ZEW policy brief

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More R&D, Less Growth? China's Decreasing Research Productivity in International Comparison

Innovation is widely considered the primary driver of growth in high-income economies. The efficiency by which an economy is able to transform research & development (R&D) inputs into output growth is captured by the measure of research productivity. In a recent study we were able to show that research productivity is declining over time, not just in the U.S., which has been shown before, but also in China and Germany. This implies that new ideas and innovations are universally harder to find. In Germany, business R&D spending has increased by an average of approximately 3.3% per year during the last three decades. At the same time, research productivity has fallen on average by 5.2% per year, which is very similar to the estimates obtained for the U.S. In China, we observe a substantial expansion of research activities during the first and second decade of this century, indicated by a growth rate of 21.9% in research spending. The resulting output growth, however, is not proportional to such inputs, which is reflected by a 23.8% decrease in estimated research productivity, or a reduction by half in only three years. We argue that China's substantial decrease in research productivity is related to diminishing returns to technological catching-up as well as mission-driven policy targeting technological self-sufficiency and national security.

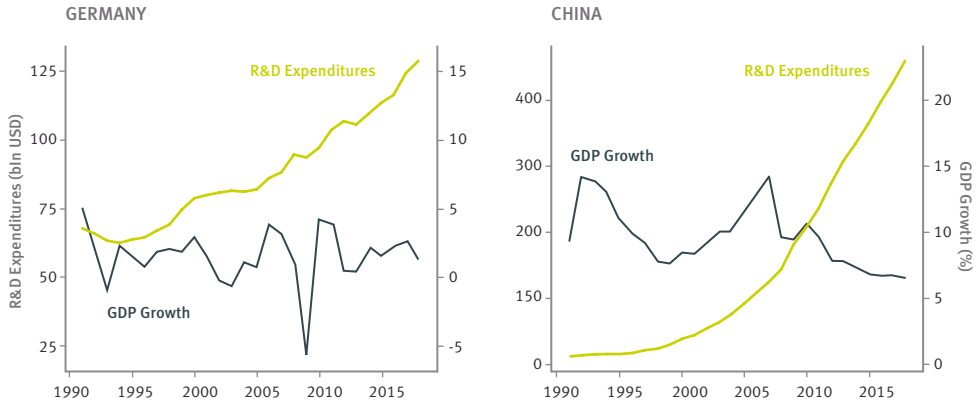
KEY MESSAGES

- Ideas are not only getting harder to find in the U.S. We provide evidence for a decline in research productivity in Germany and China.
- We relate China's particularly strong decline in research productivity to diminishing returns to catching-up oriented R&D and its mission-driven innovation policy.
- Innovation should once again become a top priority in EU policy-making to avoid falling behind in technological progress and global competitiveness.

Innovation and R&D are main drivers of economic growth

Economists have proposed that a decline in research productivity at the global technology frontier could be the main reason for sluggish growth rates in recent decades. In many advanced economies substantial increases in R&D investment are coupled with stagnating or declining GDP growth (see Figure 1 for Germany and China). As innovation and R&D are considered main drivers of growth, these trends suggest that the research productivity, by which R&D efforts are transformed into new products and more efficient production processes, has been decreasing over time.

FIGURE 1: R&D INVESTMENT AND GDP GROWTH RATES IN GERMANY AND CHINA



Gross domestic spending on R&D measured in billion USD, constant prices using 2010 as a base year. Gross domestic product (volume, expenditures approach), annual growth rates measured in percentage.
Source: OECD

U.S. and German research productivity has been decreasing

This hypothesis has recently been confirmed for the U.S. economy, where research productivity has been declining annually by around 5.3%, which implies a reduction by half (the so-called 'half-life') over an approximate time frame of 13 years. However, the U.S. has also consistently been the world technology leader since the Second World War. Such a substantial decline in research productivity could therefore simply reflect a downward convergence towards the average high-income country. For this reason, we examine evidence from the economic and innovation powerhouses of Europe and Asia in order to see how widespread the phenomenon of a declining research productivity truly is.

In a newly published study, we analyze firm-level data for Germany and China that spans up to three decades. We compare firm growth – measured by different output indicators such as sales, number of employees, labor productivity and market capitalization – with R&D investment in order to assess the development of research productivity in the long term. If research productivity remains constant, firm growth and R&D spending should roughly develop proportionally. However, this is not what our findings suggest. In Germany, business R&D spending has increased by an average of around 3.3% per year during the last three decades. At the same time, research productivity has fallen on average by 5.2% per year, which is markedly similar to the estimates obtained for the U.S.

