Can Philosophy Be Midwife of Scientific Innovation?

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Abstract
Based on the rapid developments in economy and society in past decades, China has already become one of the largest countries in scientific research and technology development. However, China is still far from being a leading country in science and technology. Can philosophy help to promote China’s scientific innovations? It is argued in this paper that philosophy, in its proper role, can help by facilitating the growth of philosopher-scientists in China, who may play key roles in some original innovations that are in need in China.

Keywords
scientific innovation, philosophy, philosopher-scientist, interdisciplinary interaction
Can Philosophy Be Midwife of Scientific Innovation?

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Abstract: With the rapid development of the economy and society in past decades, China has already become one of the largest countries in scientific research and technology development. However, China is still far from being a leading country in science and technology. Can philosophy help to promote China’s scientific innovation? It is argued in this paper that philosophy, in its proper role, can help by facilitating the growth of philosopher-scientists in China, who may play key roles in some original innovations needed in China.

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With the continuous development of the economy and society in the 21st century, China also enters its prime in the field of science and technology. Quantitative indicators and data indicate that China has already become one of the largest countries in scientific and technological development. However, China is still far from being a leading country in science and technology, where the prominent problem of lacking pioneering innovative talents and results has to be settled urgently. Can philosophy help to solve the problem? Can philosophy be the midwife of scientific innovation? What demands will the task create for philosophy? How will philosophy interact with science?

This paper explores the role of philosophy in promoting major scientific innovation in the light of American scholar Thomas Kuhn’s theory of alternate evolution of scientific development in different stages. Besides, this paper presents that philosophy can indirectly cultivate leading innovative talents and promote innovations in science and technology by creating favorable conditions and atmosphere for the growth of philosopher-scientists in China, thereby enhancing the innovation capacity of science and technology in China.

1 Transformation from a large country to a leading country in science and technology

1.1 China has become a large country in science and technology

Recent years have seen a strong growth momentum for research and development (R&D) input in China, and China has the world’s fastest growth rate, with the total input approaching that of the US in 2018[1]. The total R&D input of both countries accounted for 55% of the world’s total in 2018. In the recent ten years, the number of R&D researchers across the world has increased rapidly, with the fastest growth occurring in China. R&D researchers in China have always been growing evidently from about 1.15 million in 2009 to 1.86 million in 2018, showing an increase of about 62%. Since the year of 2011, the total number of R&D researchers in China has ranked first in the world.

Research papers are an important indicator for the basic research output by countries. From 2009 to 2018, the US took an invincible lead in research papers, taking up about 27% of the world’s total; research papers in China maintained robust growth, and the annually published papers increased from 204,000 (9.37% of the world’s total) in 2009 to 490,000 (18.61% of the world’s total) in 2018, making China the second-largest producer of research papers behind the US and far ahead of other countries. Highly cited papers are top papers of high quality and influence published in scientific research, reflecting the overall research quality of academic institutions and the influence and competitiveness of academic leaders. Publication of highly cited papers by different countries from 2009 to 2018 shows that the US ranked first with an impregnable 65,000 papers, of which about 0.98% were highly cited; there were nearly 27,000 highly cited papers in China, which, however, accounted for only 0.79%; highly cited papers in the UK, Germany, and France, though much less in number than those in the US and China, had a high proportion, which was 1.15%, 1.05% and 1.03%, respectively; Japan and South Korea fell behind in both quantity and proportion. Since the first release of the Nature Index in 2015, China has remained second place only behind the US, and the gap has been narrowing; Chinese Academy of Sciences (CAS), in terms of indicators, has topped the list of global scientific institutions, colleges and universities, far

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ahead of Harvard University, Max Planck Society (MPG) and Centre national de la recherche scientifique (CNRS) ranking second to fourth, respectively [3].

In addition, patent licensing and adoption is an important indicator to measure the R&D applied research, though most patents do not translate into actual products or industries. China has been the fastest growing country in patents over the past decade, only behind the US, Japan and Germany, although the proportion in the world’s total remains low.

China also enjoys a sound development in knowledge- and technology-intensive industries. Chinese companies have a sizeable share of the world market in such sectors as semiconductor and information service producers and pharmaceuticals.

