PATHWAYS TO ACHIEVING SOUTH AFRICA'S R&D INTENSITY TARGET*

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Introduction

This brief examines different pathways to achieve South Africa's R&D intensity target. It presents an optimistic outlook where research and experimental development (R&D) activity in the business sector is stimulated after significant government support and funding, and a pessimistic outlook where this fails to materialise, leading to continued government dominance in R&D performance while business sector investment declines.

A multinational analysis of countries has indicated that augmenting R&D expenditure by 1% leads to a corresponding 2.2% elevation in the actual growth rate of gross domestic product (Sokolov-Mladenović, Cvetanović & Mladenović, 2016).

African agreements codified in Agenda 2063 (AUC and AUDA-NEPAD, 2022) and STISA-2024 (AUC, 2014), require that governments in African countries consult with stakeholders within their R&D systems and clearly define the results they expect from R&D activities performed by public and higher education institutions, as well as the pathways to achieve the desired results.

About this brief

This brief provides two scenarios demonstrating the trajectory of growth in R&D activity required to reach the target R&D intensity of 1.5% by 2030. The first scenario is a pessimistic one, where government is the only actor that increases its investment in R&D; the other an optimistic one where the business sector increases its R&D investment in response to government efforts.

In South Africa, the 2019 White Paper on Science, Technology, and Innovation (DST, 2019) anticipates that gross expenditure on research and development (GERD) will increase to 1.5% of gross domestic product (GDP) by the year 2030. However, at the time of writing, the indicator remained stationary at around 0.6% of GDP. This brief looks at the investments in R&D that would be required to reach the policy target by considering scenarios modelling data up to 2030.

History shows that nations that have successfully restructured their R&D landscapes have typically undergone a phase where government funding has dominated in R&D endeavours.[1] Research shows that developed countries that invest a lot of money in research and development tend to be more innovative and successful. These investments come from both government and private companies with significant positive results (Soete, Verspagen & Ziesemer, 2022; Guellec & De La Potterie, 2001).

* A list of definitions of key terms used in this brief appear on pages 10 and 11.

[1] A question explored in the companion brief, *Funding R&D in a deindustrialising South Africa*.

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This stands in contrast to developing nations, where innovation and technological progress are hampered by limited expenditures on R&D activities.

Given that South Africa is comparable to countries that are in the development phase of knowledge-driven growth, large and persistent public funding of R&D is required to ignite the business sector, as argued in a companion analytical brief.[2] Such intensive government investment in R&D at the very least depends on sufficient public coffers, which in turn requires broadened tax revenues and most likely, improved economic activity over a long time period. The likelihood of such a growth regime, and favourable funding conditions, is outside the realm of this brief. Instead, the approach is, if we had such funds, what would it take to get to a business sector that dominates knowledge generation?

In the short term, governments can augment investment by subsidising R&D costs, fostering collaborations, or implementing other support mechanisms, given the limited funds allocated by the commercial sector for R&D within such growth environments (Mustapha et al., 2015).

The brief focuses on government strategy to make long-term direct investments in R&D through public sector institutions, including

R&D and innovation

The use of the terms R&D and innovation stem from the measurable approach used by statisticians and others engaged in country programmes to monitor and *evaluate the implementation of new ideas* in an *economic* context. This is designed to be consistent with the institutional sectors defined by the System of National Accounts (SNA) (European Comission et al., 2008). These are corporations (or business) sector, general government sector, non-profit institutions serving households (NPISHs) and households.

Research and experimental development

"R&D comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge" (OECD, 2015: 28, para 1.32). R&D activity thus encompasses all actions deliberately undertaken by R&D performers to generate new knowledge (OECD, 2015: 46, para 2.12). The most common proxy used to describe R&D activity is R&D expenditure.

Innovation

"An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)" (OECD, 2018: 60, para 2.99). Note that this definition applies to all four SNA sectors. Furthermore, "[r]esearch and experimental development … is one of a range of activities that can generate innovations (OECD, 2018: 46, para 2.14)".

