

P O L I C Y B R I E F

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From Nano to Notable: accelerating the development of nanotechnology-enabled products

Executive summary

The continuous discovery of nano-enabled products presents nanotechnology innovations as a rapidly growing phenomenon, and as one of the most essential scientific fields, which is critical for the achievement of sustainable development goals (SDGs). The future needs nanotechnology; it is making breakthroughs in a range of scientific discoveries, including medical and health innovations (such as rapid diagnosis, disease prevention, and vaccines), agriculture, water treatment, clean energy technology, and more. It is this potential to present impactful solutions, and contribute to development, that has attracted research and development investments from both the public and private sector. The extent of focus and collaborative effort of investment will determine the diverse benefits the country can derive from nanotechnology as a scientific field. Given that, in practical terms, nanotechnology continues to demonstrate its relevance, more must be done to ensure that the country reaps real, notable, long-lasting and impactful outcomes from its research and development. It is on this basis that efforts are directed to:

- increasing the impact of nanotechnology research in South Africa by recommending actions to accelerate the production of nano-enabled products
- exploring policy changes to accelerate the production of nano-enabled products and support the growth of companies developing nano-based products.

Introduction

Nanotechnology is a field of science that focuses on the study and manipulation of matter that is 10 000 times smaller than the width of a human hair. The exploration of phenomena occurring at this scale (<100nm) has driven the development of disruptive technologies, which have been pivotal in addressing the world's most pressing challenges. Nanotechnology has provided solutions for renewable energy generation and storage, access to clean and affordable drinking water, and various medical breakthroughs, such as the development of Moderna's COVID-19 vaccine, to name but a few. From a commercial perspective, the global nanotechnology market was valued at 79.14 billion dollars in 2023 and is projected to reach 332.73 billion dollars by 2032, with a compound annual growth rate (CAGR) of 17.6% over this period. Nanotechnology not only offers solutions to address major global issues but also represents a significant opportunity for rapid economic growth.

Policy context

South Africa, recognising the potential benefits of nanotechnology for socio-economic development, approved the National Nanotechnology Strategy (NNS) in 2005. Due to South Africa's commitment to advancing research in nanotechnology, publications in this field increased from 68 in 2000 to 1672 in 2019, representing an increase of 2 459%. Additionally, the global share of nanotechnology publications grew by 5.2% during the same period. This impressive progress demonstrated that the country was developing research expertise and the relevant skills required for nanotechnology research. However, South Africa has faced challenges in achieving two critical objectives of the NNS, which were:

- The development of unique South African nanotechnology-enabled products,
- The increased rate of technology transfer into existing industries, along with the establishment of nanotechnology SMMEs.

An analysis of the nanotechnology value chain by Masara et al. (2021) revealed that, compared to other BRICS countries, South Africa had the lowest percentage of publications reporting on nano-enabled products¹. Furthermore, Lindsay et al. (2024) identified only a handful of nanotechnology-based companies operating commercially². The limited translation of nanotechnology research into nano-enabled products poses a risk of undermining its potential to address some of the country's most pressing challenges.

The National Nanotechnology Strategy (NNS)

South Africa has made significant investments in the field of nanotechnology. These efforts have been realised through the National Nanotechnology Strategy (NNS) and the Nanoscience and Nanotechnology 10-year research plan, which was designed to ensure the successful implementation of the NNS³⁻⁴. The primary objectives of the NNS included the long-term support of nanoscience research, the development of innovative devices for application across various sectors, the promotion of human capital and infrastructure development for nanotechnology research, and the stimulation of new advancements in missions. The implementation plan for the NNS encompassed a range of activities. These activities included (i) the establishment of characterisation centres, (ii) the creation of research and innovation networks, (iii) the building of human capacity, and (iv) the establishment of flagship research projects. The Department of Science and Innovation (DSI) established two

national innovation centres (NICs): the National Center for Nanostructured Materials at the CSIR and the DSI/Mintek NIC at Mintek. Innovation networks were developed through various initiatives, including, but not limited to, the creation of centres of excellence (CoEs) by the National Research Foundation (NRF), and the establishment of the South African Research Chairs Initiative (SARChI). Human capacity was partly developed through the National Nanoscience Postgraduate Teaching and Training Platform (NNPTTP). The DSI initiated various flagship projects in areas such as water, health, mining, and minerals, which yielded highly favourable results. By 2015, a total of 464 postgraduate students had been trained, 92 postdoctoral fellows supported, 326 collaborations established, 352 articles published in highly cited journals, 80 conference proceedings recorded, and 17 patents registered⁵.