China has already become one of the largest countries in science and technology, according to the above comparative analysis.

1.2 Connotative development is emphasized to build a leading country in science and technology

China, albeit one of the largest countries in scientific and technological development, is still far from being a leading country in science and technology. There has so far been only one Chinese Nobel Prize winner for scientific research carried out in China, with few Nobel Prize nominations and few scientific achievements approaching the Nobel Prize level. Although leading the world in quantum communication, mobile communication, manned spaceflight, unmanned aerial vehicle (UAV) design and manufacture and other scientific and technological fields, China in general still lags far behind other countries such as the US, the UK, Germany, Japan and France in basic research, applied research and experimental development. As a country ranking second in total published papers and high-quality papers in science and technology and boasting a number of scientists and research institutions with a stable output of highly cited papers, China is still lacking pioneering and leading innovative scientists.

What are the deficiencies for China to move from a large country to a leading country in science and technology? Comparison with other powerful countries in science and technology such as the UK, Germany, Japan and France tells us the necessity of connotative development and upgrading for building a leading country. The goal of connotative development is to improve the cutting-edge and pioneering innovative capacity for science and technology, rather than just expanding followed and extended innovation activities. How can we effectively promote the leading innovative capacity through connotative development? This is an urgent and challenging issue facing the science and technology policy and management community in China.

Can philosophy help promote leading scientific innovative capacity? Can philosophy contribute to China’s transformation from a large country to a leading country in science and technology? Few scientists or experts in scientific and technological policy and management have thought of this, nor has modern and contemporary philosophy dreamt of being the guide and censor of science any longer. However, the CAS, China’s strategic capacity in science and technology, established the Institute of Philosophy in 2020, thus giving rise to a new thought: can philosophy be the midwife of scientific innovation?

2 Philosophy and science: diverging with subtle relationship

2.1 Diverging philosophy and science

Philosophy boasts a history of more than 2,000 years, and many scientific disciplines have derived from it. In Newton’s time, physics and astronomy were classified into natural philosophy in western countries; social science and psychology did not separate from philosophy and become independent disciplines until the end of the 19th century. Philosophy and science, with alike purports, aim to rationally and theoretically understand and explain phenomena of sensory experience, which involve the universe, nature, life, society, humanity, and almost everything. However, research methods and evaluation criteria are significantly different between them. First, observable empirical materials are systematically collected as data or evidence for science, while evidence for philosophy is selected loosely to the extent that materials from intuition, psychological feeling, realization and other less public sources also play an important role in the theoretical construction and discussion of philosophy. Second, science has stringent requirements for the testability of theoretical prediction, and it is the empiricism of science to test the results inferred from a hypothesis or theory by controlled experiments or meticulous observations. Third, despite the limited use of mathematical and quantitative methods in life science and psychological science, mathematics is required and oriented for the theoretical construction of science, and this is one of the features that distinguish science from philosophy.

Since the modern scientific revolution led by Copernicus, Galileo, Kepler and Newton 500 years ago, science has begun to flourish and has been fully systematized and specialized. Philosophy, on the other hand, has been systematized and specialized by relying on the discipline system of modern universities, thus making almost no philosophers outside the system. Due to the systematized and specialized philosophy and science, scholars in two discipline fields, like Descartes and Leibnitz, have become quite scarce. Kant, teaching at the University of Königsberg (Albertus-Universität Königsberg) for life, has lectured on several natural sciences, and his Kant-Laplace nebular theory may have earned him a place among astronomers or cosmologists. But that’s almost unworthy of mentioning compared to his status and influence as a top philosopher.

The fact that philosophy and science are independent, or
even diverging, does not mean they are completely isolated. The impact of the great success of Newtonian physics on traditional philosophy has been clearly reflected in the theories of Hobbes, Locke, Hume, Kant and other philosophers. The philosophy of science, which emerged in the early 20th century, mainly investigates science. Having received formal scientific training, practitioners try to renovate and promote the solving of philosophical problems by virtue of the materials from the progress of science or give rise to reflection on and understanding of the nature of science. Philosophical naturalism, one of the most influential schools of philosophy in the English-speaking world for nearly half a century, insists that philosophy should keep abreast with and learn from science.  

