

BUILDING A KNOWLEDGE ECONOMY IN SOUTH AFRICA

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Over the past two decades the economies of leading countries have increasingly evolved into knowledge-based economies, relying less on traditional resources such as capital and labour for wealth creation and growth. It is generally accepted that the creation of new knowledge, innovation and technological change drive progress in such countries.¹ Economic activities based on new knowledge stimulate economic growth, provide higher wages and greater employment opportunities, as well as enhance a country's competitiveness within the global environment.² These positive economic trends, prevalent in many developed countries, strongly depend on new technology investments, high-technology industries and highly skilled labour.³ These are essential ingredients in the making of a knowledge-based economy.

While innovation is identified as a driver for economic growth and productivity, the capacity to innovate remains low in most African countries.⁴ Globalisation of technology, however, presents new opportunities for development in developing countries, but deliberate efforts, which include government action, are required to absorb innovation.⁵ In order for developing countries to build their potential as knowledge economies, investments in human capital and a highly skilled labour force, as well as infrastructure for high-technology industries, are essential. The fostering of scientific-technological collaborations or networks with developed countries are furthermore required to enhance the competitiveness and international trade prospects of firms in developing countries.⁵

Knowledge economy indicators (KEIs) provide a measure of the relative state of the knowledge economy in a country. They afford a view of the bigger picture of a country's performance in the modern knowledge economy, as well as enabling monitoring and benchmarking.⁶ Such indicators play a crucial role in national policy debates regarding science, technology and innovation.⁷ Conceptual development at the Organization for Economic Co-operation and Development (OECD) has led to the formation of internationally comparable indicators relating to research and development (R&D), innovation and the information society. There is however no standard set of indicators for the knowledge economy. Indicators can consist of individual indicators such as R&D expenditure as a percentage of the gross domestic product (GDP). Composite indicators are formed when individual indicators are compiled into a new indicator such as the European Innovation Scorecard or the World Bank's Knowledge Economy Index. Composite indicators are useful communication tools in terms of their ability to integrate a large amount of information, but can be misleading and are easily manipulated.⁸

South African science and technology related policies aim to drive South Africa's transformation to a knowledge-based economy.^{9,10,11} These strategic policy instruments are based on the concept that knowledge and innovation are essential components for economic growth and development, as well as for South Africa's global competitiveness. The Centre for Science, Technology and Innovation Indicators (CeSTII) of the Human Sciences Research Council is currently engaged in a project on KEIs for South Africa. The purpose of the study, for the Department of Science and Technology (DST), is to develop indicators to measure and monitor the development of a knowledge-based economy in South Africa. Even though science and technology indicator initiatives exist in South Africa, there is still paucity in the approach to the development of such indicators as a result of gaps between the conceptual and empirical aspects of measuring the knowledge economy. This study aims to expand the list of traditional indicators, such as R&D and innovation indicators, patent data and bibliometric data on patterns of scientific publications and citations, as well as to incorporate new indicators which will allow for a broader picture of the knowledge economy in South Africa. One of the key outputs of the study is thus to create a comprehensive portfolio of existing and new indicators.

