BROOKINGS

Education Plus Development

The global triumph of the research university: A driving force of science production

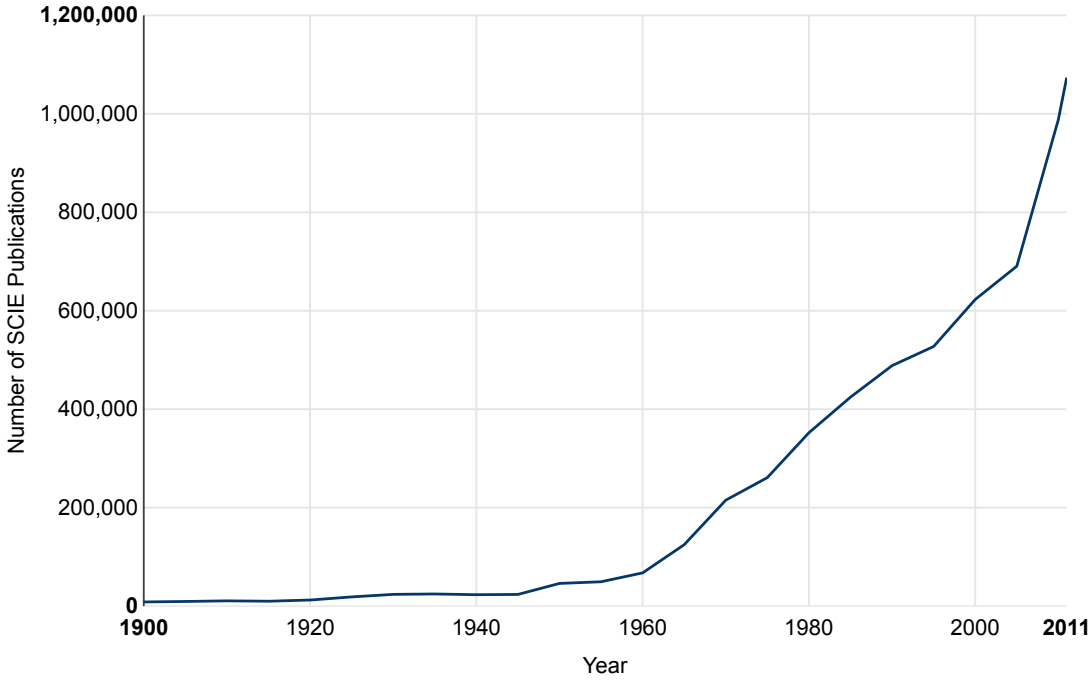
David Baker, Jennifer Dusdal, Justin J. W. Powell, and Frank Fernandez Thursday, March 29, 2018

The demand for higher education in countries around the world has never higher. This increase in education levels has generated many benefits to society, including more knowledgeable citizens, advanced economies, an enhanced longevity. We have also seen countries and universities invest heavily in science, technology, engineering, and mathematics (STEM), including health (STEM+) research and scientific output. This has resulted in unexpected pure exponential growth in science production around the world (see Figure 1). Increased competition, as well as boundary-spanning collaborations, drive unprecedented scientific advancement and technological innovation.

In a book entitled *The Century of Science: The Global Triumph of the Research University*, we explore global scientific developments from the early 20th century to today. University-based research, especially, has risen globally to become the driving force of science production in STEM+ fields. Universities, with their multiple missions of research, teaching, and public service, are uniquely positioned to contribute to scientific output while simultaneously producing the next generation of scientists.

Figure 1: Exponential growth in STEM+ articles published worldwide

1900-2011



Source: SPHERE project database of SCIE publications

Global shifts and the scientific center of gravity

In fact, "big science" was transformed by unprecedented science production, with exponential growth continuing through the contemporary era, at 3.5 percent per year since the 1960s. Early in the growth of scientific paper publication, shown in Figure 1, only a third of all scientific papers were authored by university-based scientists, yet over the next 110 years that proportion grew to 80 percent of the now well over a million annual new publications.

The 20th century has also seen major shifts in regional scientific output. Before mid-century, only a few regions like Western Europe and North America contributed most to the development of scientific research, particularly in universities. The core of science production moved from European countries in the early 20th century to the United States, where higher education and research expanded quickly through private and

public funds. More recently, in East Asia, massive investment and government support over the past few decades, in Japan, China, South Korea, and Taiwan, for example, have triggered explosive growth of science capacity and the ensuing rise in production. Whereas China in absolute terms is catching up to the United States, smaller countries, like South Korea and Taiwan, have also dramatically expanded their higher education systems, resulting in rapid growth in scientific productivity.

Europe and North America, however, remain essential players in the scientific arena, as their centuries-old research universities are projected as role models worldwide. These eminent universities also provide vast opportunities for collaboration, a key driver of the rise in scientific output globally. In fact, the median scientific article now is the result of collaboration among scientists in more than two countries. This emphasizes the global quality of the scientific enterprise, with over two hundred countries participating in publishing "gold standard" research articles in the leading journals analyzed.

The triumph of the research university

Throughout the world, the demand for higher education has steadily grown, especially since the mid-20th century. This led countries to invest in higher education, science, and collaborative efforts, leading in turn to robust infrastructure and innovative networks, growth in the number of scientists, and scientific output. Among other organizational forms that produce most research—extra-university research institutes, government agencies, private companies, and hospitals—research universities have remained the driving force behind the global growth of scientific productivity, as they connect all types of knowledge-producing organizations. Whereas research universities contributed half of all publications in France and three-fifths in Germany, in the U.K. even two-thirds were by university-based researchers. In the United States, with its world-leading universities, four-fifths of all published articles include at least one university-based researcher.

Networks creating competition and collaboration

As a result of systematic internationalization, and in the case of Europe, Europeanization, we observe growing global competition, in particular among dominant science-producing regions (North America, Europe, and East Asia), as well as between organizations and research groups. Yet at the same time, there is vastly more

international collaboration between individual scientists and organizations. Especially since the 1980s, communication technologies and accessible international travel have contributed to the establishment of truly global scientific networks responsible for solving many of the most crucial scientific puzzles.

Conclusion

The evolution of journal publications in STEM+ across the 20th century up to the current decade shows major shifts in the global and regional development of science. The remarkable exponential growth of science reflects two contrasting and simultaneous trends: rising competition across nations and international (and other forms of) collaboration among scientists. The future of science is global because the number of countries producing more than 0.1 percent of STEM+ papers in the world has increased from 18 in 1900 to 55 in 2010. As a result of systematic historical and institutional analysis, we show that research universities provide beneficial contexts for research. The university is likely to maintain its central position at the heart of scientific communities spanning the globe.