In contrast, the influence of philosophy on science is indistinct. Physicist Feynman has ever quipped that philosophy of science is to scientists what ornithology is to birds: birds fly high and live well without guidance by ornithology. Other physicists, like Weinberg and Hawking, have also repeatedly criticized philosophy for its uselessness and obsolescence for science. Yang Chen-ning believes that there is a one-way relationship between philosophy and physics, where physics affects philosophy while philosophy never affects physics. Indeed, it is hard to find convincing cases in the history of science to prove that philosophy can guide or inspire scientists for their scientific research innovations (if this is what philosophy functions and values for science). The contempt and derogation for philosophy by these great physicists, though unpleasant to the ear, are pertinent to some extent.

### 2.2 Philosophy, philosopher-scientist and scientific revolution

If philosophy cannot directly guide and inspire scientists for their innovative activities, what else can it do for science? In 1962, The Structure of Scientific Revolutions written by Kuhn, a science historian and philosopher with a PhD in physics from Harvard University, was published, and Kuhn overturned the previously accepted view in which scientific progress was regarded as “development-by-accumulation” of accepted facts and theories. According to Kuhn’s interpretation of the history of science, the establishment or maturation of a science or one of its subfields is marked by its entry into normal science, as he calls it, and the fundamental feature of normal science is the formation of a paradigm that clearly guides the daily scientific research and the training of professional talents. Paradigm, an ambiguous and controversial concept emphasized in this book, can refer to a specific scientific achievement, such as Newton’s classical physics for projectile and planetary motion, or Lavoisier’s oxidation theory for the combustion phenomenon. Meanwhile, a paradigm also represents the basic concepts and principles related to world view and methodology such as the conceptual framework and ontology system on which specific scientific achievements are based.

In this respect, a paradigm can be both scientific and philosophical. First, the accepted paradigm of specific scientific achievements can attract many followers and provide typical problems and demonstration of their solution, the scope of problems to be solved and the ideas of their solution. Second, the more philosophical part specifies the relevant or irrelevant problems, and the way to find, identify and evaluate those reasonable or legitimate problems and their solution, and they are often considered to be related to the fundamental, conceptual and methodological issues and principles in a certain field of discipline.

In the era of normal science, members of a scientific community receiving a paradigm tend to accept the whole paradigm without question instead of justifying the more philosophical part. They are then dedicated to solving the problems possibly solvable within the scope of the paradigm under the guidance of the paradigm or revising and perfecting the concept and knowledge system of the more scientific part of the paradigm. For example, the determination of basic constants and simplification and systematization of main formulas are embodied in various textbooks and core courses in which the content is virtually the same and constantly refined. The establishment of normal science is often the result of one (or very few) winning paradigm(s).

However, as problem-solving activities under the guidance of paradigm are deepened and extended, more anomalies, or puzzles that remain unsolved within the theoretical framework of paradigm, will appear in normal science activities, as Kuhn points out. With the increase in anomalies, normal science and its paradigms enter a crisis period, and some scientists are gradually doubtful about the applicability of paradigms and reflect on and question the more philosophical part. A scientific revolution takes place when old paradigms are abandoned and replaced by new paradigms. There are typical cases of scientific revolutions in history: geocentric theory replaced by heliocentric theory, Aristotelian physics replaced by Newtonian physics, Priestley’s plhogiston theory replaced by Lavoisier’s oxidation theory, caloric theory of heat replaced by mechanical theory of heat, Darwin’s biological evolution and Wallace’s relativistic physics and quantum mechanics born in the early 20th century.

A scientific revolution calls for necessary reflection on and criticism of the more philosophical part in the old paradigm. Initiators and promoters of revolution have a philosophical mind and gift; they have the courage to question and challenge the conceptual basis and theoretical system of the old paradigm, thereby opening up a new path and field in scientific exploration. Such scientists are called philosopher-scientists, and Albert Einstein is one of the most famous ones far and away. Philosopher-scientists are, above all, scientists who have received rigorous and formal scientific training and been engaged in scientific exploration at the forefront of scientific research. Besides, philosopher-scientists have a philosophical mind and vision, who are willing to think about fundamental and universal problems with no definite answers and solutions, or what we regard as philosophical problems.