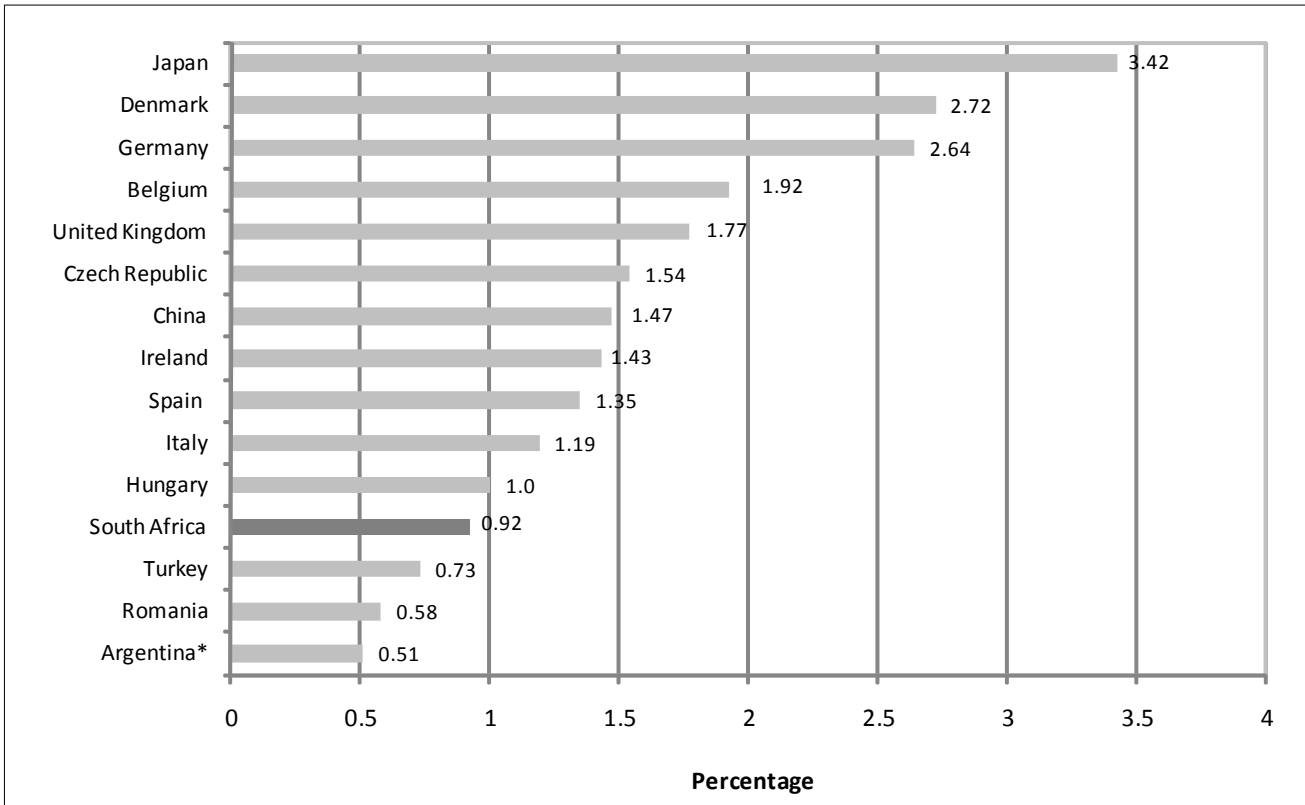
Indicators tend to have little relevance in isolation, but when compared with indicators from other countries based on the same methodology they serve as useful benchmarks for monitoring performance and competitiveness. The KEI portfolio, developed as part of the study, comprises individual and composite indicators from various databases by combining data from sources such as the R&D and Innovation Surveys undertaken by CeSTII, national and international financial data from institutions such as the World Bank, the OECD, the South African Reserve Bank and Statistics South Africa, as well as data from the Department of Education, other government departments and several higher education institutions. Data on publications and citations were available through the Thomson Institute for Scientific Information (ISI) database of research articles in ISI-indexed journals. All available, relevant and accurate data were included in the portfolio.

Knowledge creation and human resource, as well as industry and global market place indicators are provided and discussed here. These indicators provide an indication of highly skilled labour; high-technology industries; innovation, research and development and competitiveness, which we propose are essential building blocks for a knowledge economy in South Africa.

