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Science, Technology and Innovation in G20 Countries

1. Major science and technology-driven changes reshape global manufacturing and value chains in recent years.

Developments in technology and innovation based strategies have become the basic factors of competitiveness at the level of both countries and companies. One of the basic determinants of economic growth is productivity, which rises with technological change. The focus of new technologies is to enhance productivity and provide solutions for the challenges created by global megatrends in demographics, globalisation and sustainability. At the Brisbane summit in Australia, G20 Leaders set the additional 2.1% growth target by 2018. Within this context, science and technology are critical due to their contribution to the rate of growth as well as its sustainability.

2. Despite being critical for both sustainable growth and the 2.1% target, technology and innovation have not been moved in G20 agenda yet.

The parties made an effort to this end over the past years, the most recent of which was the creation of an Innovation-20 group around the G20 summit in Australia last year, as well as the organization of a conference focusing on sustainable growth and biotechnology. This year, during the G20 presidency of Turkey, technology and innovation have been included among the T20 themes. This theme is significant for taking into consideration global challenges and sustainability as well as shaping the future agenda of G20.

3. Science, technology and innovation have been on the agenda of both developed and developing countries over the past few years.

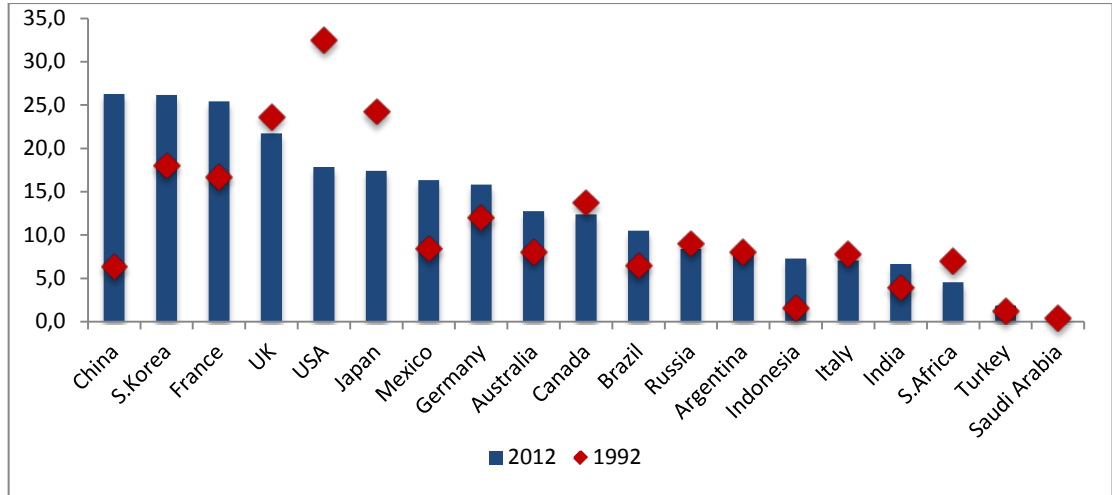
The primary difference between developed and developing countries is the knowledge gap. It is

¹ <http://www.tepav.org.tr/tr/ekibimiz/s/1280/Selin+Arslanhan+Memis>

only possible to bridge the development and income gap between them if and when knowledge gaps can be closed. Together with the structural change brought along by technological developments, companies attain a competitive edge so long as they can integrate into the global value chains. In an age when science and technology globalize at a rapid pace, and open innovation systems and cooperation schemes become prevalent, new technologies accelerate the spillover of knowledge towards closing knowledge gaps.