[2] *Funding R&D in a deindustrialising South Africa*

government departments. While specific areas of focus are omitted from discussion, our primary concern lies in the long-term investment amount. The topic is multifaceted, and it is beyond the scope of this brief to address all its complexities.

Background

In another brief in this series,[3] the authors argued that a sustained, large amount of broad-based public funding of R&D to stimulate R&D activity in public research organisations, that may then be picked up and expanded on by the business sector, is needed to achieve the long-term R&D intensity target of 1.5%.

How much public funding is required to reach this level of R&D intensity by 2030? In this brief, we set out to answer this by looking at two scenarios using the following reasoning. For this target to be reached, an acceleration in R&D expenditure is require, because if current trends persist, R&D intensity will remain stagnant or decline further. Therefore, accelerated funding of R&D is required. In the absence of local business enterprises increasing R&D funding for their activities, this may be achieved, or made more achievable, by promoting foreign funding of R&D either by donors or multinational companies. However, government has little control over decisions made by private actors. What it does have control over is the allocation of resources to R&D for the public sector, i.e. universities, government entities, science councils, and state-owned enterprises.[4] History shows that consistent and strong support for R&D in public institutions can result in increased R&D by businesses that may benefit economic growth in the long run. The reason for such phenomena is still the subject of research, and the circumstances under which this occurs are not fully understood.

Looking at examples in history, a critical level of government funding appears to trigger a significant increase in business R&D spending, likely because it adequately prepares the foundation for further development. Presumably there are other factors that come together to spark such a response. A generally favourable economic cycle, well-functioning institutions and a permissive regulatory environment, a technological infrastructure suited to economic strengths, strong networks and partnerships, a leadership culture emphasising innovation, and a productive base fuelled by a sufficiently capable workforce come to mind.

Publicly funded research provides the foundation for greatly enhanced private sector investment and reduces the risk for private R&D investments. In this brief we consider what would happen if the value of public funding of R&D appeared to be around 70% of GERD as a starting point for scenario-building.

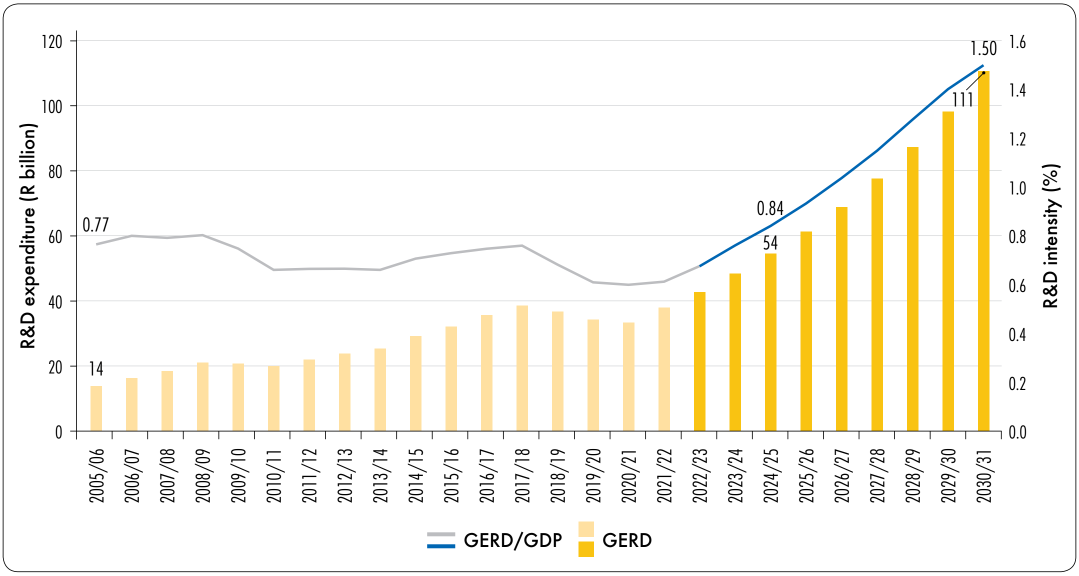
[3] *Funding R&D in a deindustrialising South Africa*

[4] Other controls that the government has are through incentives such as the R&D tax incentive programme and those offered within Special Economic Zones. For example, Malaysia, through its Government Transformation Programme, used SEZs to attract high technology multinational corporate brands (Medina, 2024).