KNOWLEDGE CREATION INDICATORS

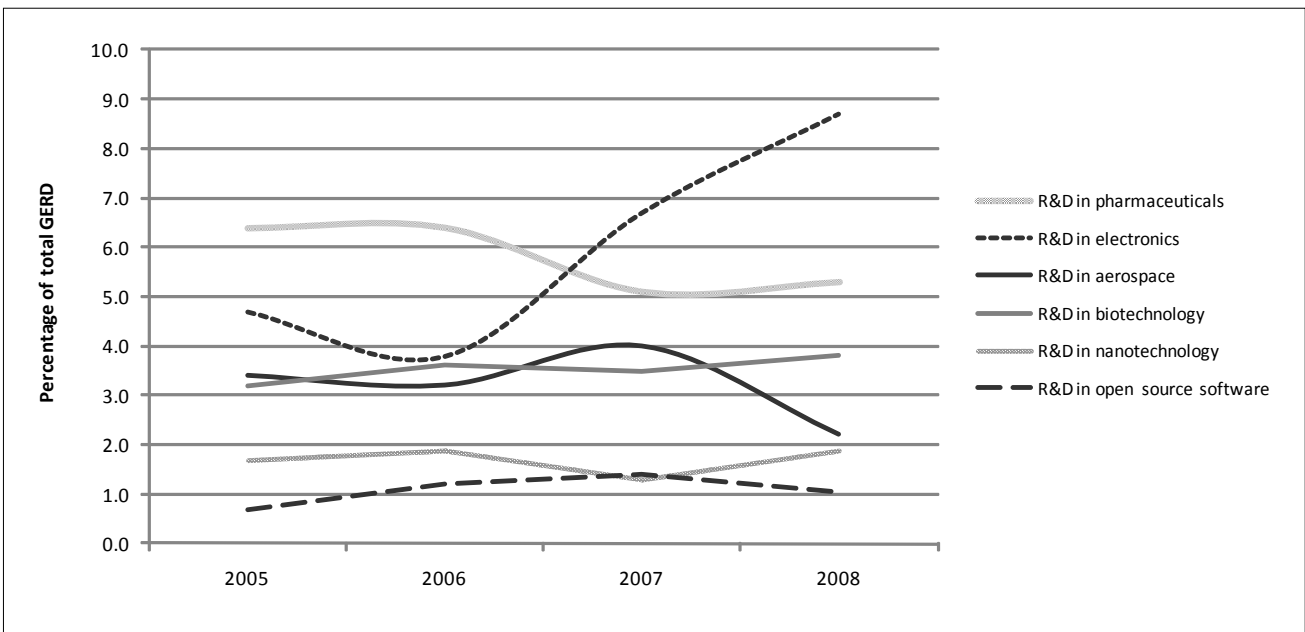
Gross domestic expenditure on R&D (GERD), as a percentage of GDP is one of the most important indicators of a country's potential for innovation and growth. This indicator reflects the intensity of R&D performance in a country. The indicator is sometimes used by politicians to set targets for future attainment such as R&D expenditure reaching 3.0% of GDP in the European Union by 2010 and South Africa reaching a 1.0% target for 2008.^{10,12} However, neither of these targets has been achieved. South Africa's GERD as a percentage of GDP amounted to 0.92% in the financial year 2008/2009 (Figure 1).

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Source: OECD¹³ and CeSTII¹⁴

FIGURE 1
Gross domestic expenditure on R&D as a percentage of GDP, 2008 or latest available year



Source: CeSTII¹⁴

FIGURE 2
South African R&D expenditure in R&D intensive industries, 2005–2008

TABLE 1
South African patent indicators

Main patent indicators	2005	2006	2007	2008
Patent applications to the USPTO	197	231	252	265
Patents granted by the USPTO	87	109	82	91
Patent applications to the EPO	136	149	146	-
Triadic patent families (EPO, USPTO & JPO)	35	33	30	28

Source: OECD¹³ and US National Science Board¹⁷
USPTO, United States Patent Office; EPO, European Patent Office; JPO, Japanese Patent Office.

South Africa compares well with middle-to-low income countries such as Hungary. With regard to other developing countries, South Africa ranked well below China's 1.47%, but higher than Argentina's 0.51%.

R&D intensive industries such as pharmaceuticals and biotechnology are those where R&D intensity tends to exceed the industry norm, because R&D is essential to maintaining a competitive edge. These industries are dynamic and new developments, resulting in new products for the market and tend to be a common occurrence. Knowledge intensive firms, in such industries, use value-added scientific knowledge created by R&D activities to enhance their products and processes in order to meet the demand for new and improved products and services.¹⁵ The knowledge-intensive parts of an economy tend to be generators of employment opportunities and intensify the demand for highly skilled workers. Learning on the part of both individuals and organisations as a result is crucial for realising the productivity potential of new technologies and longer-term economic growth.¹ South Africa has a fairly strong investment in these R&D intensive industries and they accounted for about 22.9% of GERD in 2008 (Figure 2).