4. **This note evaluates science, technology and innovation in comparative terms among G20 countries in terms of basic indicators on the one hand and policies and priorities on the other.** Each country engages in similar or different initiatives within this framework, but no taxonomy based on the accomplishments of each country has emerged so far. It will be helpful to focus on complementary aspects for solutions to global issues and sustainable growth, taking the state of affairs identified in this introductory study as a departure point. Furthermore, as innovation has also globalized in our age, a deliberation process on cooperation mechanisms will help in shaping future agendas and drafting a common G20 innovation agenda targeting global issues. On another note, identifying the different models and different focus areas that countries pursue in technology and innovation via this comparative assessment will be important for the formation of a common agenda.
5. **An assessment of the hi-tech structure in G20 countries via export data reveals considerable divergence among countries.** Among G20 countries, China has made the biggest leap forward in the transition to a hi-tech structure over the past 20 years. Within the group, China has the highest share of hi-tech products within its manufacturing exports at 26% (Figure 1), followed by South Korea and France. G20 countries can be categorized in three groups according to the change in their hi-tech exports over the past 20 years. The first group comprises countries that have made the transition to a hi-tech structure in their exports. The second group are countries that have conversely seen the share of hi-tech products in their exports dwindle. This group includes South Africa and developed countries like the US, Japan, and the UK. The third group, which includes Turkey, comprises countries that have not demonstrated any significant development in this sense over the past 20 years.

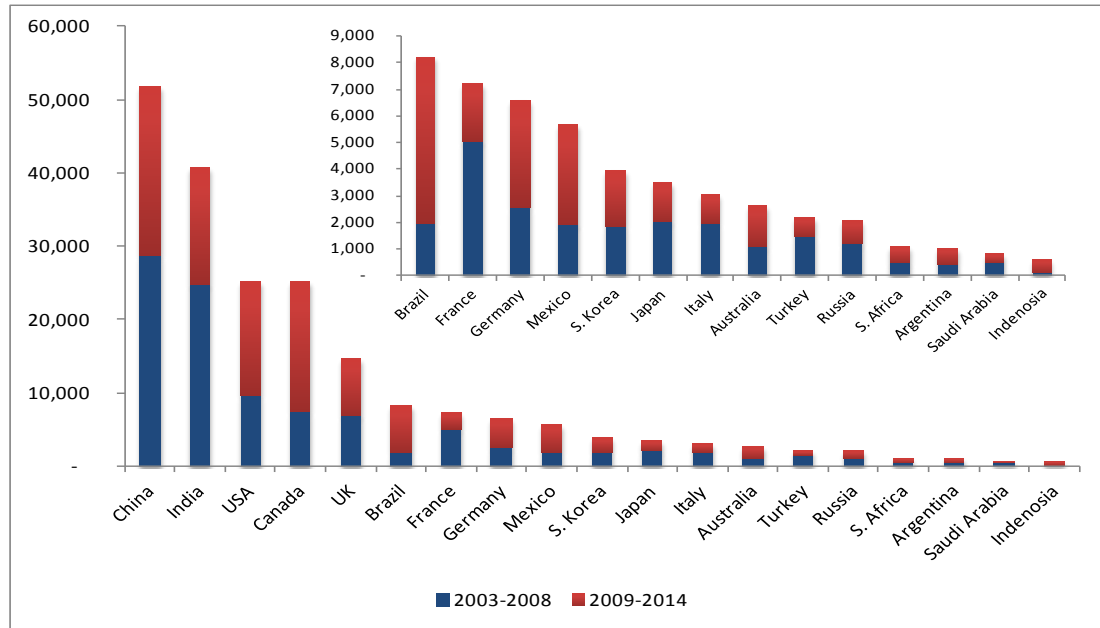
Figure 1. The share of hi-tech products in total manufacturing exports of G20 Countries (%), 1992 and 2012



Source: World Bank, World Development Indicators

- 6. The role of foreign investments with high value added is critical in both the transition to a hi-tech structure and the integration to global R&D value chains.** G20 countries were the destination countries of 73% of the global foreign direct R&D investment flows over the past 12 years. Among these, two developing countries, China and India, lead in terms of attractiveness for foreign R&D investment, with the highest new R&D investment over the past 12 years (Figure 2), followed by the US and Canada. An assessment of these figures should take into consideration what R&D investments entail and how much value added they promise to that particular country. A differentiation of R&D investments as research investments on the one hand and design and test investments on the other indicates that the investments in India in particular are dominated by design and test projects. Furthermore, the impression we get from the literature and the sectoral perspectives is that corporations make their investments in basic research and discovery mostly in their home countries.