Although most philosopher-scientists have received no
formal philosophical training and may not grasp philosophical theory and terms accurately and reliably, they are passionately interested in thinking and exploring philosophically fundamental and methodological problems, and are reflective and skeptical and willing to try new ideas. They usually do not directly contribute to philosophy, nor can they integrate easily into the academic system of philosophy of a college. However, philosopher-scientists with distinct traits are crucial for the scientific revolution: they question and challenge old paradigms and open up and promote new ones. The above-mentioned physicists disregarding philosophy can, to some degree, also be thought of as philosopher-scientists.

In 1944, Einstein wrote back to a young scholar who had a PhD in philosophy of science and was teaching physics at a university: “I fully agree with you about the significance and educational value of methodology as well as history and philosophy of science. So many people today—and even professional scientists—seem to me like somebody who has seen thousands of trees but has never seen a forest. A knowledge of the historic and philosophical background gives that kind of independence from prejudices of his generation from which most scientists are suffering. This independence created by philosophical insight is—in my opinion—the mark of distinction between a mere artisan or specialist and a real seeker after truth.”

3 Philosophy helps to create favorable conditions and atmosphere for the cultivation of philosopher-scientists

As previously mentioned, leading innovative scientists, especially those essential in scientific revolutions, are often endowed with a mind of philosophical thinking, although such ability is not specially learned or trained. Modern science originating from western countries is based on its own philosophy, religion and culture, and thus is different from other civilizations including China. There exists more or less an origin relation between modern science and ideological and cultural traditions, including philosophy, though they may sometimes be separable. Philosophy has a salutary influence on the growth of philosopher-scientists, as trace elements are to life and health. Einstein tried to read Kant’s Critique of Pure Reason at the age of 13, and took the course of the theory of scientific thought at university; he, together with his friends, formed a group called Olympia Academy in 1903 when he worked at the Swiss Patent Office, and carefully read the works of scientists and philosophers such as Mach, Poincaré, Mill and Hume. This period was the eve of what has been known as Einstein’s Miraculous Year (1905); the philosopher Schopenhauer’s works were his lifelong favorite. “East Asian education system is a waste of time, and young people should learn different things,” said Shuji Nakamura, a Japanese-American scientist who won the 2014 Nobel Prize in Physics. The previous argument showed that the modern education system in East Asia is formed by combining Confucian culture and imperial examination system with Prussian education model in the 18th century, and this system may also be influenced by the practical and speed-up program and inculcation function of Soviet-style education in China. This model aims for examination and academic qualifications and places excessive emphasis on repetitive learning and mastery of limited learning content and the so-called fair competition for scarce quality education resources. This model contributes to the cultivation of disciplined, manageable and skilled middle-level workforces and the rapid modernization of backward countries, but it is not conducive to the development of independent thinking ability and innovative talents full of curiosity, who can be self-directed for lifelong learning as well as come up with and implement new ideas.

The growth of philosopher-scientists is restricted to some extent for lack of profound atmosphere and favorable conditions in China in cultural and ideological traditions, philosophical thinking style, talent selection model, scientific research evaluation system and other aspects. Consequently, leading innovative talents are scarce, which hinders China’s development from a large country in science and technology to a leading one. In this regard, measures can be taken from four aspects to give play to the role of philosophy in creating favorable conditions and atmosphere and for philosopher-scientists.

3.1 Importance should be attached to the study of philosopher-scientists and their development to improve the understanding of their role in leading scientific innovation

In the early 1990s, Li Xing-min introduced philosopher-scientist as a concept and term in China and made a lasting and in-depth study on it. Under his general editorship, series of Philosopher-Scientists were issued in 18 volumes by Fuyian Education Press, in which biographies of famous scientists and mathematicians such as Kepler, Mach, Poincare, Ostwald, Cantor, Hilbert, Bohr and Schrodinger written by domestic scholars were included. Unfortunately, research in this area has not attracted enough attention. In the new historical period, the reiteration of philosopher-scientist under current conditions may have richer theoretical connotation and practice significance. It is necessary to extensively explore the law of growth, personality, thinking features, cultural and social background and other aspects of philosopher-scientists from the history of science, philosophy of science, sociology of science, and pedagogy, etc. This may provide academic bases and inspiration for the growth of philosopher-scientists.

