Preliminary Discussion on Paradigm Construction in the Politics of Science and Technology: With the Bidirectional Relationship Between Science and Technology and Politics as the Guiding Principle (Postprint)

Authors: Gu Chao

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Abstract

In modern society, technology has not only profoundly transformed people's modes of production and lifestyle, but also generated significant political effects. The political science of science and technology systematically studies political phenomena related to science and technology, explores the mutual relationship between science and technology and politics, and reveals the essence and regularity of political phenomena in scientific and technological activities. Although there is already a substantial body of research on the theme of the political science of science and technology both domestically and internationally, most of it is scattered across different disciplinary fields such as science of science, science and technology policy, philosophy of science, and sociology of scientific knowledge, and has not yet formed a mature academic community or a widely recognized, incommensurable disciplinary paradigm. To construct a paradigm for the political science of science and technology, this paper proposes that the political science of science and technology should explicitly adopt a political science-based research methodology, establish a research program on the "bidirectional relationship" between science and technology and politics, and in terms of agenda setting, strive to open up political science research on the history of science and technology, deepen political philosophy research on the relationship between science and power, expand empirical research in the political science of science and technology, and establish an independent knowledge system for the political science of science and technology.

Full Text

Discussion on Paradigm Construction in Political Studies of Science and Technology: Taking the Two-Way Relationship Between Science & Technology and Politics as Research Program

Gu Chao
Research Center for Chinese Politics, School of Government, Peking University, Beijing 100871, China

Abstract

In contemporary society, scientific and technological advancements have not only profoundly transformed people's modes of production and daily life but have also generated significant political effects. Political studies of science and technology systematically examines political phenomena related to science and technology, explores the interrelationship between science & technology and politics, and reveals the essence and regularity of political phenomena within scientific and technological activities. Although numerous studies on this theme exist both domestically and internationally, most are scattered across different disciplinary fields such as science studies, science and technology policy, philosophy of science, and sociology of scientific knowledge. Consequently, a mature academic community and a universally recognized, incommensurable disciplinary paradigm have yet to form. To construct a paradigm for political studies of science and technology, this article proposes that the discipline should explicitly adopt a political science-based research methodology, establish a research program centered on the "two-way relationship" between science & technology and politics, and in terms of topic setting, strive to open up political studies of the history of science, deepen political philosophical research on the relationship between science and power, expand empirical research in political studies of science and technology, and establish an independent knowledge system for the discipline.

Keywords: political studies of science and technology, paradigm, two-way relationship

Political studies of science and technology is an interdisciplinary and comprehensive research field that has emerged in developed countries since the mid-20th century. It systematically examines political phenomena related to science and technology, explores the interrelationship between science & technology and politics[1], and reveals the essence and regularity of political phenomena in sci-

[1]The concepts of science, technology, and politics are all complex. This article uses only their general meanings: "science" refers to natural science, excluding social sciences; "science & technology" refers to science and technology, and since science and technology are increasingly integrated in contemporary society, this article does not make a special distinction between them except when specifically referring to the politics of technology; "politics" adopts David

entific and technological activities. In other words, political studies of science and technology investigates both the political dimensions manifested within scientific and technological activities and the interactive relationship between science & technology and politics in general[2]. Currently, a new round of scientific and technological revolution and industrial transformation is advancing rapidly, which has not only profoundly changed the organizational forms of scientific research but has also exerted far-reaching impacts on domestic political and social development and the international economic and political landscape. As the influence of science & technology on political change and of politics on the development of science & technology continues to deepen, the academic significance and disciplinary value of political studies of science and technology are increasingly prominent[3], making it imperative to complete the paradigm construction of the discipline.

1. The Rise of Political Studies of Science and Technology

The rise of political studies of science and technology originates from the profound transformation of the relationship between science & technology and politics after World War II, with its main characteristic being that modern science has entered the era of "Big Science" and the integration between science and politics has reached an unprecedented level.

On the one hand, the institutionalization of science has become an essential organizational condition for its development. The efficient production of scientific knowledge is highly dependent on social supply and state support in terms of resources. The continuous expansion of scale, acceleration of pace, and escalation of technology and costs in scientific research have further increased this dependency. National expenditures on manpower and material resources for scientific undertakings have suddenly made science a major component of the national economy[4]. For instance, the Apollo program lasted nearly 12 years, mobilizing over 400,000 people, approximately 20,000 companies and research institutions, and more than 120 universities, costing $25 billion[5]. Such large-scale research projects could never be accomplished without full government support.