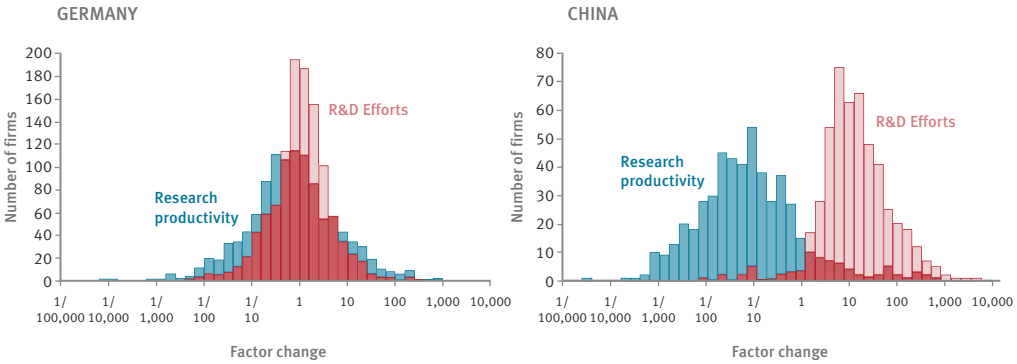
Infobox: Research productivity in the long term

The idea that growth is the result of engineers and scientists, employed by firms, developing new ideas and producing innovations at a certain rate lies at the heart of most standard economic growth models in macro and development economics, which captures the **research productivity** of R&D efforts:

$$\textit{Economic Growth} = \textit{Research Productivity} \times \textit{R\&D Efforts}.$$

A constant research productivity would thus imply constant economic growth rates for a given level of R&D spending. Figure 2 plots the distribution of factor changes across decades for the firms in our sample. If research productivity was constant, the blue histogram would center around one, which is clearly not the case. While most firms in our data have substantially increased their R&D efforts during the last decades, growth rates did not go up proportionally, implying a general decline in research productivity over time.

FIGURE 2: FIRM-LEVEL DISTRIBUTIONS OF FACTOR CHANGES IN RESEARCH PRODUCTIVITY AND R&D EFFORTS



Histogram of factor changes found for all firms in our sample. A factor change equal to two would imply a doubling of the respective variable over two consecutive decades. By contrast, a factor change of 0.5 would imply a halving.

RAPID DECLINE OF RESEARCH PRODUCTIVITY IN CHINA

China has undergone the largest decline in research productivity

China has exhibited an outstanding expansion of research activities since the turn of the century, with a 21.9% growth rate in research spending. The resulting output growth, however, is not proportional to such inputs, which is reflected by a 23.8% decrease in estimated research productivity, or a half-life of only around three years. In comparison to high-income countries such as the U.S. and Germany, China has undergone an even larger decline in research productivity over the last two decades. However, due to China's more dynamic economic development we caution against a simple extrapolation of growth rates into the future. For example, when we analyze the last decade alone, China's research productivity declines by only 7.3% per year, which comes closer to Germany's 5.2% long-term figure. Our findings not only indicate that China is converging to the global research frontier but also imply that returns to catching-up oriented R&D – which pursues the low-cost implementation of existing ideas and technologies – are diminishing.

Either way, further growth is needed for China to avoid the so-called 'middle income trap'. Despite several decades of ongoing development, Chinese GDP per capita level (purchasing power parity) has yet to reach the average income level of an upper-middle income country. Against this backdrop, the Chinese State Council strives for greater, innovation-driven growth, and world leadership in science and technology by 2050. The upcoming fourteenth Five-Year Plan (2021-2025) emphasizes innovation as the driving force to double China's GDP and income per capita until 2035, implying output growth rates of around five percent annually. Given our results on declining research productivity, the additionally required R&D inputs will be substantial. These ambitious targets are supported by government policies that not only incentivize more research activities, but also lay out a mission-driven direction for innovation. This increasingly inward-looking and mission-driven nature of Chinese innovation policy suggests that research productivity might continue to decline faster in China than elsewhere.

Knowledge production at the technology frontier crucially relies on creative freedom, serendipitous discovery, and (international) exchange. If these important channels of idea creation are further curtailed, significant knowledge-based productivity growth will be harder to sustain in the future. More government support for innovation is also not a safe way out. Instead of addressing funding deficiencies in the Chinese innovation system, R&D policy may instead crowd out private investments in R&D, or allocate resources towards less productive activities. Explicitly mission-driven policy may be even more harmful if government-supported technologies that contribute to strategic government purposes, such as national security, turn out to be economically inferior compared to the choice of the market. While China's innovation policy often addresses cutting-edge innovation and prestige projects, the desire to leap-frog and move into radically new products and technologies may come at huge opportunity costs. If China fails to generate innovation that matters for output growth, both global leadership in science and technology and higher levels of income might move beyond reach.

CHINA AS A ROLE MODEL FOR THE EU?

China's innovation policy cannot be a benchmark for Europe

China's approach to science, technology and innovation policy cannot serve as an example for the European Union. While China exhibited impressive growth rates during the last two decades, innovation-led growth at the global technology frontier relies on fundamentally different drivers than the catching-up process of an emerging economy. Furthermore, market-oriented reforms have been more important to economic performance than subsequent government intervention in these markets. In light of this, the increasingly mission-driven approach to innovation policy that is also pursued by the EU has to be viewed critically. Because of the crucial role of serendipity in producing breakthrough innovations, Europe should favor bottom-up approaches to R&D that do not remain limited to specific areas of application or rely on predetermined research goals set by the government. Instead, fighting the trend of slowing growth and declining research productivity requires the EU to further internationalize its policy initiatives and reduce fragmentation among innovation actors, invest more into education to account for longer training periods, and secure the availability of a sufficient level of public R&D support over the business cycle. It is essential that innovation becomes a top priority in EU policy-making again, otherwise technological progress and global competitiveness are likely to diminish in the not too distant future.

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