Evolutionary Characteristics and Implications of U.S. Science and Technology Policy in the 21st Century: Postprint

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Abstract

Since the beginning of the 21st century, a new round of global scientific and technological revolution and industrial transformation has been accelerating. Particularly after the 2008 international financial crisis, countries have strengthened their strategic S&T layout and R&D investment, competition among major S&T powers has intensified, and S&T policy has become a key factor determining the success or failure of technological competition. The United States, recognizing that its global technological leadership is being challenged, has employed various means to suppress major technological competitor nations. By analyzing the historical evolution of policy documents such as S&T plans, strategic guidelines, and research reports released by the U.S. government over the past two decades, as well as long time-series R&D investment data from the federal government, this study aims to systematically reveal the developmental trajectory and evolutionary characteristics of U.S. S&T policy, and to identify quantitative explanatory evidence for the relative decline of U.S. technological leadership. Research indicates that since the 21st century, the relative weakening trend of the United States' global technological leadership and national S&T competitiveness is closely associated with its S&T policy inertia and relatively stable development, the weakening strategic leadership of major S&T programs or projects, the continuous decline in government Research and Development (R&D) investment intensity, and the decreasing emphasis on basic research. The historical experience of U.S. S&T policy development offers important lessons for our country: S&T development is not only a long-term strategic undertaking, but also a highly competitive one; the enhancement of technological competitiveness is the result of long-term strategic orientation in national S&T policy, steadily increasing R&D investment, and the accumulation of major scientific and technological breakthroughs.

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Evolution Characteristics and Enlightenment of American Science and Technology Policy in the 21st Century

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Abstract

In the 21st century, a new round of global scientific and technological revolution and industrial transformation has accelerated. Particularly after the 2008 international financial crisis, countries have strengthened their strategic S&T layouts and R&D investments, intensifying competition among major S&T powers. S&T policy has become a critical factor determining the outcome of technological competition. The United States has recognized that its global S&T leadership is being challenged and has employed various means to suppress its main technological competitors. This study analyzes the historical evolution of policy documents such as S&T plans, strategic guidelines, and research reports issued by the U.S. government over the past two decades, as well as long-term R&D investment data from the federal government, aiming to systematically reveal the development trajectory and evolution characteristics of U.S. S&T policy and provide quantitative explanatory evidence for the relative decline of America' s S&T leadership. The research shows that the weakening trend of America' s global S&T leadership and national S&T competitiveness since the 21st century is closely related to the inertia and relatively stable development of its S&T policy, the weakening strategic leadership of major S&T plans or projects, the year-on-year decline in government R&D investment intensity, and the decreasing emphasis on basic research. The historical experience of U.S. S&T policy development holds important implications for China: S&T development is not only a long-term strategic undertaking but also a highly competitive one, and the enhancement of S&T competitiveness results from the accumulation of long-term national S&T strategic orientation, steadily increasing R&D investment, and major S&T innovation breakthroughs.

Keywords: science of science and technology policy, United States, science and technology policy, R&D investment, S&T competition, new technology change

1. Evolution of U.S. S&T Policy in the 21st Century

S&T policy often reflects national will in S&T governance, strategic guidelines for S&T development, and top-level design for resource allocation, exerting significant influence on a country' s S&T development [3]. This section divides the period according to U.S. presidential terms since the 21st century, starting with the Bush administration, and analyzes the priorities of S&T policies in each phase by examining strategic guidelines, S&T plans, research reports, and approved legislation, with particular focus on R&D investment intensity, frontier field layout, talent cultivation, and attitudes toward China, while avoiding operational and implementation details.

1.1 Bush Administration (2001-2008)

Building on the solid foundation laid by the Clinton administration in S&T, economy, and social development, the Bush administration' s S&T policy remained relatively stable, characterized by three main features. First, enhancing U.S. global competitiveness became a primary concern. In 2004, the Council on Competitiveness released the report *Innovate America: Thriving in a World of Challenge and Change* [9], establishing an action agenda to improve U.S. innovation capacity. In 2005, the National Academy of Sciences published *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (hereafter *Rising Above the Gathering Storm*) [10], highlighting the urgent need for comprehensive and coordinated federal efforts to strengthen U.S. competitiveness. In 2006, President Bush signed the *American Competitiveness Initiative: Leading the World in Innovation* [11], which directly 促成了 the enactment of the *America COMPETES Act* in 2007.