On the other hand, science and technology increasingly exhibit an integrated development trend. For example, nuclear fission theory led to nuclear chain reaction technology within just a few years, which in turn made possible the atomic bomb and nuclear power reactors, creating an entirely new nuclear industry. Scientific theory and nuclear energy technology developed almost simultaneously. The reverse is also true: the vigorous development of semiconductor technologies such as transistors and integrated circuits greatly stimulated the accelerated development of electronics theory and semiconductor physics. The advent of telephone and telegraph technologies prompted the birth of information science. The integrated development of scientific technologization and technological scientization possesses incomparable power[6]. In 1945, Bush stated

Easton's definition, referring to the authoritative allocation of social values.

in his science policy report *Science: The Endless Frontier* submitted to the U.S. President: "Scientific progress is, and must be, of vital interest to the government"[7]. Since then, science & technology has not only been the primary productive force but has also become an important factor affecting the consolidation of state power and a strategic national interest. After the Cold War, science not only did not lose its strategic status but has gained even richer content in the "knowledge society." For example, the U.S. government emphasizes that "science is a key investment in national interest"[8], while the Chinese government has successively proposed strategies for revitalizing the country through science and education, innovation-driven development, and building China into a world leader in science and technology.

In modern society, the rapid development of science and technology has not only changed people's production and lifestyle but has also produced significant political effects. The invention of the atomic bomb and research in biotechnology such as stem cells and genetically modified organisms have sparked major social controversies in the public sphere. Climate change issues not only affect national economic and social development but have also become important bargaining chips in international political games. Faced with this new landscape, there is an urgent need to adopt new methods and approaches to study and reinterpret the relationship between science & technology and politics, which objectively promotes the formation and development of political studies of science and technology[1].

2. "Natural" Paradigm Construction: Political Studies of Science and Technology Within Various Disciplines

According to Kuhn's definition, a paradigm constitutes the entire set of shared beliefs, values, and techniques held by members of a scientific community[9]. Different scientific communities possess different paradigms, and these paradigms are incommensurable with one another. Those who conduct research based on a common paradigm commit to following the same rules and standards in scientific practice. For a discipline, an important sign of its maturity lies in the establishment of a research paradigm. Han Laiping[10] argues that the paradigm and research program for political studies of science have already formed, presenting a research paradigm that takes the value of science for the people as its guiding principle, the "triangular structure" system composed of political subjects—scientists—the public as its core theory, and historical and social system analysis and "boundary organizations" as its main problem-solving tools and methods. From this, one can deduce research programs concerning the social historicity, macro-controllability, and democratic regulation through public participation of science[10].

However, although scholars at home and abroad have made many valuable explorations into the programs, methods, and topics of political studies of science and technology, the overall development of this field remains in its infancy. Domestic scholars' research on political studies of science and technology mostly

focuses on specific topics or cases. For instance, in domestic politics, Jiang Xiaoyuan et al.[2] analyzed the game between science and politics behind the genetically modified staple food incident. In international politics, Huang Qixuan[11] pointed out that great power competition is an important driving force for world technological change, with the most intense periods of power competition often occurring during power transitions. Ye Chengcheng[12] argued that technological revolutions are followed by political and social changes, whose civilizational dynamic mechanisms involve complex multiple system effects. In the philosophy of science and technology, Xu Zhili[13] believed that there are three types of tension between science & technology and politics: value, power, and contract. In the politics of technology, Wu Guanjun[14] argued that technology has risen from a subordinate element of politics to a dominant element shaping contemporary political forms. Systematic research on political studies of science and technology is currently only seen in Hu Chunyan's 2006 doctoral dissertation[1] and Han Laiping's 2022 monograph[10].