While it is important to measure the extent of R&D in an economy, the concept of R&D is not readily apparent unless organisations assess their activities in terms of the extent that some of these activities (and associated expenditures and human resources inputs) are truly R&D and not routine scientific and technological activities. The OECD Frascati Manual¹⁶ provides guidelines for recognising and accounting for R&D activities. In contrast, patents and publications are traditional science and technology indicators which are readily quantifiable and auditable. These indicators are considered essential for providing a technical perspective of the knowledge economy and related innovative activities, because they are indicators of the outputs or productivity of the national system of innovation. Publications generally represent the outputs of academic research while patents represent the technological outputs of industry.

South Africa applied for 265 patents at the United States Patent Office in 2008 and was granted 91 patents in the same year (Table 1) while countries such as India and Brazil were granted 679 and 103 patents, respectively. In terms of triadic patent families, where patents are sought for an invention in the United States, Europe and Japan, South Africa had 28 in 2008 compared to 9 by Argentina and 63 by the Russian Federation.

Regarding publication outputs, South Africa ranked 38th out of all countries in terms of ISI citations in all fields over the ten-year period 1999–2009. South Africa clearly lags behind other developing countries such as China, India, Brazil and Argentina (Figure 3). However the number of publications and citations should also take into account the relative size of the country's population and the total number of researchers. For example, Argentina's population was 39.5 million in 2007 – smaller than South Africa's 49.2 million – indicating that Argentina has a relatively higher number of ISI citations per capita than South Africa.

HUMAN RESOURCE INDICATORS

Highly skilled human resources are the most critical component when it comes to building a country's capacity for a knowledge-based economy. Total full-time equivalent (FTE) researchers per thousand total employment is a strong indicator of the incidence of high-level skills in a country's workforce. When comparing the selected set of countries in Figure 2, South Africa performs relatively poorly with only 1.4 full-time equivalent researchers per 1000 total employment compared to 8.2 in the United Kingdom and over 10 in Denmark and Japan. This is indicative of the well-documented education and human resource skills constraints in South Africa which is a crucial area

for improvement if the country is to increase its competitiveness in the future.

Female researchers as a percentage of total researchers amounted to 40.3% in 2007. According to South African R&D survey data the representation of female researchers has increased gradually but steadily over the last few years from 38.0% in 2003.¹ Of countries presented in Figure 3, female researchers were best represented in Argentina (51.5%) and Romania (44.7%). It is noteworthy that the representation of women in European countries like Belgium (31.1%), Denmark (30.2%) and Germany (23.2%) was considerably lower.