Research method and approach

This policy brief utilised secondary data collected from ongoing stakeholder engagements (such as conferences), strategies (for example, the NNS) and publications from leading government departments (such as the DSI, NRF, CSIR, etc), as well as civil society organisations.

Results and policy implications

Low translation of nanotechnology research into nano-based products

From an academic perspective, it is evident that the NNS has been able to achieve some of its objectives. However, two of the critical success criteria for the NNS were the development of unique South African nanotechnology-enabled products, and increased rate of technology transfer into existing industry, and the establishment of nanotechnology SMMEs. There are methods that can be used to evaluate the amount of publications reporting on nano-enabled products, one of which is through the nanotechnology value chain. The transformation of nanotechnology from ideation to commercialization occurs in three main steps known as the nanotechnology value chain shown in Figure1 below.

Figure 1: Nanotechnology value chain

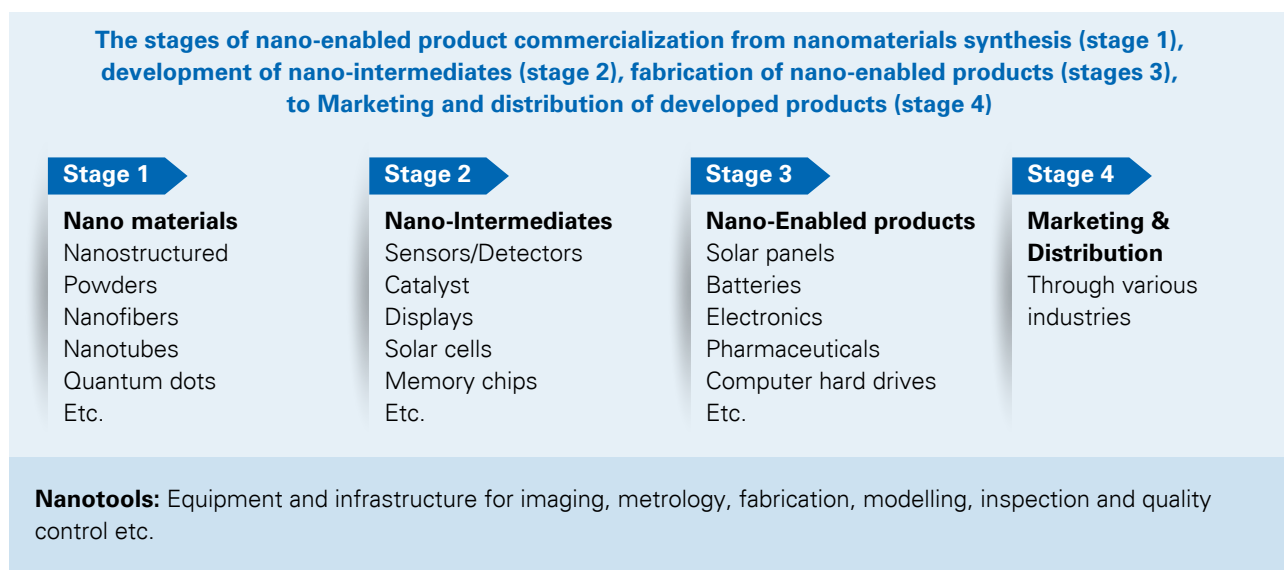


Figure 2: Publications classified according to the nanotechnology value chain for two periods