Foreign research on the interrelationship between science & technology and politics is voluminous. For example, Jasanoff[15] believes that science and politics have a "co-production" relationship: "doing science is political, and STS itself is thoroughly political." As Brown[16] points out, sociotechnical practices and institutions may have political roots, implications, or effects, and are therefore political, though not necessarily models, sites, or objects of politics. Pielke[17] advocates that the "honest broker" of policy options is the role scientists should choose when participating in political affairs. Taylor[18] argues that a state's internal and external security affects technological progress. These studies mostly bear the titles "Politics of Science" or "Politics of Innovation" but are widely distributed across various disciplinary fields such as science studies, science and technology policy, philosophy of science, and sociology of scientific knowledge (SSK). Such broad disciplinary distribution precisely indicates that a mature academic community and a universally recognized, incommensurable disciplinary paradigm have not yet fully formed, and that paradigm construction for political studies of science and technology remains in a "natural" state of separate development.

2.1 Marxist Perspective

Marx demonstrated that "the productive power of labor is constantly developing with the continuous progress of science and technology"[19], and that science should be regarded "first of all as the great lever of history, as the highest revolutionary power"[20]. At the same time, Marx also initiated profound reflections on the negative effects of science & technology and their political values. Through the relationship between science & technology and alienation, he revealed how science, yielding to the dictates of capital, became an accomplice in exploiting workers, leading to the alienation of human beings themselves and the enslavement of nature. Therefore, "only in a republic of labor can science play its true role"[21]. Once the various forces that obscure science are removed,

science will become free science[22].

In the view of Marxist classical writers, science & technology do not belong to ideology or the superstructure but to productive forces. However, according to the main representatives of the Frankfurt School, science & technology have acquired legitimate ruling status in contemporary society, with scientific and technological rationality becoming the most important organizational principle of contemporary social domination. They inherited Marx's view on science & technology and alienation but equated the social function of science & technology with ideology, arguing that science & technology serve to conceal social problems, divert people's dissatisfaction and resistance, and maintain existing social domination[23].

Marcuse[24] believed that science & technology have instrumental and enslaving characteristics because the scientific methods by which people control nature provide concepts and tools for the domination of people over people. Habermas argued that scientific and technological progress determines production development and economic growth, making science & technology the primary productive force. Consequently, science & technology have become the basis of legitimacy for domination. As a new form of legitimacy, science & technology have shed the old form of ideology and become a new type of ideology—technocratic ideology. Although technocratic ideology is less ideological, it is more difficult to resist and more extensive in scope than old ideologies because, while covering up practical problems, it suppresses local demands for liberation and damages humanity's own interests in demanding liberation[25].

2.2 Perspective of Science Studies

The founder of science studies, Bernal, proposed that science is a social institution with its own traditions and disciplines, its own professional workers, and its own funding[26]. The science system is one of the subsystems of society, possessing a structure similar to the social system and engaging in exchanges of energy and information. Therefore, conscious social intervention can cause changes in the science system to achieve the purpose of regulating science. He also devoted himself to studying how the decisions of power holders affect the processes and outcomes of scientists and specific research projects, believing that rational decision-making in research management is crucial to scientific development. Bernal believed that the purpose of achieving political regulation of science is to make science serve the people. As agents of the people's interests, political subjects represent the public in confirming the value of scientific activities, regulating interest distribution, and standardizing scientific and technological activities. Overall, Bernal's science studies research employs the research paradigm of Marxist political economics, explaining the relationship between science and politics from the perspective of production relations in the research field[27].

2.3 Perspective of Science and Technology Policy

Science and technology policy researchers are concerned with the interaction process between the scientific community and non-scientific communities, as well as the political behaviors existing within the scientific community. Through their research, they seek to identify the people, power, traditions, and processes of policy formulation and implementation that determine the allocation of research resources, thereby understanding how science politics operates[28].

Guston[29] points out that science and technology policy essentially delegates power from funders of science to its executors, with its primary purpose being to ensure the integrity and productivity of publicly funded scientific research. From World War II to the 1970s, the ideological assumption of the "social contract for science" was that under the direction of "some invisible hand," the integrity and productivity of science would be automatically guaranteed, thus allowing the self-regulating mechanism of science to handle various issues. Beginning in the late 1970s, politicians felt that their expectations for the integrity and productivity of research were not being met. Where there was once trust, there is now a need for supervision, measurement, and incentives. Consequently, they established "boundary organizations" between politics and science, such as the Office of Research Integrity (ORI). ORI employs a formal incentive and supervision system, becoming a formal mechanism for managing issues of research integrity and internalizing the boundary between science and politics in adjudicating research misconduct. Such boundary organizations serve as platforms for dialogue, consultation, and multi-stakeholder participation in knowledge production. The state's new role in science policy has become one of collaborating with scientists to jointly ensure the integrity and productivity of the science it funds.