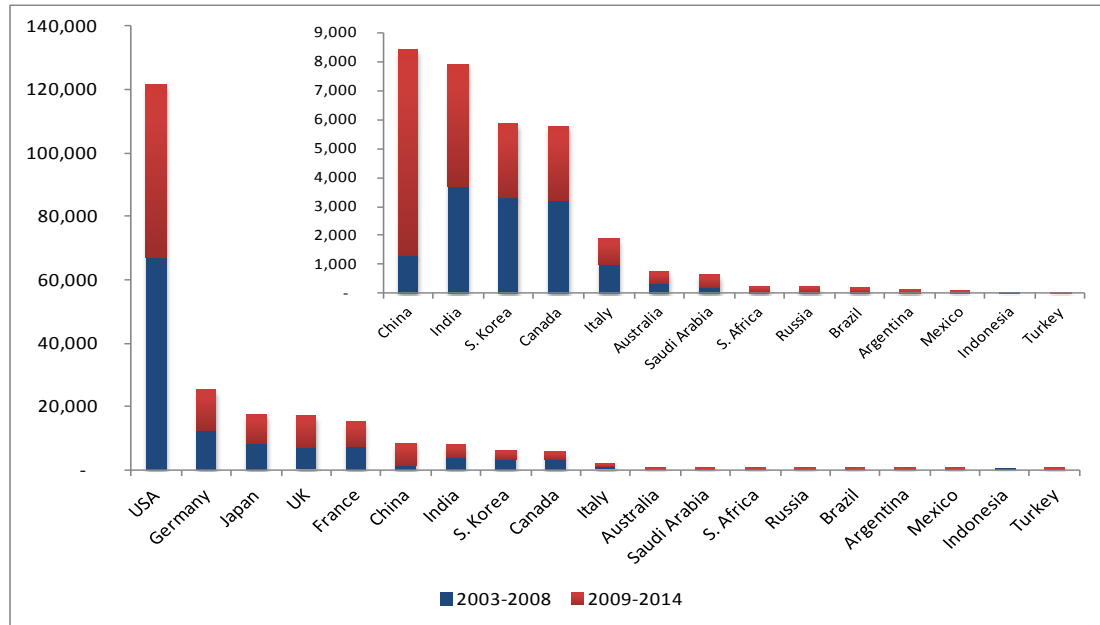
Figure 2. Foreign Direct R&D Investment Flows into G20 Countries (Periods 2003-2008 and 2009-2014)



Source: fDimarkets

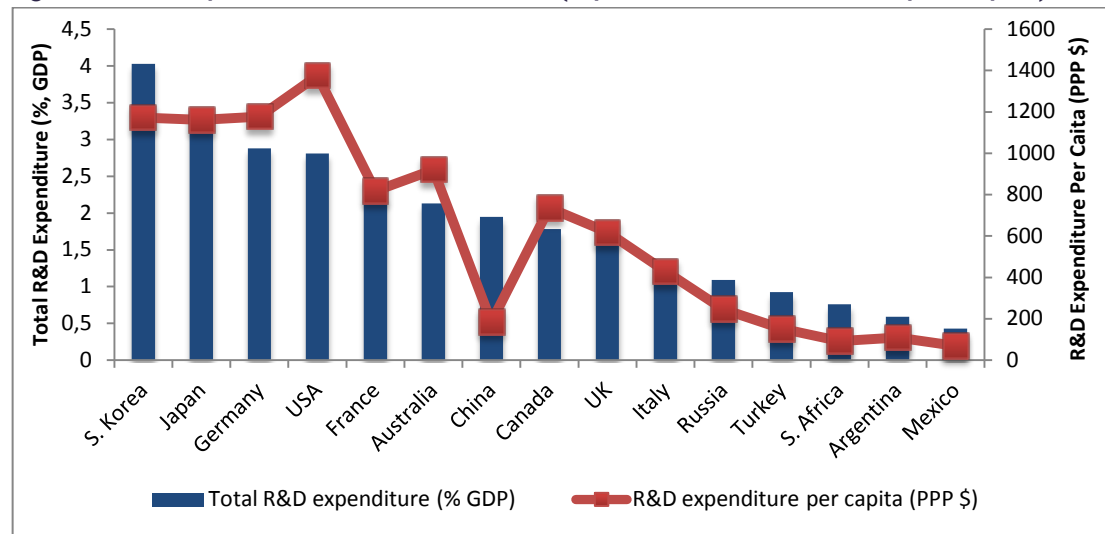
7. **An overview of the source countries of foreign R&D investments suggests a predictable trend.** R&D projects funded by foreign direct investments by G20 countries constitute 82% of the world aggregate. The biggest investor in R&D among these countries by a significant margin is the US, followed by other developed countries in the top five (Figure 3). China, the top recipient of R&D investments, ranks 6th in this category. In terms of foreign investments, it is expected that the attracted investment will create capacity at the local level and lead to a transformation first. Following the transformation prompted by foreign investments on local industry, local companies get the chance to become integrated to global value chains, which then ramps them up to a position as source companies of foreign investment. When we divide the period of the last 12 years into two intervals, we see that China has registered the highest increase as the source of R&D investments. Public policies implemented to attract these projects have been critical in their facilitative role.