INDUSTRY AND GLOBAL MARKET PLACE INDICATORS

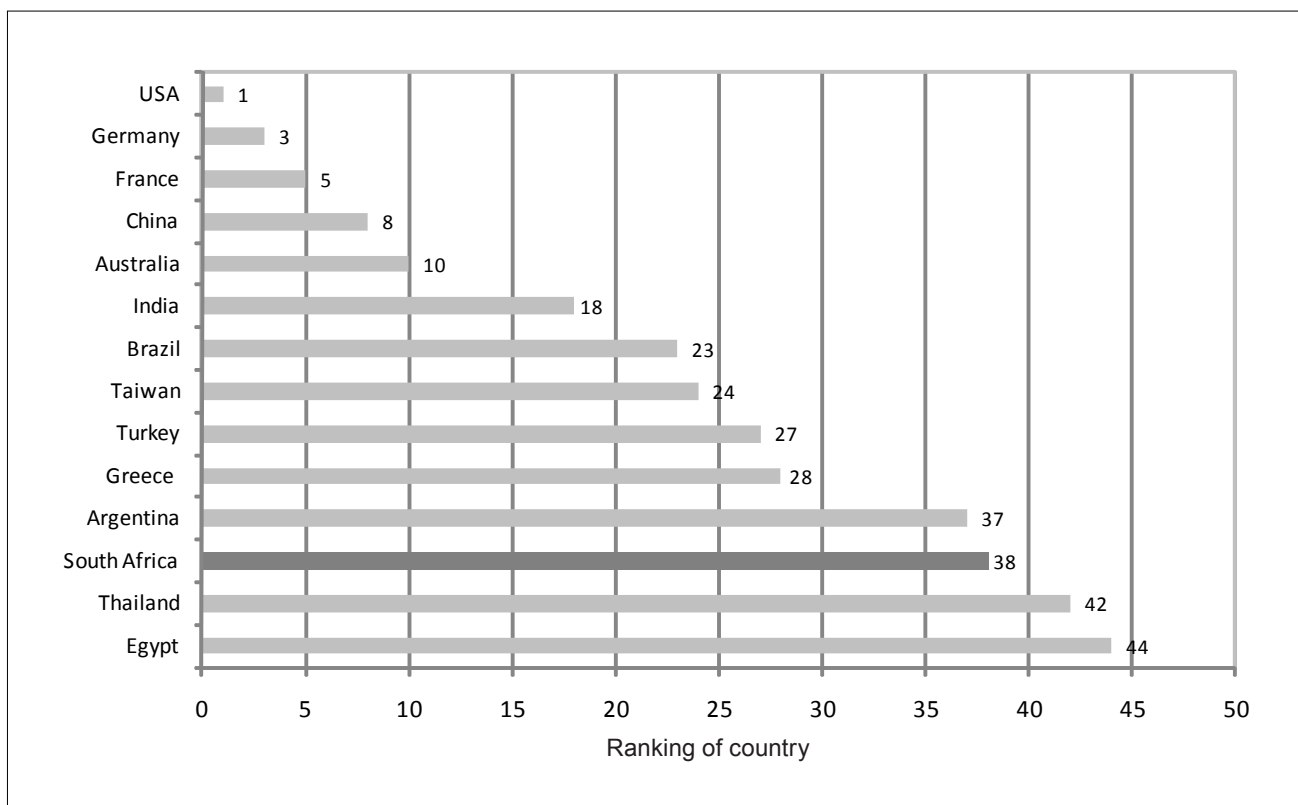
Industry and global market indicators are measures of overall competitiveness and how South African industry features in the international marketplace. A few key indicators are provided in Table 2. Foreign direct investment (FDI) as a percentage of GDP fluctuated between 2005 and 2007 and was quite low. FDI however increased to 4% of GDP in 2008. A large part of the FDI in South Africa comprises purchases of equity and share portfolio investments as opposed to fixed productive investment. South Africa has however recently become an increasingly attractive destination for investment and in 2009 attracted FDI totalling R43.8 billion (2% of GDP).²¹ The manufacturing trade balance, as well as the high technology manufacturing trade balance, is negative and it is clear that payments for technology are much higher than receipts. This means that South Africa imports and buys more technology than we export or sell. However these imports of technology can have a positive impact on the country if they are used productively or incorporated into new developments.

For 2007 South Africa's technology balance of payments as a percentage of GERD stood at 60.2% compared with 4.0% for Japan, 35.8% for the United Kingdom, 50.6% for Spain and 91.3% for Belgium. The merits or demerits of these figures for different countries have to be examined in terms of the particular industrial structures and resources of each country.