2.4 Perspective of Philosophy of Science

Logical positivism holds that scientific knowledge is the only true knowledge, while power belongs to the political category and is a product of social culture and history. Knowledge, however, is a representation of objective reality that has been verified. Knowledge is independent of power and can only obtain epistemological status by operating independently of power. The famous philosopher of science Popper believed that a proposition is scientific if and only if it is falsifiable. The principle of falsificationism separates knowledge from the background of social culture and its relationship with power. Thus, the relationship between knowledge and power is external to each other: power can cause us to deviate from true knowledge but plays no constructive role in knowledge production[30].

Kuhn conducted a profound critique of logical positivism. He argued that scientific revolutions share similar characteristics with political revolutions. In paradigm selection, as in political revolutions, there are no standards beyond the consensus among members of the relevant community, and problem res-

olution depends on agreement. More importantly, the problem of paradigm selection cannot be solved by logic and experiment alone; it requires studying "the persuasive argumentation techniques effective in various specific scientific communities"[9]. Kuhn's groundbreaking comparison of scientific revolution with political revolution is not merely metaphorical but reveals the inherent characteristics of scientific progress from the practice of scientific history, fundamentally shaking the foundations of logical positivism's view of knowledge and revealing the socialization and politicization of epistemology. Subsequently, Feyerabend[31] further proposed an anarchistic view of science, arguing that science's dominant position is not due to its superior objectivity and truth but because of the close integration between science and the state, which guarantees science's dominant position and suppression of other cultures. He advocated for a "humanistic science," with the fundamental approach being the separation of science from the state.

2.5 Perspective of Sociology of Scientific Knowledge

Shapin and Schaffer's *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*[32] is a classic work in the Sociology of Scientific Knowledge (SSK). The book demonstrates the connection between the behavior of the natural philosophy community and the social whole during the Restoration period in England. The restored regime was most concerned with disciplining the production and dissemination of knowledge to prevent a relapse into anarchy. Therefore, the purposes of experimental philosophers represented by Boyle and political philosophers represented by Hobbes were identical: to establish and protect public peace. Both assumed "a causal connection between the political structure of philosophical communities and the purity of the knowledge they produce." However, their political positions differed sharply: Boyle's experimental community consisted of free individuals, modeled on free action, witnessing, and believing in individuals, where domination, authority, and arbitrariness would distort legitimate knowledge; Hobbes, conversely, believed that any effective solution to knowledge problems must be a solution to order problems, which must be absolute, with social order maintained by the reason (similar to axioms in geometry) of certain arbitrators or judges. Therefore, philosophical truth should be produced and maintained by authoritarian politics. Boyle described his community as an ideal society where controversies could be safely conducted and subversive errors immediately corrected. Hobbes argued that no independent knowledge group could avoid posing a threat to civil society, and only secular political power could serve as "judge" and "interpreter."

Shapin and Schaffer[32] argue that the scientific community creates, selects, and maintains a polity in which it operates and produces intellectual products. The intellectual products manufactured within this polity become an element of national political activity. There is a constraining relationship between the nature of the polity occupied by scientific intellectuals and the nature of the larger polity. Thus, political factors permeate the entire process of scientific

knowledge production. As Shapin and Schaffer state, the forms of life by which we make scientific knowledge will survive or perish according to how we conduct our national affairs.

2.6 Perspective of Science Communication

The relationship between science and the public is both a core issue in the field of science communication and an important topic in political studies of science and technology, because "science that succeeds in the public sphere may be the result of the mutual construction of science and politics"[33]. This mutual construction is manifested in two dimensions in science communication: (1) Public understanding of science. In 1985, the Royal Society published the *The Public Understanding of Science* report, recommending that "scientists must learn to communicate with the public, be willing to communicate with the public, and indeed feel responsible for communicating with the public." This "deficit model," which aims to educate a "knowledge-deficient" public, considers scientists as experts with knowledge and the public as ignorant laypeople, believing that public distrust of science stems from their ignorance of relevant scientific knowledge[34]. Therefore, the public must be taught to understand science, improve their scientific literacy, and thus win their support for science.