Figure 3. Foreign Direct R&D Investments by G20 Countries (Periods 2003-2008 and 2009-2014)



Source: fDimarkets

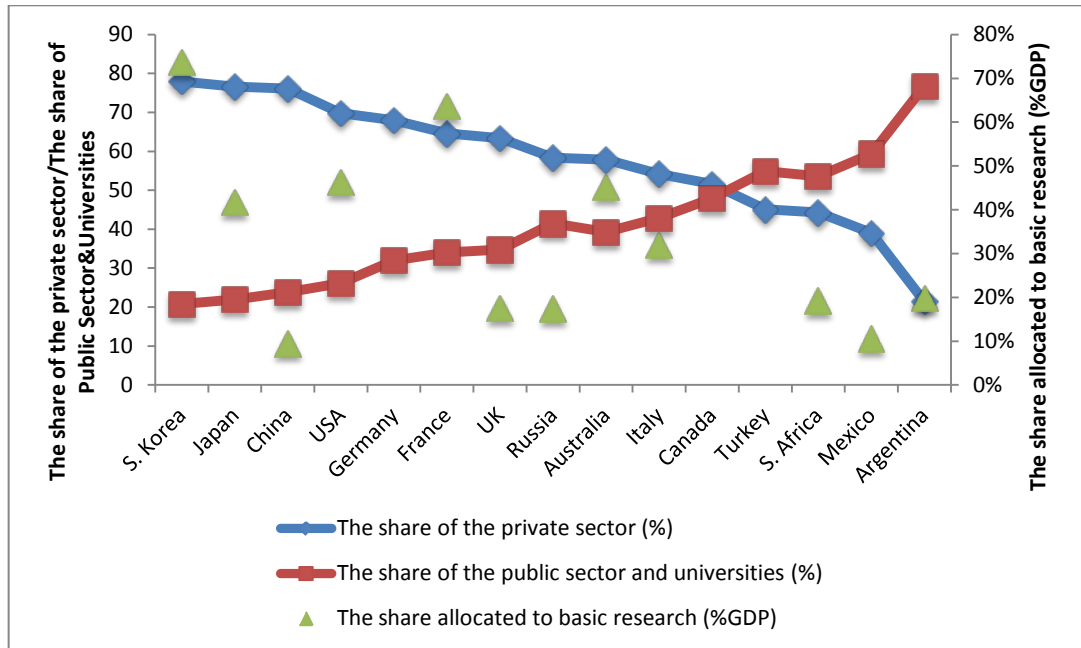
8. Among G20 countries, South Korea allocates the biggest share of GDP to R&D at 4%, followed by Japan and Germany (Figure 4). After China, South Korea records the second highest increase of R&D expenditures as a share of GDP. China, on the other hand, ranks 7th in this criterion despite being among the lowest ranks in early 2000s. The outlook changes when the criterion is R&D expenditures per capita, where China drops again to the bottom ranks among G20 countries. The US has the highest R&D expenditure per capita at around \$1400, followed by South Korea and Germany. Turkey is also ranks among the bottom in terms of R&D expenditure per capita.