A modelling approach

The data exploration considers how much funding will be required from the public to reach an R&D intensity of 1.5%, given forecasts of GDP (provided by the International Monetary Fund (IMF)) and assuming the gross domestic expenditure on R&D (GERD) trend persists geometrically into the future (Figure 1.1).

Figure 1.1 Nominal R&D expenditure and R&D intensity for South Africa from 2005/06, with values projected between 2022/23 and 2030/31 to achieve 1.5% R&D intensity



Source: South African National Survey of Research and Experimental Development, 2005/06 to 2021/22, and authors' own calculations.

The analysis draws heavily on trend data collected by South Africa's annual national R&D survey, and uses projections based on mathematical/statistical models.

There are two outlooks that may hold. The first looks at what funding is required from the public sector if business R&D activity continues to stagnate. The second considers the situation where the public sector increases the rate of funding (as in the first outlook), until a critical value of 70% publicly funded GERD is reached, whereupon the business sector starts to

How these scenarios were built

For readers who appreciate the technical aspects of creating forecasts and scenarios, the following describes the methodology used.

The GDP series from Stats SA was forecasted from 2022 to 2030 using growth indices by the IMF obtained from National Treasury. Inflationary indices were used to model growth in R&D expenditure such that the R&D intensity reached 1.5% by 2030. This determined the funding required to reach this level of R&D expenditure in 2030.

increase its rate of funding. Assuming that the threshold value of 1.5% R&D intensity is again reached by 2030, the savings to government is calculated, compared to the first outlook.

1. Pessimistic outlook
Continued stagnation in business sector R&D

The business sector trend of decreasing R&D persists until 2030. The government sector is compelled to increase its funding drastically to reach the target of 1.5% R&D intensity. This could be the case if medium-term interventions to promote R&D activity in businesses were ineffectual, for example, mechanisms to increase private-public collaborations. The level of funding required from the public sector (government, science councils and higher education) and the business and NPO sectors is displayed in Figure 1.2.

2. Optimistic outlook
Government support ignites business investment in R&D

In a situation where the government is the leading performer of R&D, the system relies on government to increase its funding of R&D, which in turn drives growth of R&D in the business sector. Under favourable conditions, growth persists until it reaches a critical point at which the business sector becomes the main funder of GERD, and eventually the major performer of R&D as well. In a previous brief, the level of government funding reached a maximum value at around 70%. For the purposes of exploration, we have used this critical value in the scenarios modelled. Under favourable circumstances, this tipping point is reached long before the target date of 2030, for South Africa's R&D intensity to reach 1.5% by 2030 (Figure 1.3). In less favourable circumstances, this could take longer.

What public sector funding does South Africa need to reach the R&D intensity target of 1.5%?

The first outlook, where business remains stagnant in growing R&D activity, allows for a straightforward estimation of the public sector funding of R&D needed to reach the policy target. Needless to say, the second outlook is preferable. This turns around the declining trend of R&D investment and activity in the business sector. For this to take place, we suggest that it would be necessary for the critical level of R&D investment to overlap with an existing culture of innovation and strong production capabilities in

Public sector and private sector

The public sector is composed of the government, science council and higher education sectors, plus state-owned enterprises within the business sector. The private sector is the business sector and NPO sectors, excluding state-owned enterprises. In this brief, we refer to the public sector interchangeably as the government sector consisting of government, science council and higher education sectors, without the SOEs. This is to simplify the discussions and modelling done.

the economy, as well as supportive policy actors. But we leave as open questions, the factors that are most important, and the confluence of factors that are potentially critical levers.