However, Sheila Jasanoff[35] argues that the public as a collective neither passively accepts nor fearfully rejects all scientific progress but rather shapes, constructs, reflects, writes, experiments, plays with, tests, and resists. Therefore, the public's one-dimensional understanding of science is superficial and must be transformed into multiple understandings of science. The public's evaluation of scientific claims or claims based on science has become a basic element of political culture in today's knowledge society. She uses the term "civic epistemology" as a core concept for analyzing national political cultures, referring to how, in different political environments, knowledge can be considered reliable and how scientific claims used as the basis for collective choices should be examined, expressed, represented, defended, and opposed.

(2) Public engagement with science. The "deficit model" treats the public as a homogeneous collective needing unified science education, believing that as the public's knowledge becomes richer, they will increasingly support science[36]. In fact, opposition to science is often not caused by misunderstanding but by insufficient trust, with public consultation and participation seen as important ways to regain public trust. In recent years, the "deficit model" has gradually been replaced by public engagement with science, which emphasizes dialogue between the scientific community and the public. Jasanoff[37] points out that the U.S. science and technology governance structure is actually formed through negotiations among the government, the scientific community, and the public. This science and technology governance model has the structural characteristics of the public sphere, with multiple subjects, public participation, and equal dialogue and consultation as its internal requirements. Western societies

have developed specific practices for public engagement with science, such as science dialogues, science hearings, and citizen consensus conferences, from deliberative democratic forms like citizens' assemblies, citizen juries, deliberative workshops, and participatory theater.

Most of the above research examines the relationship between science & technology and politics from within various mature disciplines using their own paradigms. Although there are very few studies that consciously use political studies of science and technology as an independent research paradigm to systematically consider the relationship between science & technology and politics, these "natural" paradigm constructions still provide theoretical and empirical foundations for "conscious" paradigm construction.

3. "Conscious" Paradigm Construction: Exploring Research Methods, Research Programs, and Topic Setting in Political Studies of Science and Technology

What constitutes a "conscious" paradigm construction? In essence, it involves consciously exploring research methods, research programs, and topic settings that can be universally recognized by the academic community.

3.1 Clarifying a Political Science-Based Research Method

All the above-mentioned meta-level studies of science in philosophy, history, sociology, communication, and other disciplines can be summarized under the rubric of "Science and Technology Studies" (S&TS), correspondingly forming disciplines such as philosophy of science, history of science, sociology of science, and science communication[38]. S&TS primarily explores how scientific knowledge and technological artifacts are constructed, with a new trend being research on the relationship between science & technology and the public interest, as well as the political nature of science & technology[33]. Jiang Xiaoyuan et al.[39] believe that S&TS disciplines, in essence, merely take science as their research object, employing research methods from their own disciplines—philosophy, history, sociology, etc.—rather than those of science itself, and using their own rather than scientific criteria to evaluate research outcomes. Therefore, for political studies of science and technology, conducting meta-level studies of science using the more mature discipline of political science as the matrix is theoretically sound, practically feasible, and consistent with the developmental path of disciplines with S&TS attributes.

Since political science serves as the parent discipline, the research methods of political studies of science and technology should be based on political science research methods while highlighting a distinct path of interdisciplinary integration. This mainly includes two research approaches: (1) Political philosophical studies of science & technology. This represents an expansion of traditional political philosophy and an intersection with philosophy of science & technology. It builds upon and adapts the model of philosophy of science & technology's

exploration of science & technology itself, focusing on examining science & technology within complex political environments, conducting fundamental reflections on the political philosophical significance of science & technology from a holistic perspective, and particularly studying the essential relationship and evolutionary laws between knowledge and power within the horizon of political philosophy. (2) Employing political science research methods to examine the relationship between science & technology and politics at the empirical level. This represents political science's response from the meta-level to various political phenomena, issues, and challenges triggered by science & technology. It not only enriches the research topics of political science but also facilitates cross-fertilization between political science and S&TS disciplines.

