

The scientific and technological competitiveness of nations: A network analysis

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We use citation data of scientific articles produced by individual nations in different scientific domains to build a bipartite country - scientific domains network to determine the structure and efficiency of national research systems [1]. We characterize the scientific fitness of each nation, i.e. the competitiveness of its research system, and the complexity of each scientific domain by means of a non-linear iterative algorithm able to assess quantitatively the advantage of scientific diversification [3]. We find that technological leading nations, beyond having the largest production of scientific papers and the largest number of citations, do not specialize in a few scientific domains. Rather, they diversify as much as possible their research system. On the other side, less developed nations are competitive only in scientific domains where also many other nations are present. Diversification thus represents the key element that correlates with scientific and technological competitiveness. A remarkable implication of this structure of the scientific competition is that the scientific domains playing the role of markers of national scientific competitiveness are those not necessarily of high technological requirements, but rather addressing the most sophisticated needs of the society. We complement this analysis with a correlation study between the scientific impact of a nation with a normalized measure of RD funds and the level of internationalisation [2]. Finally, we present some new results of a similar approach to the interactions between scientific, technological and industrial innovation dynamics based on mutual citations and co-occurrence in national research systems. This permits to determine the main flows of information from the different sectors of the multilayered innovation space, science-technology-market, and to study and compare the innovation trajectories of different countries in this space. Moreover, it is possible to discover the typical delay for a technological innovation or scientific progress to impact in other innovation layers. In particular we find that disrupting technological innovations typically impact in science and industry with a typical delay of 10-15 years.

[1] G. Cimini, et al., *J. of Informetrics* **10**, 200 (2016).

[2] G. Cimini, et al., *Plos One* **9**, e113470 (2014).

[3] A. Tacchella, et al., *Scientific Reports* **2**, 723 (2012).