The Trump administration is considering measures to prevent Chinese citizens from being involved in sensitive research at American universities. Alessandro Iaria, Carlo Schwarz and Fabian Waldinger look back at history to reveal the potential damage that such policies might cause to scientific progress and technological innovation.

The Trump administration is considering measures to restrict Chinese citizens from performing sensitive research at American universities and research institutions. The boycott appears to be motivated by fears that Chinese researchers may be carrying out espionage activities and handing over sensitive US discoveries to the Chinese government.

The exact details of the restrictions are still under discussion but they would probably affect graduate students, postdoctoral researchers and employees of high-tech companies in the United States on temporary visas. Roughly 300,000 researchers every year could fall victim to these measures.

While the overall effects of such a boycott are hard to foresee, there are lessons from history that can inform policy-makers about the possible detrimental long-run effects for scientific progress and technological innovation. In a recent study, we explore the repercussions of a boycott against scientists that arose as a result of the First World War.

As that conflict began, the world split into the Allied camp (the UK, France, later the United States and several smaller countries) and the Central camp (Germany, Austria-Hungary, the Ottoman Empire and Bulgaria). The involvement of scientists in the development of chemical weapons, and the extremely nationalistic stance taken by many in support of their homeland pitted the opposing scientific camps against each other.

Immediately after the end of the war, Allied scientists enforced a boycott against Central scientists, which separated scientists from opposing camps until the mid-1920s. Our study finds that the increased barriers to international scientific
co-operation during the boycott led to a
decline in the number of papers published
by scientists on either side.

Those scientists who had relied on
‘frontier research’ from abroad – for
example, US biochemists who relied
on frontier research from Germany –
published fewer papers than scientists
who used to work with frontier research
from home, such as US biologists who
mostly relied on frontier research from
within their own country. As a result, the
productivity of US biochemists declined by
33% relative to US biologists. Importantly,
the boycott did not only affect Central
scientists but the entire international
scientific community.

Affected scientists also produced fewer
scientific breakthroughs, measured by the
introduction of novel words in paper titles
and by nominations for a Nobel prize, and
fewer of their scientific discoveries found
application in patents. These results show
that barriers to international scientific
co-operation not only slow down the
production of basic science, but that they
also harm the application of science in the
development of new technologies.

The importance of frontier
knowledge for the generation
of ideas

The creation of ideas is crucial for scientific
progress, technological innovation and
economic development. One of the major
inputs in the creation of new ideas is
existing knowledge, something described
most famously by Isaac Newton in his 1675
letter to Robert Hooke, where he wrote:
‘If I have seen further, it is by standing on
the shoulders of giants.’

This quotation not only emphasises
that scientists build on existing knowledge
to produce new ideas, but also that
knowledge produced by scientific ‘giants’
– that is, frontier research – is particularly
important. Access to existing knowledge
not only fuels basic scientific progress, but
it is also key for the development of new
technologies.

Scientific articles that cite frontier
research are more likely to become a ‘hit’
– that is, to end up in the top 1% of the
long-run citation distribution. But while
citing the research frontier is correlated
with writing hit papers, it is not clear
whether access to the research frontier
has a causal effect on the production of
high-quality ideas.

The correlation could be motivated by
networks of highly productive scientists,
who mostly cite each other’s research,
such as the physicists who advanced
the quantum revolution in the 1920s
and 1930s. Because of this and other
endogeneity concerns, researchers have
not been able to isolate empirically the
causal effect of frontier knowledge on the
creation of ideas.

To overcome these challenges, we
study the dramatic decline in international
scientific cooperation that occurred during
the First World War and the early post-war
years. Allied scientists were suddenly cut
off from their peers in Central countries, in
particular from Germany, a country whose
scientists had received more than 40% of
Nobel prizes in physics and chemistry
in the pre-war period. Similarly, Central
scientists were cut off from their peers in
Allied countries; in particular from the UK.
(20% of Nobel prizes), France (15% of Nobel prizes) and the United States, the rising scientific superpower.