3.2 Establishing a "Two-Way Relationship" Research Program Between Science & Technology and Politics

Research methods define "how to study," while research programs define a discipline's "hard core"—the "greatest common divisor" on which the academic community reaches consensus regarding the discipline's most fundamental principles. Salomon[40] explicitly proposed the concept of "politics of science," stating that "there is a two-way relationship between science and politics, knowledge and power, politicians and scientists." This assertion is programmatically significant for political studies of science and technology. In other words, as long as research takes the two-way relationship between science & technology and politics as its program, it can be included within the scope of political studies of science and technology. This two-way relationship has two aspects:

(1) The production, distribution, and development of science & technology are political. As Greenberg[28] states, science also has vested interests, elites, the oppressed, allies, bosses, as well as love and hate. The politics of science is not substantially different from other politics. Even pure basic science, which seems farthest from politics, involves vested interests, mutual lobbying, political favors, public relations activities, and even ideology. Shapin argues that the work of producing scientific knowledge is social; there is no impersonal, global standard to regulate scientific judgment, and the credibility of scientific claims is never a matter of pure evidence or pure logic—that is, it always involves persuasion, which is what we call politics[28]. Because science & technology are political, political studies of science and technology can examine the political relationships in scientific activities and political phenomena occurring within the science system through dimensions such as interest games, conflict mediation, and resource allocation, using politics as the independent variable and science & technology as the dependent variable. For example: the impact of political systems on science & technology development, the allocation of science & technology resources by political power, political struggles in scientific and technological activities, interest compromises in science & technology controversies, and how the public participates in science & technology

decision-making.

(2) Science & technology have important impacts on political change. Science & technology profoundly transform political order and power structures, driving political development, transformation, and change. Taking international relations as an example, since the birth of modern nation-states, science & technology have always had a major impact on world order and the pattern of international relations. In the 1760s, the Industrial Revolution that first emerged in Britain laid the material foundation for the establishment of the "Empire on which the sun never sets," forming an international strategic pattern dominated by Britain. The improvement and widespread application of the steam engine played a key role in the Industrial Revolution, establishing the hegemonic position of the capitalist system worldwide. The impact of this scientific and technological revolution lasted 100-200 years. By the second half of the 19th century, the Second Scientific and Technological Revolution, marked by the invention and application of electricity and internal combustion engines, formed a unified capitalist world system centered on a few Western countries that practiced colonial oppression on the vast majority of the world's population. Its effects lasted half a century. The nuclear weapons invented during World War II also had a major impact on the international relations pattern. The strategic significance of nuclear weapons lies in maintaining peace while promoting the formation of the Cold War structure[41]. Regarding the impact of science & technology on politics, political studies of science and technology can use dimensions such as state construction, state capacity, ideology, state-society relations, and international politics to examine politics as the dependent variable with science & technology as the independent variable, such as the relationship between scientific revolutions and modern state construction, the impact of science & technology on ideology, and the international political impacts of new scientific and technological revolutions.

By defining the research methods and research program of political studies of science and technology, some cutting-edge research in domestic political science in recent years, such as big data political science and computational political science that use big data and new computational methods to study political issues, do not belong to political studies of science and technology. The essence of computational political science is using modeling and quantitative methods from natural sciences to study political issues, rather than studying the two-way relationship between politics and science & technology. These represent different paradigms. However, science & technology governance and science & technology policy can be subjects of political studies of science and technology, but must emphasize the characteristics of political studies of science and technology. For example, when studying science & technology policy from the perspective of political studies of science and technology, the focus should be on how power structures, institutional systems, state capacity, interest groups, and ideology affect science & technology policy decision-making and implementation, rather

than on policy analysis and evaluation.

3.3 Enriching the Topic Setting in Political Studies of Science and Technology

The academic community's consensus on core research topics is an important component of a disciplinary paradigm. Currently, S&TS has conducted extensive research on topics such as national science & technology policy, international political games in climate change issues, political controversies generated by biotechnology such as genetically modified organisms and stem cells, and public participation in and trust in science. This article proposes four prospects for research topics, hoping to provide direction for the future core topic setting in political studies of science and technology.