RECOMMENDATIONS

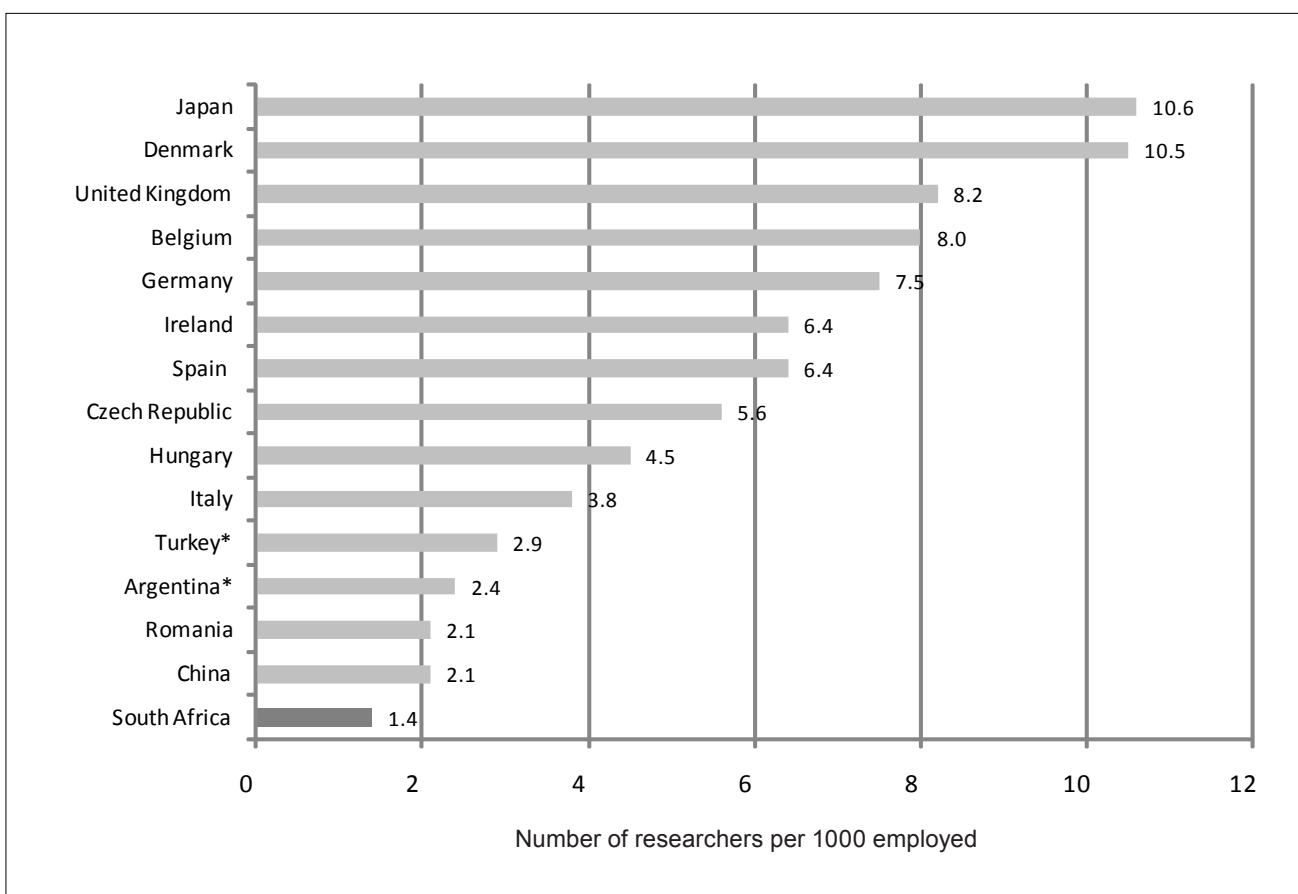
A specific framework of conditions is necessary to enable South Africa to make the required transition towards a knowledge-based economy. Important building blocks in this regard include: a focus on education and human capital development in order to meet the economy's demand for a highly skilled workforce, an effective national system of innovation which supports knowledge generation and a conducive business environment with a considerable degree of internationalisation and innovation. Policies to enhance the knowledge economy in South Africa should therefore include economic development strategies built around innovation, education and learning, as well as policies to develop competitive structures and strong organisations able to deal with global competition and market forces.

The European Union and South Africa have both set targets for reaching R&D expenditure equivalent to a certain percentage of GDP by a given year. In the DST's ten-year innovation plan the target of R&D expenditure reaching 1% of GDP by 2008 has been increased to a target of 2% of GDP by 2018. However, in both the European Union and South Africa the business sector provides the greatest share of R&D expenditure. In 2007, approximately 63% of R&D expenditure was provided by the business sector in European Union countries, while in South Africa, business R&D expenditure was nearly 58% of GERD. This means that either government would have to invest in vast new R&D projects in order to achieve these new targets or an alternative would need to be found to encourage business to significantly increase its expenditure on R&D and this would best be achieved as a partnership with government. To have reached the 1% target for



