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Research on empowering innovations in nanotechnology

This study reminds us that, in many countries, nanoparticles have become part of our daily life. They are also found in clothing, tyres, fertilizers and cosmetics, for instance. Given the breadth of potential applications, nanotechnology has become a research priority for many countries, as towards 2030 explains. Nanoscience and nanotechnology is a priority field for today's innovation leaders. Switzerland, for instance, topped both the EU's Innovation Scoreboard and the Global Innovation Index in 2014 and is one of the top three countries for innovation among members of the Organization for Economic Co-operation and Development (OECD). It also has some of the highest output in nanotechnology: 198 scientific articles per million populations in 2013. Switzerland leads other strong players in this field, including the Republic of Korea, Germany, France, the USA and Japan, according to Thomson Reuters' data cited by the UNESCO Science Report and analysed by Statnano. However, when it comes to the number of patents per 100 articles on nanotechnology, the order of these countries is reshuffled. The USA now takes the lead, with 44, followed by Japan, the Republic of Korea, Germany, Switzerland and France. The European Union (EU) is encouraging its members to embrace smart specialization in their national strategies. To help narrow the research gap with its newest members, the EU launched the Teaming Action in 2013 within Horizon 2020, its biggest research programme ever. One of the first team projects to be approved for funding is developing the Wroclaw Centre of Excellence in new materials, nanophotonics, additive laser-based technologies and new management organization systems, with competitive funding from the Research Executive Agency. This project involves collaboration between the German Fraunhofer Institute for Material and Beam Technology and the University of Würzburg, on the one hand, and Wroclaw University of Technology and the Polish National Centre for Research and Development, on the other. Steered by a committee drawn from the industrial, labour and academic sectors, this partnership benefits from an investment of US$ 2.9 billion under the Revitalize American Manufacturing Act (2014). These funds, which are to be matched by private and non-federal partners, are being used to create an initial network of up to 15 institutes, including several with a focus on additive manufacturing, such as three-dimensional (3D) printing, digital manufacturing and design, lightweight manufacturing, wide band semiconductors, flexible hybrid electronics, integrated photonics, clean energy and revolutionary fibres and textiles. Japan ranks sixth worldwide for the sheer volume of articles on nanotechnology, behind China, the USA, India, the Republic of Korea and Germany. However, industrial investment in nanotechnology dropped from ¥ 155 billion to ¥ 111 billion between 2008 and 2013 as private enterprises cut back on research spending in reaction to the global financial and economic crisis. Many firms moved their R&D and manufacturing centres abroad, in reaction to an overappreciated yen and a shrinking Japanese market. Although university funding for nanotechnology has risen to ¥ 55 billion since 2008, it remains well below industrial levels. Moreover, Japan is one of the rare cases where the volume of scientific articles has declined over the past decade. Consequently, Japan's world share of articles has also shrunk, including in chemistry.

The BRICS (Brazil, Russian Federation, India, China and South Africa) are all striving to become nanotechnology hubs. Their contribution to this field nevertheless remains relatively modest, with China counting 25 articles per million population, the Russian Federation 23, Brazil and South Africa 9 and India 6. Although their academic output in nanotechnology is growing, related patents and products are not always progressing at the same pace: in 2015, the ratio of nanotechnology patents to articles on nanotechnology was 2.47 per 100 articles for South Africa, 2.28 for China, 1.67 for Brazil, 1.61 for India and 0.72 for the Russian Federation, according to Stat nano. In comparison, Italy recorded 4.46, the UK 8.39 and Canada 10.08. In Brazil, the number of articles on nanotechnology climbed from 5.5 to 9.2 per million inhabitants between 2009 and 2013 but the average number of citations per article dropped over the same period, from 11.7 to 2.6. By 2013, Brazilian output in nano science represented 1.6% of the world total, compared to 2.9% for Brazilian scientific articles, in general. In 2008, Brazil made a strategic investment. It established the National Nanotechnology Laboratory for Agriculture (LNNA) and, three years later, the Brazilian Nanotechnology National Laboratory (LNNano). This investment, combined with federal and state funding of specific research projects in related fields, 'has led to considerable growth in the number of researchers working in materials science', observes the UNESCO Science Report. It recalls that technology tends to be transferred from public research institutions to the private sector in Brazil. A 2014 report by the Brazilian Materials Research Society cites researcher Rubén Sinisterra from the Federal University of Minas Gerais, who has been developing drugs to alleviate hypertension. Sinisterra expresses confidence that Brazilian universities now have the capacity to develop nanoscale materials for drug delivery but also observes that 'our domestic pharmaceutical companies don't have internal R&D capabilities, so we have to work with them to push new products and processes out to market'. In the Russian Federation, on the other hand, over 500 companies were engaged in manufacturing nanotech products in 2013, according to the state corporation Rusnano. In 2010, the UNESCO Science Report had stressed the significance of the Russian Strategy for Nano-industry Development (2007). By 2013, sales of nanotechnology-related products exceeded RUB 416 billion (more than US$ 15 billion). This is 11% over the target fixed in 2007 and means that the industry has grown 2.6 times since 2011.

Almost one-quarter of Russian nanotech products are exported. Moreover, export earnings doubled between 2011 and 2014 to RUB 130 billion. By the end of 2013, Rusnano was supporting 98 projects and had established 11 centres for technological development and transfer (nanocentres) and four engineering companies in different regions. These specialize in composite materials, power engineering, radiation technologies, nano-electronics, biotechnology, optics and plasma technologies, information and communication technologies, etc.. Substantial achievements have been made in such areas as nanoceramics, nanotubes, composites and both hybrid and medical materials. Since its inception in 2011, the Centre for Nanotechnology and Nanomaterials in Saransk has begun manufacturing unique nanopincers for microscopes that allow particles on a scale of 30 nanometers to be captured; this is a real breakthrough, with a multitude of potential applications in electronics and medicine.