Figure 4. R&D Expenditures in G20 Countries (Expenditure as % GDP and per capita), 2012

Source: OECD, 2015

- 9. Whether R&D expenditure is funded by public or private sector provides us clues about the innovation-based strategies of the country.** We can speak of two different models here. In the first model, private sector R&D is at the forefront. The dominance of the private sector in R&D expenditures accelerates the transition to the hi-tech structure in production and exports. However, lapses in research in basic sciences by public research centres and universities in this model will jeopardize the sustainability of innovation-based growth. In the second model, public sector and university R&D takes the lead. Here, the dominance of the public sector and universities in R&D expenditure and the relative inertia of the private sector renders the effectiveness of R&D expenditures questionable. The problematic issue here is the failure to convert at least part of the outputs of basic research in public research centres and universities to applied research or to relay these outputs to the private sector.
- 10. As Figure 5 demonstrates, South Korea has the highest share of the private sector in R&D expenditures among G20 countries.** A success story in terms of its transition, the share of the private sector in R&D expenditures in South Korea has risen from 30% in the early 1980s to 80% today. In the South Korean model, the priority has been a rapid increase in the share of high technology in production and exports, while the trajectory followed can be called “from imitation to innovation.” At the beginning of the transition process, R&D initiatives by the private sector to imitate and improve on existing products were the priority. As the private sector matured and global companies emerged, a different trajectory focused on basic sciences and public sector research has been adopted with the consideration that an innovation process cannot be independent from core basic research. The figure below verifies this storyline and demonstrates that South Korea allocates the highest share of GDP to basic research among G20 countries. This share has increased from 2% in the early 2000s to 8% today.

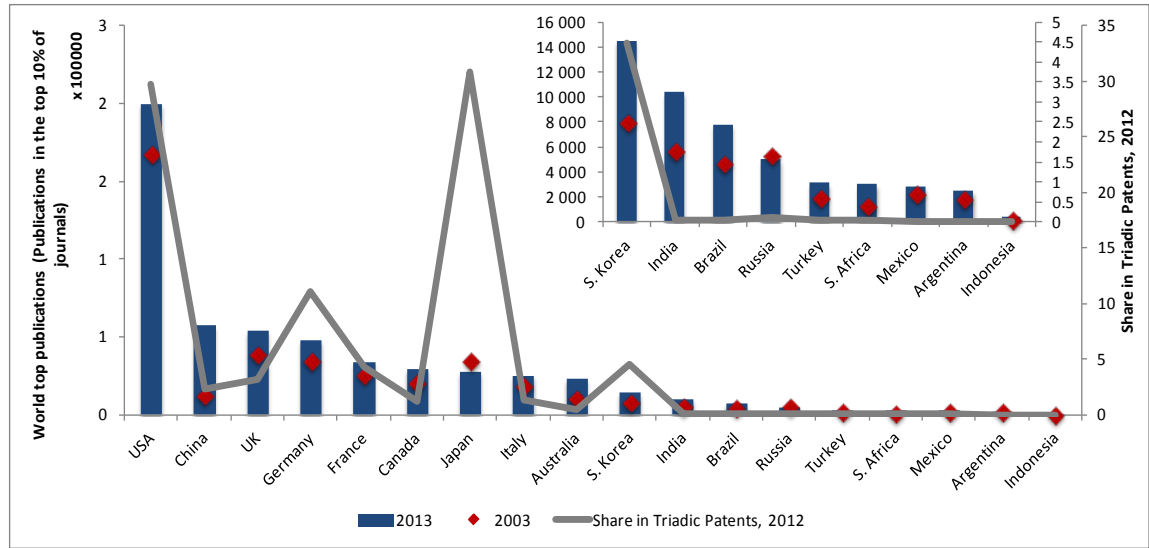
Figure 5. Private Sector vs. Public Sector & University Share in R&D Expenditures among G20 Countries (%) and the Share Allocated to Basic Research (% GDP), 2012