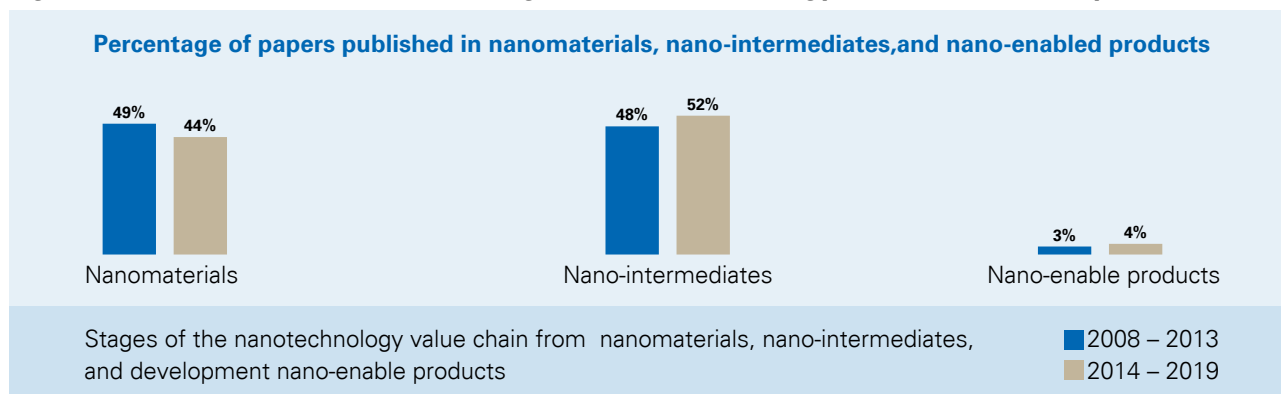
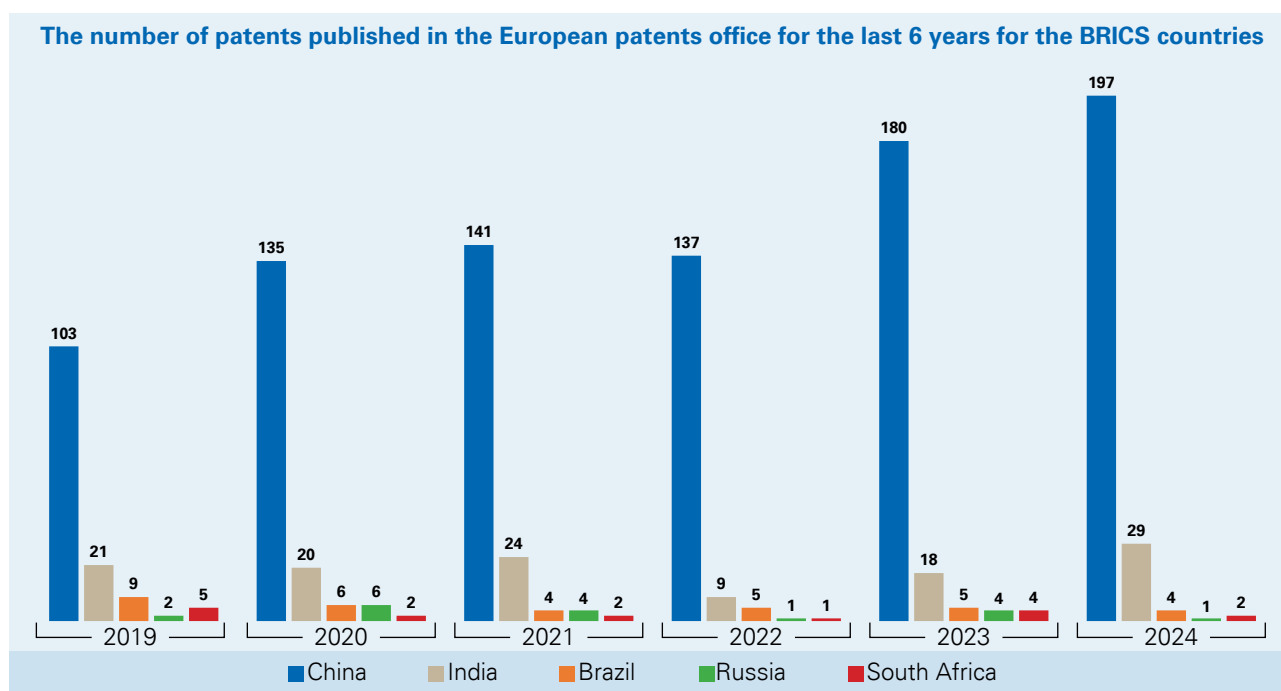


Figure 2 shows the percentage of publications according to the nanotechnology value chain.