Second, the administration pursued education reform and expanded educational investment. Early in his term, President Bush proposed the "No Child Left Behind" education reform initiative, which became law in 2002 to improve the quality of primary and secondary education. The *America COMPETES Act* of August 2007 required the National Science Foundation to focus on scholarship programs, STEM teacher training, and university-level STEM research. In October 2007, the National Science Board (NSB) released *National Action Plan for Addressing the Critical Needs of the U.S. Science, Technology, Engineering, and Mathematics Education System* [12], emphasizing the urgent need to build a robust, coordinated STEM education system.

Third, the administration prioritized energy and nanotechnology development. While maintaining advanced positions in information technology, the Bush administration designated energy and nanotechnology as priority areas. In nanotechnology, the White House released the *National Nanotechnology Initiative: Leading to the Next Industrial Revolution* in February 2000 [13], marking a new phase of comprehensive nanotechnology development in the U.S. In 2003, President Bush signed the *21st Century Nanotechnology Research and Development Act*, after which the U.S. regularly released *National Nanotechnology Strategic*

Plans (six editions to date) [14], maintaining its world-leading position in nanotechnology.

1.2 Obama Administration (2009-2016)

The Obama administration fully leveraged federal S&T policy guidance, releasing three national-level innovation strategies that formed the framework of its S&T policy. First, it emphasized investment in basic innovation elements such as basic research and STEM education. The *American Recovery and Reinvestment Act* (ARRA) of February 2009 stimulated U.S. economic recovery through active fiscal policy, resulting in a historically unprecedented increase in R&D funding that year. Based on this act, the federal government released *A Strategy for American Innovation* in 2009 [15], calling for increased government investment in basic science, education, and emerging industrial technologies to create jobs and restore the U.S. economy. The Obama administration also elevated STEM education to a national strategic level, focusing on improving STEM educator quality while implementing liberal immigration policies to attract international high-tech talent. In 2013, it released the *Federal STEM Education Five-Year Strategic Plan*, and in 2015 passed the *STEM Education Act*.

Second, the administration focused on frontier innovation in advanced manufacturing, clean energy, and other S&T fields. The 2011 *Strategy for American Innovation* [16] emphasized innovation serving people's livelihoods, shifting focus toward stimulating innovation vitality to promote sustained economic growth and prosperity. The U.S. strengthened efforts to tackle frontier technologies, releasing a series of initiatives including the "Advanced Manufacturing Strategic Plan," "National Robotics Initiative," "Materials Genome Initiative," "BRAIN Initiative," "Precision Medicine Initiative," and "Clean Energy Plan." Among these, advanced manufacturing was a key priority, with numerous related laws and strategic reports issued [17-19].

Third, the administration emphasized the important role of government in S&T innovation. In January 2012, the Department of Commerce released *The Competitiveness and Innovative Capacity of the United States* [20], explicitly stating that S&T innovation was key to U.S. economic growth and maintaining competitive leadership in the 21st century. The 2015 *Strategy for American Innovation* [21] emphasized that government should be the primary facilitator of innovation, proposing specific measures including building innovation infrastructure, promoting private-sector innovation, and catalyzing prioritized breakthroughs in key national areas to enhance government capacity to serve innovation.

1.3 Trump Administration (2017-2020)

The Trump administration' s S&T policy orientation can be discerned through its R&D budget priorities, strategies and documents released by the Office of Science and Technology Policy, and the 2020 federal summary report *Advancing America' s Global Leadership in Science and Technology: Trump Administration*

Highlights: 2017-2020 [22]. The policy featured three main aspects. First, it prioritized national security and implemented an "America First" policy. The administration pursued unilateralist protectionist policies, withdrawing from international agreements such as the Trans-Pacific Partnership (TPP) and the Paris Agreement, while tightening visas for students from competitor countries. In emerging S&T fields, it emphasized American interests first to achieve the strategic goal of "Making America Great Again." In December 2017, the federal government released the *National Security Strategy* [23], clarifying strategic directions for restoring U.S. global leadership.