Source: OECD, 2015

- 11. The basic indicators used to assess innovation outputs are the numbers of scientific publications and patents.** In order to put the relative positions of countries into perspective, it is important not to make this assessment solely at the quantitative level and to take quality into consideration. Therefore we used the number of scientific publications that have been published in the best journals for the assessment of scientific material outputs of G20 countries. The US ranks first in this criterion, (Figure 6) which is a predictable trend considering the global rankings of the best research centres and universities. The US is followed by China, which has made the biggest progress over the past decade. The production of high-quality scientific publications and their materialization in the form of inventions depend to a large extent on the quality of the existing research environment as well as the qualifications of the actors. However, as noted above, a certain preference for an innovation model may also be at stake here. The focus on basic research in the South Korean model emerged after the transition from imitation to innovation. The US and Japan rank highest in the number of internationally recognized triadic patents that jointly assess the applications to the three patent offices (the EU, the US, Japan). The parallel between patents and high-quality scientific publications observed in the US does not emerge in the case of Japan, which ranks 7th among the number of scientific publications whereas it ranks first in the number of patents.

Figure 6. World top publications by G20 Countries (2003 and 2013) and the Share in Total Number of Triadic Patents Around the World (% , 2012)



Source: OECD, 2015

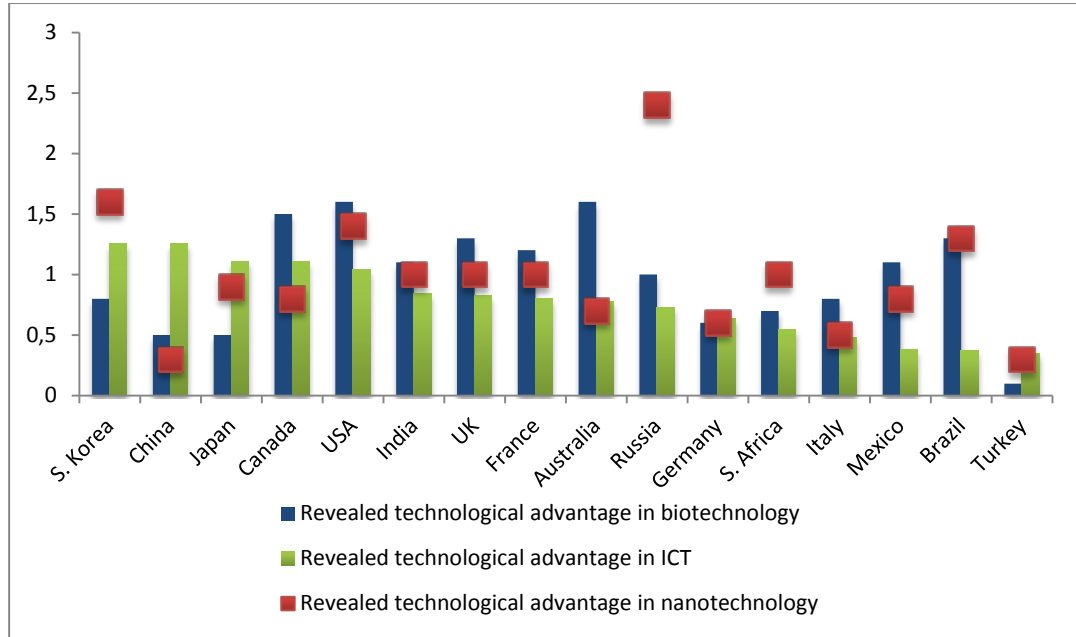
12. The world has recently been undergoing a process of technological transformation. All trends from industry to services, and agriculture to climate change are being reshaped with the impetus of new technologies. As distinct from the industrial revolution technologies, the new and recent technologies are expected to have a major social and economic impact apart from helping the search for solutions to global problems. This expectation partly stems from the fact that new technologies are in fact technology platforms cross-cutting several different sectors.² By doing so, they change the modus operandi in these sectors. Three technology platforms constitute the source of the recent global technological transformation: Biotechnology, nanotechnology and information-communications technologies (ICT).

