Taking innovation to the next level

Prof David R Walwyn

Over the period 1994 to 2008, gross expenditure on research and development (GERD) more than doubled in real terms. This expenditure was driven mainly by rising government-funded research and development (R&D).

Since 2008, government funding has plateaued and GERD has declined. More worryingly, business expenditure on research and development (BERD) has dropped in real terms. This decrease was exacerbated by the closure of South Africa's pebble bed modular reactor (PBMR) project and would have been even more pronounced had it not been for Sasol, whose R&D expenditure now accounts for 12% of total BERD. BERD plays an important role in overcoming the low-growth trap from which South Africa must escape.

Although contested, the concept of the middle-income trap, which refers to the phenomenon where rapidly growing countries stagnate at middle-income levels, remains useful. It has been adopted as an analytical framework for many economies, including countries in Latin America, Africa and South-East Asia.

The basis for the middle-income trap is that rising wages in recently industrialised economies make traditional low-value exports uncompetitive in global markets. Moreover, these economies have limited capability in high technology or high value-added production, and cannot yet replace their declining share of commodity markets with speciality products and services. Such countries suffer from low investment, slow growth in secondary industries, limited industrial diversification and rising unemployment. In order to sustain stronger growth, these countries require specialisation in production, decentralised economic management, low inflation, stronger medium- and high-technology exports and reduced inequality.

Countries such as South Africa and (until recently) Brazil are frequently used as examples of the middle-income trap. This analysis is also reflected in the National Development Plan (National Planning Commission, 2011), which states:

> "South Africa displays features of a low-growth, middle-income trap, which is characterised by a lack of competition, large numbers of work seekers who cannot enter the labour market, low savings (hence a reliance on foreign capital inflows) and a poor skills profile. The net effect is a high level of unemployment, inequality and low levels of investment."

The plan recognises the central role of innovation in the country's development. It is also a means of escaping the middle-income predicament and refers to the importance of innovation in addressing the important developmental goals. It particularly recognises the need for R&D, internships for experiential learning and public policy focus on R&D.

In order to understand how innovation could be stimulated in the pursuit of inclusive growth, it is important to initially define the key success factors for innovation. Although there are many such interpretations, the following five main factors are highlighted:

- Innovation depends on a strong base of skilled human resources, which is equipped with the appropriate levels of education and experience (Cornell University, INSEAD and WIPO, 2014).
- Innovators' outputs are highly disproportionate, as a small group of innovators is responsible for most innovations. This probability profile is known as the Pareto distribution. It is also evident in a number of research outputs, including publications and patents (Walwyn and Sibisi, 2014).
- Innovation requires extensive risk sharing, most of which is absorbed by government funding. Although public research institutions have globally been the target of criticism and policy reform to minimise the state's role, these actions ignore the important role of such institutions in incentivising

investment, building networks and undertaking high-risk R&D. Repeated calls to downsize public institutions in order to "unleash the power of entrepreneurship and innovation of the private sector" have largely been overdone. It could lead to a weakened state that is unable to deliver on economic growth and foster radical innovation (Mazzucato, 2013).

- BERD is critical. The business sector understands markets, commercialisation and the positioning of a new product or service so that it can be an economic success. BERD supplies this pipeline and provides the knowledge that is subsequently embedded in innovative products (Cornell University et al., 2014).
- Innovation requires a vibrant and low-cost venture capital market, which is underwritten by high levels of capital availability in order to finance product development and economic growth. In developing countries, where foreign capital flows may be fickle and expensive, domestic savings (represented by a positive trade balance) are essential as a source of capital.

Although South Africa scores poorly in international surveys of human capital, especially at secondary and tertiary levels (Cornell University et al., 2014), the most recent R&D survey indicates two important aspects: rising numbers of full-time equivalent (FTE) researchers and more relaxed labour market conditions, as reflected by falling labour cost (expenditure per FTE).

Although levels of good education are not sufficiently widespread, the education system has pockets of excellence that are capable of delivering world-class scholars. For instance, South Africa ranks 18th on the global list of Nobel prize winners, ahead of all developing countries and many developed countries, including Finland, Ireland, Spain and New Zealand. However, retention of these top researchers is an ongoing challenge. Many of the country's top minds emigrate to Europe, the United Kingdom and the USA in order to pursue their careers.

A similar situation applies to the top innovators. Some prominent entrepreneurs, including Patrick Soon-Shiong, Mark Shuttleworth, Elon Musk, Pieter de Villiers, Roelof Botha, Percy Amoils, Chris Pinkham and Willem van Biljon now live in other countries. In terms of innovators or patent holders, South Africa, alongside many developing countries, records a net loss based on the listed authors of international patents. Furthermore, it has a low rate of patenting relative to other countries, a situation that has been deteriorating over the last ten years, as measured by the number of patents per FTE or R&D expenditure.