The highest percentage of publications is in nano-intermediates (52%), while only a small fraction of publications focuses on nano-enabled products¹. South Africa accounted for 3–4% of nanotechnology publications reporting on nano-enabled products, which was the lowest percentage among the BRICS countries, except for Russia¹. However, it is worth noting that the number of publications on nano-enabled products increased from 2008 to 2019, indicating progress, though South Africa continues to lag behind the other BRICS countries. This is further reinforced by looking at the number of nanotechnology related patents that were granted in the European patent office for the BRICS country as shown in Figure 3.

Figure 3: Bar graph showing the number of patents granted for nanotechnology at the European patent office for the BRICS countries over the last 6 years.



The data on granted patents was obtained from StatNano ([StatNano](https://www.statnano.com/)), which is a publicly available database which provides statistics in nano-based science, technology, and industry. The data shows that the number of nanotechnology related patents from South Africa has remained stagnant in the last 6 years while the number of granted patents for China, India, and Brazil has increased in that time period. A similar trends have been observed for patents granted in the United States patent office. The development of companies specialising in nanotechnology-based innovations is underway in the country, with notable examples including SABinano, Stellenbosch Nanofiber Company, and Synexa.

Many other organisations are still in developmental stages and are not yet operating commercially². While these emerging companies are working on nano-enabled products, the technology transfer from laboratory prototypes to commercially viable products has been notably slow. The limited reporting of nano-enabled products and the slow pace of technology transfer threaten the ability of the nanotechnology to fully realise its potential in addressing social and economic challenges.

Policy recommendations

From challenges to impact partnerships

Several challenges hinder the development of nano-enabled products. These include limited investment in relevant research and development, a lack of laboratory equipment and appropriate infrastructure to facilitate research and its commercialisation, insufficient funding opportunities to support research with commercial potential, immature markets, and stringent regulatory requirements⁶⁻⁷. Another significant challenge is the divide between academia and industry. The establishment of partnerships between these two sectors could enhance funding for research with commercial potential while providing incentives for researchers to focus on technologies that can be seamlessly integrated into existing industries. Collaboration between these sectors would also enable researchers to participate in entrepreneurial activities – a major obstacle in the commercialisation of technologies, as most researchers lack the entrepreneurial vigour and expertise necessary to explore the commercialisation of their research outputs.

Intellectual property/regulatory framework

Technology transfer offices (TTOs) at universities are responsible for assisting researchers in translating their research into products with commercialisation potential. TTOs have made significant strides in enhancing partnerships between academia and industry, supporting researchers with patent applications and intellectual property (IP) protection, securing potential funders, assisting in the development of viable prototypes, and providing education in entrepreneurship. TTOs have also introduced researchers to the various pathways for commercialising technology, including licensing to the establishment of start-ups. However, not every university and science council has a well-established and capable TTO which severely impedes the development of nano-enabled products.

- Universities should establish and further equip their TTOs to ensure that researchers aiming to commercialise their nano-enabled products are given the best chance of success.
- TTOs should publish and promote the university's nanotechnology IP for potential licensing. This would provide exposure to the innovations being developed at universities and encourage partnerships between academia and industry.
- It would be beneficial for the DSI to establish a governmental body committed to developing technology transfer policies and practices. The United States has achieved considerable success through the establishment of the National Nanotechnology Initiative (NNI), and adopting a similar approach could benefit not only nanotechnology but other fields as well.
- Universities should integrate entrepreneurship training into their MSc and PhD programmes.
- The NRF should establish funding programmes that encourage collaboration between academia and industry.

Conclusion

To avoid unjust beneficiation and ownership of innovations related to nanotechnology, intellectual property issues must be integrated into the processes to ensure the standardisation of effective governance and regulatory protocols. This would help orient all stakeholders towards stable, predictable and effective systems that protect and guarantee returns on investment. The continuous discovery of nano-enabled products highlights the existence of untapped opportunities, which directly influence and accelerate sustainable and resilient socioeconomic development.

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