3.3.1 Opening Up Political Studies of the History of Science Scholars of the history of science have provided rich research materials for political studies of science and technology through their outstanding work. By clarifying the "two-way relationship" between science & technology and politics, major events in the history of science can be re-analyzed using political science, striving to gain new knowledge beyond the horizon of history of science research. For example, the core of the "Needham Question" is why modern science did not develop in Chinese civilization but only in Europe. Historical materials on the Scientific Revolution are very solid, and its historical context is well documented, but the mechanism of the Scientific Revolution cannot be solved by history of science research alone. History of science research can trace the development of Greek scientific thought from the Milesian school, Pythagoras to Euclid and Archimedes, but cannot well explain why Greek science exhibited rational and free macro-structural characteristics. History of science research can answer how Newton's law of universal gravitation evolved from ancient Greece, the Middle Ages, the Renaissance to early modern times, but cannot completely answer why the Scientific Revolution occurred only in Europe rather than in China. Political studies of science and technology, based on detailed historical materials and employing political science analytical methods, can provide new answers to the "Needham Question." On the one hand, the key reason why China did not develop modern science lies not in the level of scientific and technological development but in the macro-structural characteristics of science. Ancient Chinese science had four main structural characteristics: a historical rationality mode of thinking, a natural history scientific system, a closed technological system, and a high degree of institutionalization. These structural characteristics enabled ancient Chinese science to develop continuously and reach high levels but were not conducive to the emergence of scientific revolutions. The fundamental cause of these structural characteristics was the power structure of the Confucian-Legalist state: the imperial Confucian state ideology shaped the historical rationality mode of thinking and the natural history scientific system, the integration of political and ideological power reinforced the closed technological system, and the stable crystallization of power relations shaped the high degree of institutionalization.

On the other hand, the Scientific Revolution occurred in Europe due to mechanisms at both macro and micro levels. The macro mechanism of the Scientific Revolution was also determined by power structures: from Greek city-states to medieval feudal states to the initial formation of modern nation-states, ideological power and political power remained separate. To elaborate the micro mechanism of the Scientific Revolution requires not only analogizing the Scientific Revolution with political revolutions but also employing highly developed theories of revolution in political science to conduct more in-depth research on how "actors" such as Copernicus, Bacon, Galileo, Descartes, Boyle, and Newton initiated and completed this "revolution." Similarly, the Industrial Revolution can also be deeply analyzed using political studies of science and technology. Conversely, new theories about the Scientific Revolution and Industrial Revolution proposed in political studies of science and technology research can also influence the basic paradigm transformation of political science research.

3.3.2 Deepening Political Philosophical Studies of the Relationship Between Science and Power From Bacon's vision of New Atlantis[42], to Polanyi's "Republic of Science"[43], to Kitcher's "well-ordered science"[44], the political philosophical study of the relationship between science and power has always been a core theme of political studies of science and technology. Durant, a renowned scholar in the S&TS field, believes that because existing S&TS research has lost contact with political philosophy, its defense of public participation in science & technology policy formulation is usually unsatisfactory. Habermas's deliberative democracy theory holds that non-professional citizens can conduct reasonable deliberations on the nature of problems and the reasons for decisions through everyday language. Therefore, Durant's[45] suggestion is to use Habermas's political philosophy to compensate for the deficiencies in S&TS research and provide legitimacy for public participation in science.

Looking ahead, one possible research approach is to further reveal the internal connection between scientific knowledge and power along the lines of Foucault[2]. Foucault insists that the relationship between power and knowledge is not external but internal. In modern society, knowledge, especially scientific knowledge, plays a normative role, and knowledge is essentially a form of normative power. Rouse further develops Foucault's view. He argues that the daily practices of seemingly "non-political" actors and institutions actually contain significant political meaning. Natural science is permeated by power relations, so the laboratory must be understood as another institutional "apparatus" where power shapes people into subjects/actors. Scientific experimental and theoretical activities themselves are ways in which power operates, and the development of knowledge may lead to new forms of power. The exercise of power itself can produce knowledge. Rouse particularly emphasizes the productive nature of power rather than its repressive and distorting effects, representing a new understand-

[2]Michel Foucault (1926–1984), French philosopher, social thinker, and "historian of systems of thought." His works include *The History of Madness in the Classical Age*, *The Archaeology of Knowledge*, *Discipline and Punish*, and *The History of Sexuality*.

ing of "knowledge is power"[30].

Another possible research approach is to expand the political ecology proposed by Latour[3]. Latour[46] criticizes the old bicameral "cave politics" that divides public life into nature and society and carefully designs a "new building." He emphasizes exercising the rights of consideration, ordering, and follow-up according to proper procedures, allowing different professionals to contribute their expertise to the "cosmopolitics" of the collective of humans and non-humans. As Brown[47] states, Latour's work provides the most innovative effort since philosopher Dewey to understand science and politics from a democratic political perspective. Political ecology may offer new ideas for studying deliberative democracy between science & technology and politics.