The problem of migration and "brain drain" in science and technology has been evident over a long period of time and several solutions have been attempted. The country's challenge is to retain such talent, especially in areas of high strategic focus, such as advanced manufacturing or information technology.

Government or public funding of R&D has been growing in real terms since 1993, and has now reached 45% of the GERD, much of which is directed at early-stage, high-risk research.

At this stage, it is important to distinguish between funding and performance. Although BERD is defined as expenditure, it actually measures performance. In other words, the value for

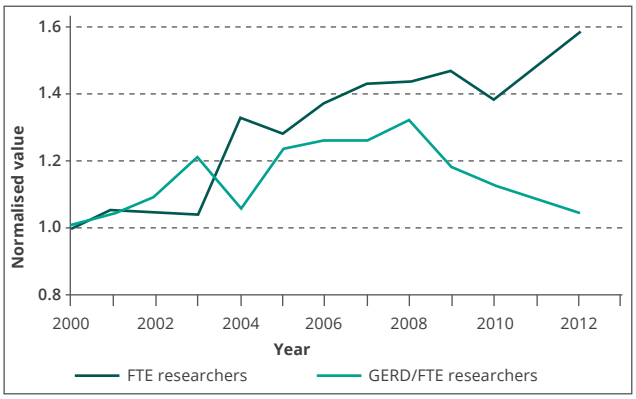


Figure 1: Number of FTE researchers and GERD/FTE (normalised to 2000)

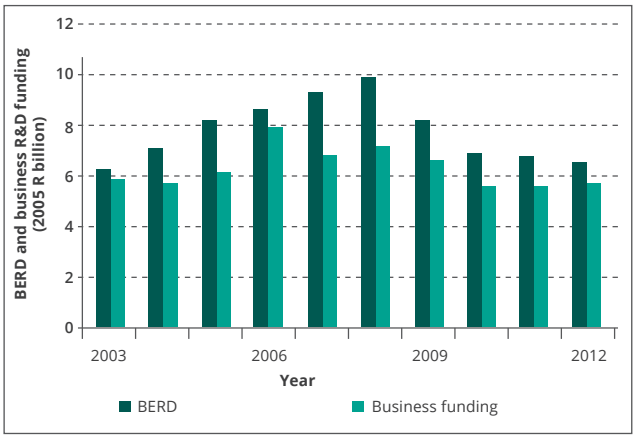
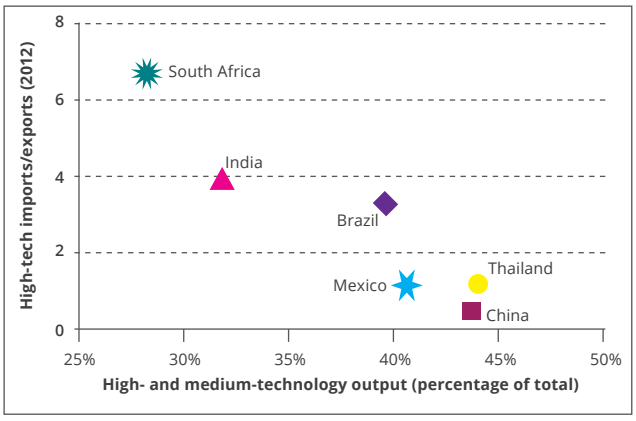
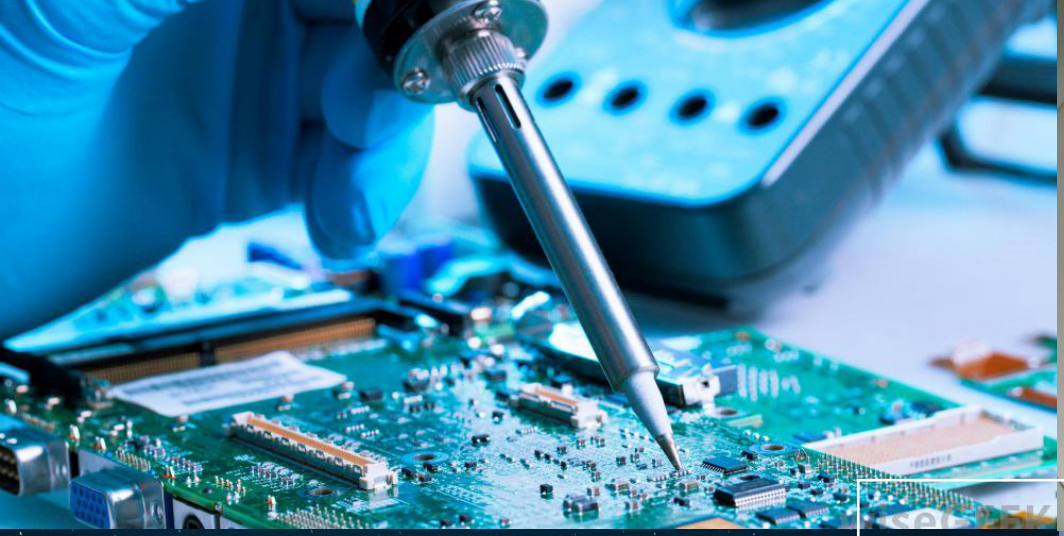