The timeline for achieving a turnaround will differ between countries, influenced by numerous factors, including changes in both internal and external framework conditions. For instance, a strong market for commodities over the next decade could ease fiscal constraints and lead to increased government support for research and development. However, the decision of domestic firms to adopt R&D as a business strategy is highly unpredictable.

The results from modelling

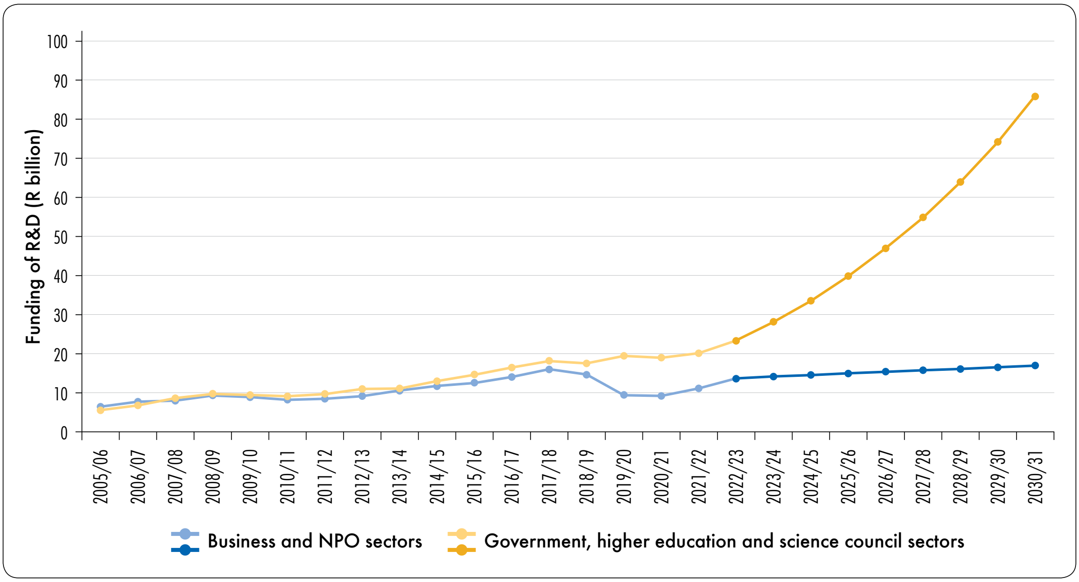
Pessimistic outlook

The amount of funding from the broader public sector (i.e. the government, science council and higher education sectors) required in the pessimistic scenario (Figure 1.2) is R450 billion from 2024 until 2030, an average of R50 billion per year.

Optimistic outlook

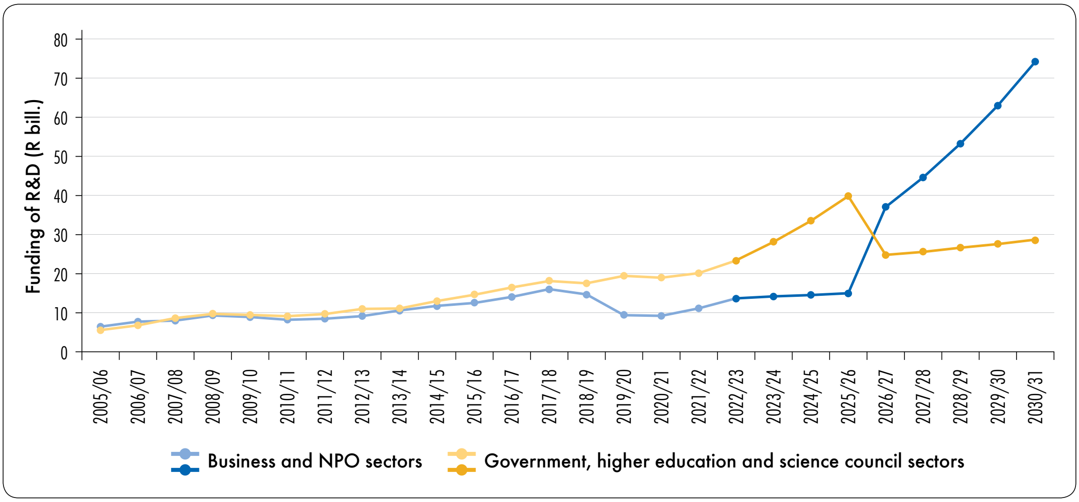
Funding from the public sector required in the outlook depicted in Figure 1.3 is R258 billion from 2024 until 2030, an average of R29 billion per year. That translates to a saving for the public purse of R21 billion every year between 2024 and 2030, a significant amount.