Second, R&D investment continued to grow while incentivizing corporate innovation. Although the Trump administration's annual R&D budget proposals advocated cutting non-defense R&D expenditures such as basic research, Congress ultimately controls U.S. research funding [24], and total federal R&D funding continued to increase. To incentivize corporate innovation and job creation, the federal government introduced the *Tax Cuts and Jobs Act* in December 2017.

Third, the administration emphasized emerging technology R&D to promote future industries. In October 2020, the White House released the *National Strategy for Critical and Emerging Technology* [25], explicitly listing 20 "critical and emerging technologies" including advanced manufacturing, artificial intelligence, and quantum information science. The federal government subsequently issued strategic plans, research reports, and legislation around these areas [26–28].

1.4 Biden Administration (2021-Present)

The Biden administration's S&T policy direction can be assessed through executive orders and statements on the White House website and the R&D budgets for fiscal years 2022 and 2023. The policy shows three main trends. First, actively responding to COVID-19 and climate change. In April 2022, the White House released a memorandum on addressing the long-term impacts of COVID-19 to promote citizen health and national economic recovery. The Biden administration also expressed high priority for climate change and sustainable development, promoting a green economy and rejoining the Paris Agreement.

Second, increasing S&T R&D investment to seize innovation initiative. In 2021, the Biden administration called for $180 billion in investment for R&D and future technologies [29], explicitly emphasizing the need to firmly grasp innovation initiative in areas critical to national strategic survival and development such as artificial intelligence, semiconductor chips, 5G communications, biotechnology, and quantum computing. In 2022, the National Science and Technology Council (NSTC) released an updated *Critical and Emerging Technologies List* [30], serving as an important reference for supporting U.S. national technology security, protecting sensitive technologies, and competing for international talent, and 促成了 the formal enactment of the *CHIPS and Science Act of 2022*.

Third, intensifying efforts to attract global talent and implementing a "friendshoring" multilateralist policy to strengthen S&T military alliances. The Biden administration introduced new talent attraction policies [31], such as adding 22 STEM fields, extending J-1 visa durations for STEM majors, and streamlining green card application processes for STEM professionals. The administration also emphasized joint responses to external threats with allied nations, as reflected in the March 2021 *Interim National Security Strategic Guidance* [32] and the 2022 *National Security Strategy*, which explicitly identified China as America' s primary competitor and called for revitalizing U.S. alliances and partnerships worldwide to jointly address the climate crisis and other shared challenges.

2. Historical Evolution of U.S. Federal Government R&D Investment

R&D investment policy constitutes an important component of national S&T policy and serves as the most direct reflection and manifestation of S&T policy effectiveness [33]. As the core of national S&T investment, analysis of the long-term historical evolution of U.S. federal government R&D investment helps deepen understanding of the evolution patterns of U.S. S&T policy since the 21st century and observe the impact of S&T policy on innovation capacity.

2.1 Overall U.S. R&D Investment Intensity

Since World War II, U.S. R&D funding has continued to grow [Figure 1: see original paper]. Examined through the lens of S&T policy development, U.S. R&D investment intensity trends align closely with national S&T policy evolution: from 1953–1964, the U.S. recognized the important role of S&T in WWII and, influenced by the Soviet satellite launch, strongly supported scientific research, leading to rapid growth in R&D intensity. In the late 1960s–1970s, negative impacts from scientific development caused public skepticism, resulting in declining R&D intensity. In the 1980s, to counter Japan' s economic challenge, the U.S. actively encouraged and supported industrial R&D, increasing R&D funding and expanding its application scope. Since the 1990s, having won the Cold War and economic competition with Japan, U.S. R&D intensity began stable development, gradually maintaining a level of 2.5%–3.0% of GDP. After 2017, facing intensifying international competition and the rapid rise of China and other emerging economies, the U.S. perceived renewed challenges to its S&T status and increased R&D funding again, surpassing 3% for the first time in 2019, reaching 3.12%.