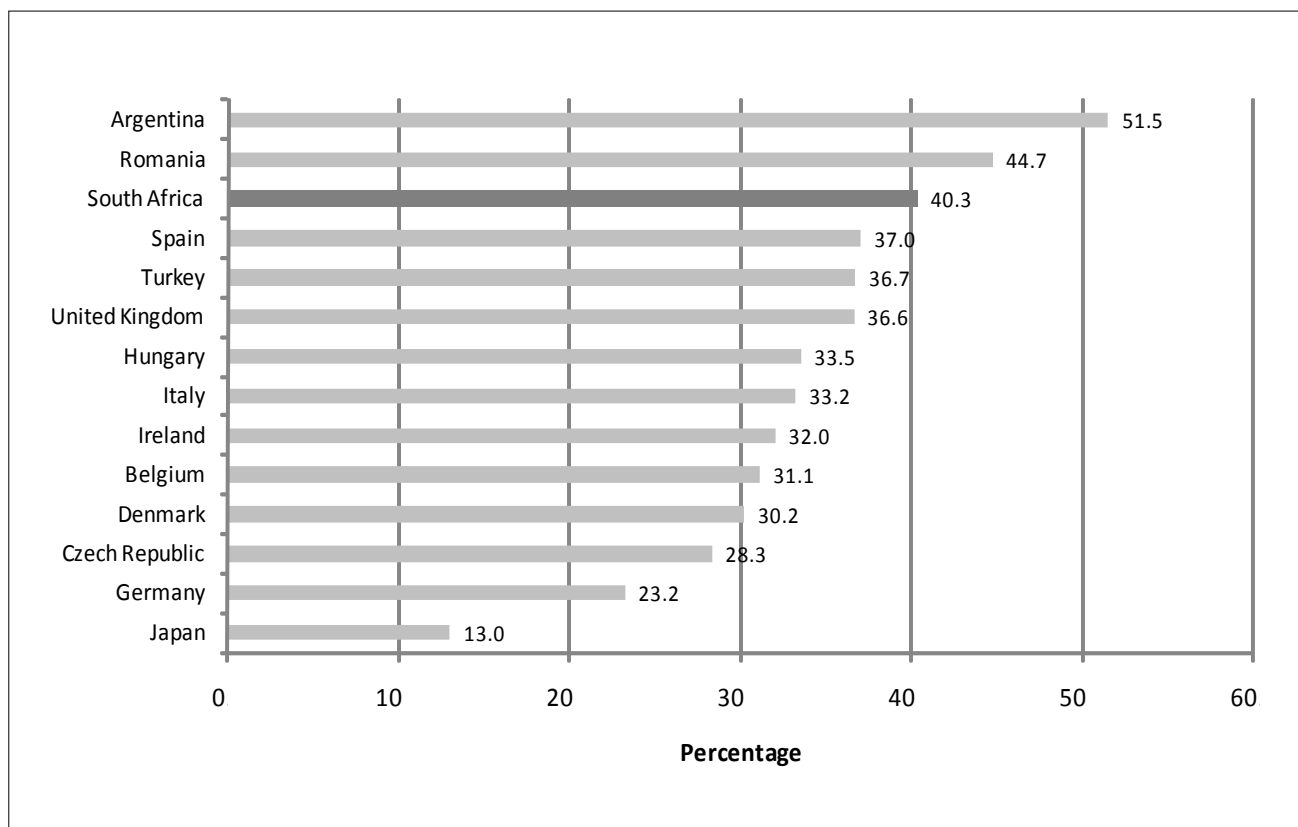
Source: Thomson Reuters ISI, Essential Science Indicators®

FIGURE 3
Country rankings on the Institute for Scientific Information citations in all fields, 1999-2009



Source: OECD¹³ and CeSTII¹⁴

FIGURE 4
Total researchers per thousand total employment, 2008 or latest available year



Source: OECD¹⁹

FIGURE 5
Female researchers as a percentage of total researchers (headcount), 2007

TABLE 2
South African industry and global market indicators

Main indicators	2005	2006	2007	2008
Foreign direct investment (% of GDP) ²⁰	2.0	-2.0	1.0	4.0
Gross fixed capital formation (% of GDP) ²¹	17.1	18.8	21.1	23.2
Information and communication technology expenditure (% of GDP) ²⁰	9.0	10.0	10.0	-
Manufacturing trade balance (% of total trade) ²²	-56.8	-67.0	-65.5	-67.3
Trade balance of high technology manufacturing goods (R millions) ²²	-66 566	-78 700	-81 372	-98 571
Technology balance of payments: Receipts (million current dollars) ¹³	45.3	45.7	52.7	53.2
Technology balance of payments: Payments (million current dollars) ¹³	1070.8	1279.6	1591.3	1662.1
Technology balance of payments (% of GERD) ¹³	48.1	52.4	60.2	-

South Africa in 2008 would have required an extra R1.8 billion in R&D expenditure and the target of 2% by 2018 appears elusive.