Figure 1.2 Funding required from the public sector and business and NPO sectors to reach the R&D intensity target between 2022 and 2030, where business R&D remains stagnant



Note: Foreign and other sources were projected using a linear growth trend.
Source: South African National Survey of Research and Experimental Development, 2001/02 to 2021/22, and authors' own calculations.

Figure 1.3 Funding required from the public sector and business and NPO sectors to reach the R&D intensity target, where business R&D activity picks up dramatically between 2022 and 2030



Note: Foreign and other sources of funding were projected using a linear growth trend.
Source: South African National Survey of Research and Experimental Development, 2001/02 to 2021/22 and authors' own calculations.

The steep slope of the projected curve in both scenarios suggests that a significantly accelerated funding regime would be required to achieve the 1.5% R&D intensity target by 2030. While reaching this goal is not impossible, the authors consider it unlikely. This outcome likely reflects the current maturity level of South Africa's National System of Innovation (NSI). In more mature NSIs, economic growth is often driven by outputs with high R&D intensity. At present, incremental innovation predominates in South Africa, and policy efforts are naturally focused on fostering an environment conducive to high R&D activity as a long-term objective. Therefore, the steep slope is not inherently negative but rather provides valuable insight that the 1.5% R&D intensity goal may realistically be achieved later than 2030.

Conclusion

The data exploration presented in this brief demonstrates that significant fiscal savings, amounting to an average of R21 billion over nine years in nominal terms, could be realised by fostering research and development (R&D) activities within the business sector, with the aim of achieving the 1.5% R&D intensity target by 2030. Attaining this target is expected to catalyse economic expansion through the production of knowledge-enriched goods and services. More-over, the steep slope of the projected R&D intensity curve highlights the need for accelerated funding to meet the 1.5% target by 2030. However, this challenge likely reflects the current maturity level of South Africa's National System of Innovation, where incremental innovation is prevalent. The analysis suggests that while achieving the target by 2030 may be unlikely, the slope provides valuable insight into the necessary long-term efforts required to create an enabling environment for high R&D activity, potentially delaying the target's attainment beyond 2030.

This brief, while addressing a long-term strategic policy objective, has also highlighted the potential benefits of near-term policy measures. These include fostering collaborations between the public and private sectors and implementing initiatives to stimulate R&D efforts within the business sector. It demonstrates how the fiscal burden could be lessened if the private sector assumes its role in increasing the funding for business R&D. Furthermore, it emphasises the importance of thoroughly understanding the essential framework conditions within the context of a national system of innovation (NSI) to integrate these efforts effectively.

The NSI framework views R&D actors and their interactions as drivers of economic growth, inherently involving a non-linear dynamic that suggests the possibility of critical behaviour. Consequently, the primary challenge is to identify the elements relevant to the South African context and leverage them effectively. This is crucial for successfully fostering an environment where both public and private sectors can collaborate and drive innovation, ultimately contributing to sustainable economic growth.