Figure 2: BERD and business R&D funding in constant 2005 R billion (2003 to 2012)

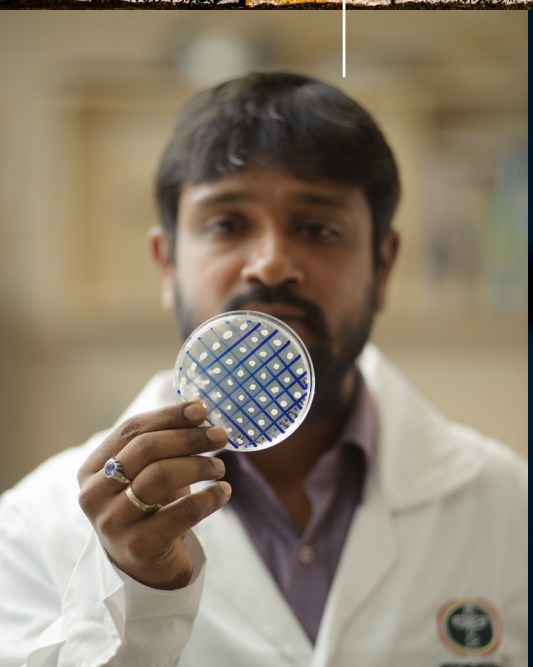


Source: Cornell University et al. (2014) and World Trade Organisation (2014).

Figure 3: High-technology manufacturing output supports exports in developing countries



→ *In most countries, government funds more research than it performs, and the business sector performs more research than it funds.*



BERD covers the amount of R&D performed by the business sector. Similarly, government funding of R&D covers funding and not performance. In most countries, government funds more research than it performs, and the business sector performs more research than it funds.

Much of the additional funding has been granted to universities, with government support of R&D in this sector rising by 450% in nominal terms or 250% in real terms.

Innovation holds the key to inclusive growth and recovering from the middle-income trap.

This funding focus, which indicates a growing role for universities as R&D performers within the national system of innovation, follows a pattern set earlier in many developed countries (OECD, 2011).

Business funding for R&D is perhaps the greatest concern in terms of innovation success factors. It is clear that both funding and performance of R&D in this sector has declined by 34% in real terms since its peak period from 2006 to 2008. The data for performance is complicated by the funding of the PBMR, in which government invested R8.8 billion from 1999 to 2010 (McKune, 2010).

The decline in business funding for R&D would be even more severe if one were to exclude Sasol, whose funding for R&D rose to R1.26 billion in 2012 (Sasol, 2013). A target or desirable value for BERD has been a much-debated subject over a long period of time, with values from 0.7 to 1.8% of gross domestic product (GDP) or at a company level from 4 to 25% of revenue, with little agreement on the value with the highest return or indeed the methodology by which this value can be calculated.

In earlier research, it has been suggested that South Africa's BERD should be about 0.9% of GDP (or about three times the present value of 0.34%) based on an analysis of the country's industry structure and benchmark values for each industry, as derived from an international comparison (Walwyn, 2008).

Local innovators are constrained by the limited availability and high cost of local venture capital funding for the commercialisation of R&D. South Africa needs to pursue other ways of addressing these constraints. The link between a positive trade balance, high levels of domestic savings and a reduced reliance on foreign capital flows has already been noted.

In summary, the most realistic path to this reduced reliance is to develop an export-based higher value-added industry, and thereby increase the level of high- and medium-technology exports.

Innovation holds the key to inclusive growth and recovering from the middle-income trap. Getting to the next level in terms of innovation intensity within the economy will require attention to several important factors.

In this article, it has been argued that these factors must include focus on value-added export-oriented manufacturing, the improvement of human capital, increased efforts to retain top innovators, and higher levels of BERD.

Together, these factors can realise new opportunities, including additive manufacturing, telecommunications, robotics, energy storage, artificial intelligence and digital genomes.

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