The current growth oriented exposition of the knowledge economy, rooted in the notion of free competition, is insufficient in terms of promoting long-term human development.²³ This is specifically of importance with regard to developing countries aiming to compete in the international environment while facing various developmental challenges at home. A knowledge-based economy will not necessarily ensure national economic prosperity, improved health and well-being, ecological sustainability and reduced inequalities. A balance between the expansion of the knowledge economy and the issues concerning sustainability, long-term growth and development are therefore important policy considerations for South Africa. However, current policies in support of a knowledge-based economy in South Africa are too broad and attempt to simultaneously address the objectives of growth and development, while these essentially require distinct and specific policy emphases.

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REFERENCES

1. Organisation for Economic Cooperation and Development (OECD). The knowledge-based economy. Paris: OECD; 1996.
2. Houghton J, Sheehan P. A primer on the knowledge economy. CSSES Working Paper No. 8. Melbourne: Centre for Strategic Economic Studies, Victoria University of Technology; 2000.
3. Powell WW, Snellman K. The knowledge economy. *Annu Rev Sociol.* 2004;30:199–220.
4. Wolf S. Encouraging innovation and productivity growth in Africa to create decent jobs. Paper presented at: The DPRU/ TIPS Coherence; 2006 Oct 18–20; Johannesburg, South Africa.
5. Archibugi D, Pietrobelli C. The globalisation of technology and its implications for developing countries: Windows of opportunity or further burden? *Technol Forecast Soc.* 2002;70:851–883.
6. Gault F. Science, technology and innovation indicators in the OECD: Next steps. Paper presented at: The VII Ibero-American Congress of Science and Technology Indicators; 2007 May 23–25; Sao Paulo, Brazil.
7. Freeman C, Soete L. Developing science, technology and innovation indicators: What we can learn from the past. *Res Policy.* 2009;38:583–589.

8. Freudenberg M. Composite indicators of country performance: a critical assessment. OECD Science, Technology and Industry Working Papers 2003/16. Paris: OECD; 2003.
9. South Africa. National Research and Development Strategy. Pretoria: Government Printer; 2002.
10. Department of Trade and Industry (DTI). National Industrial Policy Framework. Pretoria: DTI; 2007.
11. Department of Science and Technology (DST). Ten Year Innovation Plan: Innovation towards a knowledge-based economy 2008–2018. Pretoria: DST; 2008.
12. Brussels European Council. Presidency conclusion [document on the Internet]. c2002 [updated 2002 Mar 16; cited 2010 July 26]. Available from: http://www.bologna-berlin2003.de/pdf/Pres_Concl_Barcelona.pdf
13. Organisation for Economic Cooperation and Development (OECD). Main science and technology indicators, Volume 2010/1. Paris: OECD; 2010.
14. Centre for Science, Technology and Innovation Indicators (CeSTII). National R&D survey database. Cape Town: Human Sciences Research Council; 2010.
15. Bell J, Crick D, Young S. Small firm internationalization and business strategy: An exploratory study of 'knowledge-intensive' and 'traditional' manufacturing firms in the UK. *Int Small Bus J*. 2004;22:23–26.
16. Organisation for Economic Cooperation and Development (OECD). Frascati Manual: Proposed standard practice for surveys on research and experimental development. Paris: OECD; 2002.
17. US National Science Board (USNSB). Science and engineering indicators: 2010. (NSB 10-01). Arlington: USNSB; 2010.
18. Thomson Reuters ISI. Essential Science Indicators database [homepage on the Internet]. No date. [cited 2010 July 14]. Available from: <http://www.apps.isiknowledge.com>
19. Organisation for Economic Cooperation and Development (OECD). Main science and technology indicators, Volume 2009/2, OECD, Paris.
20. World Bank. Africa development indicators 2010: Silent and lethal – How quiet corruption undermines Africa's development efforts. Washington DC: World Bank; 2010.
21. South African Reserve Bank. Quarterly Bulletin 2010 March.
22. Department of Trade and Industry (dti). South African trade statistics [homepage on the Internet]. c2009 [cited 2010 July 26]. Available from: <http://www.dti.gov.za/econdb/raportt/rapmenu1.html>
23. Lin BC. A new vision of the knowledge economy. *J Econ Surveys*. 2007;21:553–584.