The **South African National Survey of Research and Experimental Development data** for the period 2001/02 to 2021/22 that is cited in this report was created by the Centre for Science, Technology and Innovation Indicators at the Human Sciences Research Council. Data is available for download and use by readers in different formats on the HSRC's website (hsrc.ac.za). For specialised data requests from CeSTII, visit https://data-request.hsrc.ac.za/

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DEFINITION OF TERMS

Applied research is original investigation undertaken to acquire new knowledge. It is directed primarily towards a specific practical aim or objective.

Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

BERD refers to business expenditure on research and experimental development.

Biotechnology is an application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services.

Capital expenditure is the annual gross expenditure on fixed assets used repeatedly or continuously in the performance of R&D programmes for more than one year. Such expenditure is reported in full in the period in which it took place and is not registered as an element of depreciation. Capital expenditure includes expenditure on land, buildings, instruments and equipment.

Constant 2015 (Real) Rands is the value of goods and services of a given year using the prices of a determined base reference year, which is 2015 in this case. These values were obtained by deflating with the GDP deflator using data published in the Statistics South Africa GDP survey P0441, Fourth quarter 2021 (Stats SA 2021).

Current expenditure is composed of labour costs of R&D personnel and other current costs used in R&D. Services and items (including equipment) used and consumed within one year are current expenditures. Annual fees or rents for the use of fixed assets is included in current expenditures.

Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems or services, or to improving substantially those already produced or installed.

Full-time equivalent (FTE) refers to the number of hours (person-years of effort) spent on R&D activities.

FTE per 1 000 in total employment is the number of professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, as well as in the management of these projects during a given year expressed as a proportion of 1 000 employed people. It is calculated by number of researchers during a given year divided by the total employed people and multiplied by 1 000.

Gross domestic product (GDP) is the total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports.

Gross domestic expenditure on research and experimental development (GERD) covers all expenditures for R&D performed on national territory in a given year. It thus includes domestically performed R&D that is financed from abroad but excludes R&D funds paid abroad, notably to international agencies.

Headcount refers to the actual number of people directly involved in or supporting R&D (i.e. the total number of R&D personnel).

New materials refer to the technology and R&D activities of high-technology companies particularly in the aerospace, construction, electronic, biomedical, renewable energy, environmental remediation, food and packaging, manufacturing and motorcar industries. New materials include multi-functional materials, advanced materials, nanomaterials, nanocomposites and nanotechnology.

Other support staff includes skilled and unskilled craftsmen, secretarial and clerical staff participating in R&D projects or directly associated with such projects.

Research and experimental development (R&D) comprises creative and systematic work undertaken to increase the stock of knowledge—including knowledge of humankind, culture and society—and to devise new applications of available knowledge.

Researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned.

Research field (RF) refers to a branch of science, either natural or social and humanities sciences.

R&D intensity refers to gross expenditure on R&D as a percentage of GDP.

R&D personnel include all persons (irrespective of nationality) employed directly on R&D activities, as well as those providing direct services, such as R&D managers, administrators, technicians and clerical staff. These include emeritus professors, honorary fellows and research fellows.[5]

R&D-performing sectors comprise the government, higher education, business and not-for-profit institutional sectors.

Standard Industrial Classification (SIC) are codes used by Statistics South Africa for all economic activities of industries.

State-owned enterprises (SOEs) are public corporations owned by government units mainly engaged in market production and sale of the kind of goods and services often produced by private enterprises.

Technicians and equivalent staff are persons whose main tasks require technical knowledge and experience in one or more fields of engineering, physical and life sciences, or social sciences, humanities and the arts.

Total employment is the total employment in the economy. This statistic is obtained from the Statistics South Africa Labour Force Survey series P0211 (Stats SA 2022), where employed persons are those aged 15-64 years who, during the reference week, did any work for at least one hour, or had a job or business but were not at work (temporarily absent).

Year-on-year changes are calculated as follows: (current year's figure - previous year's figure) / previous year's figure × 100%.

[5] Prior to 2016/17, emeritus professors, honorary fellows and research fellows were not required to be explicitly included in the estimates of R&D personnel.

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