13. To formulate a new agenda, G20 countries can be assessed in terms of their position in these three new technology platforms. Figure 7 compares the revealed technological advantage of G20 countries in biotechnology, nanotechnology and ICT. The revealed technology advantage (RTA) index provides an indication of the relative specialisation of a given country in selected technological domains and is based on patent applications filed under the Patent Cooperation Treaty. It is defined as a country's share of patents in a particular technology field divided by the country's share in all patent fields. The country with the top revealed technology advantage in ICT is South Korea, demonstrating a similar performance by ranking second in nanotechnology. However, it is yet to prove superiority in biotechnology. The US and Australia have the highest technological superiority in biotechnology, whereas Russia has the highest technological superiority in nanotechnology by a

² Selin Arslanhan Memiş, 'Teknoloji Platformları Yaklaşımıyla Yeni Sanayi Politikası' (The New Industrial Policy from the Technology Platforms Approach), TEPAV Policy Note, 2015.

significant margin. The primary focus in these three technology platforms is devising a solution to global issues relevant to sustainable growth and materializing productivity boosts in different sectors. G20 growth targets and the sustainable growth agenda which has issues like climate change and energy in its focus on the one hand, and the complementary status of countries in these technology platforms on the other, are realities that should be taken into consideration in tandem.

Figure 7. A Comparison of the Technological Superiorities of G20 Countries in Biotechnology, Nanotechnology and ICT, 2013



Source: OECD, 2015

14. The structural transformation in industry and sustainable growth in the economy, tagged along by technology platforms, also entail the need for new policy instruments. The new concern for industrial policy in addition to designing independent policies for the competitiveness in individual sectors, is devising mechanisms for the spillovers of technology platforms that will influence several sectors simultaneously.³ It will be helpful to tackle this issue within the framework of solutions to global issues and sustainable growth for the shaping of the future agenda of the G20. It is also important to develop international R&D cooperation schemes for these issues, which are common concerns answerable by new technology platforms. According to studies by the European Commission and the OECD,^{4,5} the replacement of conventional practices in industry with practices of

³ Selin Arslanhan Memiş, 'Teknoloji Platformları Yaklaşımıyla Yeni Sanayi Politikası' (The New Industrial Policy from the Technology Platforms Approach), TEPAV Policy Note, 2015.

⁴ OECD, 'Industrial Biotechnology and Climate Change: Opportunities and Challenges', 2011.

⁵ EU, BIO4EU Project, 'The Biotechnology for Europe Study: Modern Biotechnology in Industrial Production Processes, energy and the Environment', 2007.

industrial biotechnology led to productivity rises between 10% and 20% in different sectors, as well as reductions in CO₂ emissions of 20% to 40%. Similar trends are emerging in other technology platforms as well. The picture is not what it used to be: industrialization with new technologies also contributes to the efforts to stop or reverse climate change.

- 15. While G20 countries differ in terms of science, technology and innovation, the G20 can be utilized as a platform for R&D cooperation schemes.** National innovation strategies for global challenges such as climate change will not be sufficient and cooperation is required at the multilateral level to create solutions against global issues towards global sustainable growth. This study aims to provide a general overview of the state of affairs in G20 countries, but a more detailed analysis in terms of innovation models and focus areas in technology may help identify complementary roles to build a G20 R&D cooperation. Although each country has similar or different initiatives, there is no taxonomy at hand that indicates their accomplishments. In an age when issues like climate change, food security and natural resource constraints constitute a bigger chunk of the global agenda, countries to devise common solutions. That is why it is of critical importance that international R&D cooperation models are developed among G20 countries based on new technology platforms. These cooperation schemes can accelerate the diffusion of new technologies and contribute to achieving the growth target of 2.1% for the G20, while also creating solutions for global issues.