This schism in the scientific world persisted during the post-war years because Allied scientists organised a boycott against Central scientists to punish them for their involvement in the war effort. The boycott was strongest in the first years after the war and lasted until 1926. We document that the delivery of international journals was severely delayed, and that international conferences were cancelled or only involved scientists from one of the warring camps (see Box 1).

**Measuring the interruption of international knowledge flows**

We show that the First World War and the ensuing boycott against Central scientists severely interrupted international scientific cooperation. After the conflict began, papers cited relatively less research from outside the camp, compared with

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**Box 1:**

**Central scientists at the Solvay Conferences in Physics**

A. 1911

B. 1913

C. 1921

D. 1924

E. 1927

F. 1930

These are historical pictures of delegates at the Solvay Conferences in Physics. Circles indicate delegates from Central countries. The first Solvay Conference was organised in 1911 and was attended by the leading physicists of the time, including Marie Curie, Ernest Rutherford, Max Planck, and Albert Einstein. In that year, nine of the 24 participants came from Central countries. In 1913, nine of the 31 participants came from Central countries.

During the war, the Solvay Conferences were discontinued. The first post-war conference took place in 1921. Scientists from Central countries were not invited. No one was invited to the 1924 conference.

By 1927, the boycott had ended and five of the 30 participants came from Central countries. The 1927 conference is possibly the most famous scientific conference ever organised. It took place at the height of the quantum revolution, and 17 of the 30 participants were current or future Nobel Laureates. In 1930, six of the 36 participants came from Central countries.
research from home. Similarly, papers cited less research from foreign countries inside the camp, but this decline was markedly smaller. Importantly, the decline in international citations did not only affect average quality research but also research at the scientific frontier.

We also investigate whether the collapse in international scientific cooperation affected the direction of research in the opposing scientific camps. Using the machine-learning technique known as Latent Semantic Analysis, we document that the similarity to papers from outside the camp fell sharply after the onset of the First World War and then slowly recovered during the 1920s.

**Effects on scientific production and technological applications**

In the second part of our study, we show that reduced international scientific cooperation led to a decline in the production of basic science and its application in new technology.

We compare productivity changes for scientists who, in the pre-war period, relied on frontier research from abroad, to changes for scientists who relied on frontier research from home. After 1914, scientists who relied on frontier research from abroad, and who were now suddenly cut off from it, published fewer papers in top scientific journals.

The interruption of international knowledge flows led to stark declines in the production of research deemed worthy of a Nobel prize nomination. Furthermore, scientists introduced fewer novel scientific concepts, as measured by the introduction of novel scientific words – for example, magnetron and electroencephalogram.

Scientific fields that were suddenly cut off from the research frontier produced fewer scientific concepts that were used in patents. Thus reductions in the output of basic science also had a negative effect on the development of new technologies.

**Implications for science and innovation policy**

These results show that access to frontier research is key for the production of ideas, including pathbreaking ones. Facilitating access to frontier research can therefore substantially increase the production of basic science.

Access to the knowledge frontier needs to be interpreted in a broad sense: not only physical access to journal articles, conferences and research seminars; but also discerning the thin, ever-advancing and truly pathbreaking edge of the frontier from the millions of scientific papers published every year.

Science policy should be geared towards the facilitation of access and capitalising on the potential catalytic effects of frontier research in enhancing scientific progress. Providing open access to journals may partly achieve this goal. But discerning what constitutes frontier research requires skills that are hard to develop without guidance from leading scientists working at the forefront of scientific endeavour.

Personal contacts are particularly useful because face-to-face interactions are a superior way of transmitting ideas. High-quality doctoral programmes at universities where frontier research proliferates can therefore help to put young scientists on the most promising career paths. Even more established scientists can profit from short- and long-term visits at centres of science, and from attending high-quality conferences and research seminars.

Finally, our results show that access to frontier research not only affects the production of basic science, but that it also increases the application of science in the development of new technology. Policies that widen access to frontier research could therefore benefit society beyond the confines of science itself.

**Policies that widen access to frontier research could benefit society beyond the confines of science itself**


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