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Supporting Basic Research by Classification to Promote Whole-Chain Innovation of Disruptive Technology

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Abstract: In recent years, China has made great progress in science and technology, but it still falls behind in terms of key technologies. To promote original innovation in science and technology and fundamentally overcome its weakness in key technologies, China should focus on basic research. To examine how basic research leads to the creation of disruptive technologies, this paper expounds the connotations of basic research and categorizes it into four types according to its targets: basic research toward major scientific objectives; basic research driven by national demands; talent-based basic research for free exploration; and basic research aimed at practical application. Based on the analysis of the characteristics and development needs of the various types of basic research, we propose the developmental suggestion of providing differentiated and stable support to promote whole-chain disruptive technology innovation.
Keywords: basic research; disruptive technology; differentiated support

1 Introduction

China's reform and opening up policy has brought about great progress in the nation's economy, society, science, and technology in the past four decades. However, it is not enough to break through in some difficult and core technology to accomplish the country's objective to go from "standing up" to "getting rich" and "getting strong." The development of science and technology in China needs to achieve breakthroughs at each key point. There is no doubt that China's scientific research leads the world in terms of certain technical indicators. For example, the University of Science and Technology of China has set many world records in the research on quantum information. Recently, a team led by Prof. Pan Jianwei achieved a record 18-qubit entanglement with six photons, each with three degrees of freedom [1]. However, because quantum information research aims to realize practical and disruptive technology, it needs more original innovation from basic research to precise measurement technology in a comprehensive and complete chain. Otherwise, we will eventually encounter a blockage in the full chain from science to technology. Thus, although China has achieved many world records in various fields, there are few original breakthroughs in terms of scientific ideas and technological revolutions, and many of those achieved can only be considered integrated innovations as a result of extremely high investment. Therefore, to fundamentally solve the key problems that restrict the development of science and technology, we must focus more time and effort on basic research. It should be noted that different types of basic research will lead to technological breakthroughs with different time scales.

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2 The connotation of basic research

The main task of basic research is to explore the fundamental laws of nature and discover new phenomena. Usually, basic research does not lead directly to the creation of practical and disruptive technological innovations. It is often interest-driven, but should also be demand-oriented. Basic research can be viewed in both a broad and narrow sense. In the broad sense, basic research generally refers to all scientific activities that can trigger scientific innovation and technological breakthrough; in the narrow sense, basic research refers only to those purely scientific explorations that do not aim directly at application. The latter cannot and does not require short-term solutions to key problems. Pure basic research is related mainly to physics, mathematics, and other basic disciplines, which are the "foundation of the foundation." Different types of basic research have different time scales for achieving scientific goals and technological innovations. Accordingly, differentiated support should be provided considering our limited comprehensive national strength and urgent needs. To promote original innovation in science and technology in China effectively, we need to distinguish four categories of basic research: basic research toward major scientific objectives; basic research driven by national demands; talent-based basic research for free exploration; and basic research aimed at practical application. Different types of basic research should be provided differentiated and stable support; otherwise progress in disruptive technology will be hindered. Institutions engaged in various types of basic research should define their own position, not only to face the frontiers of science, but also to meet the challenges of national strategic needs. Application-oriented basic research should focus not only on solving easy problems, but also on addressing tough issues. Otherwise, such research will not be able to form a comprehensive bedrock of strength for China's key technologies.

3 Supporting basic research by classification to promote whole-chain innovation of disruptive technology

In the following section, we discuss the stable support modes for the different types of basic research.

3.1 Basic research toward major scientific objectives

This kind of basic research is represented by big national science projects and large-scale scientific facilities, which are costly. As a developing country, China must focus on what our abilities allow us to achieve and decline projects that do not have clear scientific objectives. Major scientific objectives are almost always derived from original scientific theories. For example, the discovery of the Higgs boson by the Large Hadron Collider at CERN was predicted more than 50 years ago by the Standard Model of elementary particles, which describes the energy scale of the Higgs boson. Another example is the Laser Interferometer Gravitational-wave Observatory, which detected gravitational waves that were described about a century ago in Einstein's theory of general relativity. Of course, some major scientific projects, such as inertial confinement fusion (ICF), face difficulty in achieving their objectives, but the intermediate process is also of significance, such as the physical simulation of the nuclear detonation process in ICF. Considering our limited national strength, it is not advisable to blindly fund research projects without clear scientific objectives. In addition, for this kind of basic research, construction and operation are equally important. Therefore, we must change the previous support mode of "construction first, operation second," reinforce the support for operation, and fully achieve major national scientific objectives. Once the scientific objectives of such research are determined, they may be carried out over a long period of time, and then, achieving the world record on a single indicator should not be the only objective.