3.3.3 Expanding Empirical Studies in Political Studies of Science and Technology Currently, empirical research using political science research methods and the two-way relationship between science & technology and politics as a research program is relatively rich, though mostly scattered across S&TS disciplines. Looking ahead, two themes are particularly worthy of further development.

(1) Politicization of science & technology issues. As the mutual penetration between science & technology and politics deepens, the politicization of public science & technology issues is a widespread and important phenomenon. Politicization is an important concept because it illuminates the process of agenda formation. Moderate politicization of science & technology controversies is conducive to obtaining necessary political support for solving public problems; however, if the degree and impact of politicization are excessive, it will trigger political controversies and cause internal consumption of public resources[48]. In contemporary Western societies, discussions around controversial science & technology issues such as nuclear energy use, AIDS treatment, global warming, embryonic stem cell research, and vaccination are often dominated by politics. It is necessary to select typical cases with important political significance and reveal the general characteristics and patterns of the politicization of science & technology issues from a comparative political perspective, exploring their causes and consequences.

(2) Impact of the new scientific and technological revolution on politics. The third scientific and technological revolution, centered on changes in information and communication methods, has accelerated competition among nation-states into competition over information processing capabilities. In recent years, frontier fields such as artificial intelligence, big data, and cloud computing have entered a stage of "technological explosion," and generative AI large models represented by ChatGPT have been particularly brilliant in 2023, making the "singularity" seem near and heralding

[3]Bruno Latour (1947–2022), philosopher, sociologist, and anthropologist. Founder of the STS (Science, Technology and Society) Paris School.

the beginning of a new scientific and technological revolution. As a large language model, generative AI has changed the basic mode of human information transmission, reconstructing the entire society's process of knowledge production and inheritance, including a large amount of political information and knowledge. As a new knowledge authority, generative AI will inevitably have a major impact on how the general public acquires political and social knowledge and thinks about political and social issues. Therefore, a future research focus for political studies of science and technology is to use empirical research rather than philosophical speculation to clarify how generative AI produces political knowledge and how it achieves political socialization in the process of interacting with users.

3.3.4 Establishing an Independent Knowledge System for Political Studies of Science and Technology Addressing China's special science & technology political problems based on China's historical background and political-social environment. For China, self-reliance and strength in science & technology are the foundation of national prosperity and security and the necessary path to promoting high-quality development and realizing Chinese-style modernization. Particularly in recent years, China and the United States have formed a competitive relationship centered on science & technology. Therefore, a core issue for Chinese political studies of science and technology should be how to transform the enormous potential of scientific and technological innovation into overall social benefits and promote China's better achievement of its development goal of building a world leader in science and technology[3]. The author's series of studies on high-temperature superconductivity, which defined the concepts and connotations of original innovation, first-order innovation, and normal science[49], and on this basis elaborated the mechanism of co-production of normal science by the state and the scientific community[50], represents a preliminary exploration of such issues. In the future, topics such as the new national system, the development of national strategic scientific and technological forces, and international competition in scientific and technological innovation are all key concerns for Chinese political studies of science and technology.

Exploring universal problems of world science & technology politics from a Chinese perspective and contributing more original theoretical and empirical research to the disciplinary development of political studies of science and technology. While a Chinese-problem-oriented consciousness is important, what is more important is to reveal universal laws of political studies of science and technology starting from Chinese problems. Ancient Chinese science & technology was highly developed and long-lasting but did not produce scientific and industrial revolutions; modern Chinese science & technology development has been arduous, and although its development speed since the reform and opening-up has been remarkable, it still faces the problem of lacking original innovation. If political studies of science and technology ignores the distinctive characteristics of Chinese science & technology development from ancient times to the

present and fails to conduct in-depth analysis of the mechanisms of interaction between science & technology and politics behind these phenomena, it will be incomplete. Chinese experience can also be elevated into theories with broad applicability, such as the role of the state and state-society relations in different stages of scientific and technological development like innovation catch-up and original innovation, striving to construct a Chinese independent knowledge system.

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Author Introduction: Gu Chao, Assistant Professor at Research Center for Chinese Politics, School of Government, Peking University. Main research field: political studies of science and technology. E-mail: guchao1986@pku.edu.cn

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