, is that to a large extent, current understanding of the strengths and weaknesses of different funding arrangements; their relevance and applicability to specific contexts; and of the supporting mechanism needed for them to function are not clearly established. Further, research funding schemes and models differ radically from those for innovation funding even if they are within the same agency. Limited attention is paid to assessing whether the funding vehicle (its structure, governance and support measures or funding models) is optimal for the types of technological and non-technological innovations in the country. Against this backdrop, we highlight the following as key areas for African countries' quests to build research capacity:

Importance of science policy

Science policy provides the mechanisms by which public resources are allocated for the conduct of science. This covers multiple domains and a wide range of activities, including fundamental research (enhancing the understanding of phenomena via breakthroughs), applied research (the application of scientific knowledge to practical advances such as technologies), and their connections into commercialization and marketization. The latter two areas are the focus of innovation policy; science and innovation policy are highly interconnected policy domains through value chains, institutions, and skilled personnel. Within the umbrella of science policy, there will be multiple constitutive areas of policy instruments, such as the management of funding for R&D, human

intellectual capital, research infrastructure and facilities, intellectual property laws, and more. A science policy designed to advance social and economic capacities does several things (Steenmans et al., 2019). First, it has to foster R&D and innovation and facilitate the production of high-quality outputs from research activity. Equally, it must explore the diversity of pathways between production and uses of science. For this, it needs to foster broader engagement and intermediary capabilities. The building of scientific capacity therefore spans a range of natural and physical sciences, social science and management skills, responding not only to the needs of individuals, but also of organizations and institutions. The allocation of funding for R&D is a foundational component of science policy. It links the national strategic agenda with the research activities identified as related priorities. It also frames and clarifies the mechanisms by which government targets its support towards the capacities it believes should be developed, with what actors, and within which areas.

Importance of data

In Africa, the African Science Technology and Innovation Indicators Initiative has played an important role in capturing data on research and innovation activities in countries. The extent to which this evidence is used to inform decisions is yet to be confirmed, but it is undoubted that data on the funds being spent, on what activities, and to which recipients, is essential for oversight of the state and health of the performance of the national science system overall, as well as for more granular insight into which areas might benefit more from alternative modes of support. Without a consolidated evidence base of total and disaggregated expenditure, wider mechanisms for transparency and scrutiny are severely restricted.

Conclusions

African countries as late industrializers need to invest in research, innovation and technology development if they are to rapidly industrialize while at the same time protecting the environment through observance of sustainable development goals. However, attaining these economic and industrial development targets requires a shift in strategy from African countries viewing themselves as recipients and consumers of innovation and technologies developed elsewhere. We have argued in this chapter that local funding of research, innovation and technology is important for solving first, the contextualized challenges for African

countries, and second, it is important for African countries to play their role as global partners in generating knowledge and innovation. Although at AU level there are pronouncements and declarations to support research and innovation, state funding of research should assume the importance that it requires. This is not new, given the historical role the state played in supporting agricultural research and innovation translation in some African countries.

We have further argued that it is important that African countries explore new and innovative approaches, sources, tools, and institutional arrangements to catalyse industrial and economic development on the back of research and innovation. Foreign funding has dominated funding of research and innovation on the continent. SGCs have not historically played a huge role in funding research and innovation, though in the last five years, the role played by SGCs has significantly improved. To capitalize on this momentum, and if SGCs are to leverage their performativity role, they need to be capacitated by allocation of more resources from government to support the research and innovation community. This will also further strengthen their capacity to act as boundary-bridgers and boundary brokers between government, universities, and the commercial sector. The increased importance of local needs as drivers of research and innovation necessitates a purposive collaborative strategic focus that is driven by the grounded theory approach that uses locally identified research themes driven by these local needs. Systemic collaborations are key among all funders, and recognizing that collaborations take time to build, mechanisms for collaboration must be built into strategies at national and even regional levels. This will be especially important to manage the wicked problem that will persist for some time.

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