3.2 Basic research driven by national demands

This kind of basic research is represented by China's future national laboratories, which must be designed at the national level; it has a clear demand scenario and national mission. The China Academy of Engineering Physics and some national laboratories in the United States fall under this category. Although such basic research must be oriented toward national missions, it should not be managed in the "production" mode. The funding mode for such research could take inspiration from the Defense Advanced Research Projects Agency to focus on original innovations driven by long-term goals and make up for shortcomings through civil–military integration. To solve the problems of national defense and national security, basic research should assist in determining the direction of key technologies, to avoid technical misjudgments and "strategic deception" by western countries. The scientific tasks in this kind of research must be cohesive and the specific research work should not be fragmented. Our government needs to be patient with respect to the development of key technologies driven by basic research. The

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current evaluation mechanisms should be oriented toward key problems, not just driven on paper. Such basic research should be driven by national demands, oriented to key science and technology problems, and targeted at the research and development of practical equipment.

3.3 Talent-based basic research for free exploration

This type of basic research is represented in the research supported by the National Natural Science Foundation of China and universities. It aims at discipline construction and talent cultivation by developing a conducive environment for significant scientific breakthroughs, which require long-term and stable support. Therefore, we need to change the current evaluation model based on quantity; otherwise, it will prevent young talent from concentrating on and overcoming difficulties in major scientific issues. China should create a healthy environment for the growth of talent and overcome the huge losses caused by the disorderly flow of talent in recent years. It is important to avoid administrative intervention in talent evaluation. The national and local governments and departments should not solely pursue the GDP role of talent for their political ends while failing to focus on the high-quality cultivation of talent. In fact, solving major scientific problems should be the driving force in attracting talent. In addition, there should not be too many titles for leading talent, and the incidental benefits should be reduced. We hope that all national talent programs can be unified and the types of titles can be reduced, to create a new style of talent pooling across the country. Otherwise, the younger generation will always be catching up with current trends and will lose originality while pursuing one title after another. Therefore, we must create an environment for talent to prioritize efficient and hard work. To some extent, achievements of pure basic research should be materialized in original scientific papers; however, talent cannot be judged by papers alone. There can be titles in the process of talent cultivation, but not for their own sake. Only in this way can there be an objective and reasonable evaluation standard to stimulate original scientific innovation.

3.4 Basic research aimed at practical application

The goal of this kind of basic research is practical application that can solve key problems in technologies within a relatively short time scale. Therefore, there should be an evaluation mechanism guided by market objectives. Industry investment should be the major component supporting application-oriented basic research, and there should be a policy mechanism to solve the problem of severely insufficient funding of industrial research in China. Taking research on semiconductors as an example, in the past few decades, the government has invested heavily in this area and related fields. However, this approach still lacks organization and continuity, and has not yet led to the formation of a comprehensive research chain for chip technology. At present, China should not support application-oriented basic research directly through large-scale administrative interventions. For this type of basic research, we should not rely excessively on government support, but instead, should give full play to the core role of market adjustments. Support from the government should be limited to a few essential directions with the goal of achieving results in a short period of time, and should gradually be withdrawn from application-oriented basic research. The government should encourage industry sources to support basic research projects through policies or even by restricting funds. When deciding on support for specific projects, attention should be paid to their technological maturity, and their technical direction and feasibility should be judged scientifically. We must realize that using the role of market adjustment is not the same as blindly using high-risk loans for financing, or other such options, to transform immature scientific research into market products, especially in military-related fields such as national defense and security. In addition, media propaganda should be carefully controlled to prevent the public from being misled into the fantasy of “technology populism” and “easy catching-up;” otherwise, it will affect the national strategic and technical structure and affect national security.

4 Conclusion

Based on the classification of basic research, we briefly illustrate the differences in the requisite support modes. It should be noted that the disruptive technological innovations resulting from the four types of basic research are related. For example, the significant scientific engineering demands of CERN gave birth to the World Wide Web. Therefore, it is important to be patient when supporting various types of basic research, and to expect the discovery of unintended research byproducts in the formation of disruptive technologies.

Reference

[1] Wang X L, Luo Y H, Huang H L, et al. 18-qubit entanglement with six photons' three degrees of freedom [J]. Physical Review Letters, 2018, 120(26): 502–506.