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3.2 Emphasis should be placed on the positive role of philosophy in shaping the quality and thinking mode of philosopher-scientists

Typical reflective and critical spirits of philosophy are fundamental to philosopher-scientists. Reflective scientists will realize their academic background, knowledge structure, and scope of thinking and its advantages and disadvantages, so that they can improve their ability to find, raise and describe questions. Critical scientists can broaden their horizons, go off the beaten track, raise doubts and learn from others to avoid overly narrow vision and rigid thinking and develop a new method. Scientists with philosophical accomplishment and thinking will, when necessary, divert their attention from minor details to fundamental concepts and principles and major universal and profound problems. Elon Musk, the most active inventor as well as the leader of a number of star high-tech enterprises, has made remarkable achievements in such fields as space flight, electric vehicles, automatic drive and brain-computer interface (BCI). Musk stressed that he always thinks from first principles as he talked about his unusual thinking. Thinking from first principles means that one in the face of complex problems can bypass the complicated superficial phenomenon and find some counterintuitive contents from the most basic and fundamental principles and problems and then dismantle and reorganize these contents. One with such razor-sharp thinking can grasp the essence of problems and simplify the problems. First principles thinking surpasses the common analogical thinking in daily life, and thus can break the routine and solve the problems; first principles thinking is also a universal way that can realize transfer learning and application to adapt to different problems and fields.

Philosophy itself also needs some adjustments and transformations once involved in the creation of favorable conditions and atmosphere for philosopher-scientists as described above. It is essential for philosophy to revise excessive scholarliness and academic style and reduce unnecessary jargon and terms. Philosophy involved in the cultivation of philosopher-scientists aims to be enlightening, reflective and inspirational rather than disseminate and inculcate specific doctrines and ideas, and philosophers should be the participants, guides and coordinators of multiparty dialogue and exchanges rather than proselytizers. Philosophers ought to have a sufficient scientific background. Philosophers should keep abreast of frontier science and combine them with related philosophical concepts and theories rationally, thereby entering into a dialogue with scientists effectively and providing philosophical expertise and insights. Philosophy should not be involved directly in scientists’ innovative activities. Over-involvement of philosophy in scientific development may be counterproductive for lack of necessary professional training and skills. Philosophy should be detached to some extent.

3.3 Favorable conditions should be provided for philosopher-scientists in talent selection, research evaluation and other aspects

Generally, the East Asian education and examination system criticized by Shuji Nakamura is detrimental to the cultivation and growth of philosopher-scientists. Philosopher-scientists’ valuable qualities, including curiosity, willingness to explore fundamental questions, independent thinking and autonomous learning, can not be suppressed or destroyed by a uniform examination system. Different from the standard talent cultivation line, the cultivation of philosopher-scientist is personalized, and only in this way, leading innovative talents can be cultivated. Performance evaluation of scientific researchers should allow philosopher-scientists to dive into basic problems instead of being overburdened with the declaration of topics, paper publishing and other quantitative indicators. The Overall Plan for Deepening the Educational Evaluation Reform in the New Era, issued by the CPC Central Committee and the State Council on October 13, 2020, provides direction for the construction of a world-level education evaluation system that accords with China’s reality, and creates favorable conditions for the cultivation of philosopher-scientists.

3.4 Institute of Philosophy of CAS (China’s strategic capacity in science and technology) should begin a new attempt to cultivate philosopher-scientists

The Institute of Philosophy should neither be the counterpart of the philosophy department in a university, nor a copy of the Institute of Philosophy, Chinese Academy of Social Sciences (CASS). It is completely unnecessary only for this. This institute, a surprise move, should be a new measure to promote the leading scientific innovation capacity of the CAS. It is intended to assist in scientific innovation, rather than just for the normal construction of philosophy disciplines and training of professional talents. Its value is reflected not in national projects, papers in professional philosophical journals or published works, but in its role in facilitating the growth of philosopher-scientists in China. Instead of only revolving around philosophy, it should organize interdisciplinary dialogues and exchanges for basic issues, and participate in facilitating the cultivation of philosopher-scientists, thus making philosophical contributions to China’s development into a leading country in science and technology from a large one.

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