Specifically, U.S. R&D funding primarily originates from the federal government and enterprises. Before the 1980s, U.S. R&D intensity trends closely matched federal R&D intensity; afterward, they aligned with enterprise R&D intensity. This indicates that U.S. R&D investment began with federal government leadership, but as enterprise R&D investment grew rapidly, enterprises became increasingly important in the national innovation system and gradually became the primary influence on R&D investment. Notably, before 2000, U.S. federal government R&D intensity had been declining overall (to around 0.6%), stabilized during the first decade of the 21st century (with a small increase in 2009 from one-time ARRA funding), but shrank significantly after 2010—one reason why U.S. S&T policy has continuously emphasized increasing federal R&D investment since the 21st century.

2.2 U.S. Federal Government R&D Activity Distribution

U.S. federal government R&D activities mainly include basic research, applied research, and experimental development, with their distribution shown in [Figure 2: see original paper]. Before the 21st century, over 50% of federal R&D funding was allocated to experimental development. However, as U.S. enterprise innovation capacity and R&D investment increased substantially in the 1980s, assuming most experimental development activities, the federal government' s R&D focus gradually shifted from experimental development to basic research, with basic research' s share growing significantly. Notably, basic research investment has shown a stable or even declining trend since the 21st century, prompting calls from the scientific community for increased federal R&D investment, particularly in basic research. For example, in September 2014, the American Academy of Arts and Sciences (AAAS) warned in *Restoring the Foundation: The Vital Role of Research in Preserving the American Dream* [36] that if the nation did not act quickly to support the scientific enterprise, especially basic research, America' s long-standing advantage as an innovation engine would be diminished. In September 2020, AAAS released an updated report, *The Perils of Complacency: America at a Tipping Point in Science and Engineering* [37], highlighting that due to COVID-19, talent mobility restrictions, and research funding cuts, America' s lead in science and engineering was rapidly shrinking, with China surpassing the U.S. on many important indicators. The report urged urgent increases in R&D budgets with heightened emphasis on basic research and strengthened STEM education to enhance the U.S. workforce. While specific basic research projects' contributions to future economic growth cannot be predicted, historical evidence shows that America' s world-leading S&T position in the early 21st century was inseparable from sustained federal investment growth in basic research across successive administrations.

2.3 R&D Investment in Core Federal Departments

Major core federal S&T departments include the Department of Defense (DOD), Department of Energy (DOE), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), and National Institutes of Health (NIH). These functional agencies with clear domain characteristics reflect corresponding policy changes through their R&D investment evolution trends [Figure 3: see original paper]. The U.S. has long prioritized defense R&D, with DOD' s share consistently exceeding 40%. However, as national strategy shifted toward S&T and economic development, military funding was reduced, showing a declining R&D investment trend. Meanwhile, to address infectious diseases, cancer, and other human health threats, NIH launched initiatives such as the "BRAIN Initiative" and "Precision Medicine Initiative," with its R&D share rising to over 20% since the 21st century. In recent years, as international climate change and ecological environment issues have become prominent, DOE R&D funding has steadily increased since 2015. NASA' s R&D investment declined with the end of space competition with the Soviet Union and the "Star Wars" program, stabilizing at 6%–10% in the 21st century. As the core department funding U.S. basic research, NSF' s R&D investment has remained at 2.5%–5.0%. This demonstrates that federal R&D investment allocation aligns with national strategic development priorities.

2.4 Defense vs. Non-Defense R&D Distribution

U.S. federal defense and non-defense R&D investment evolution is shown in [Figure 4: see original paper], consistent with the trends in [Figure 3: see original paper]. In the late 1950s, to counter Soviet space competition, and in the early 21st century, to address terrorism, the U.S. prioritized military development and defense R&D. From the late 1960s–1970s, the energy crisis led to growth in non-defense R&D, while health fields aligned with public welfare gained development opportunities. In the 1980s, the Reagan administration' s "Strategic Defense Initiative" renewed increases in defense R&D spending. In the 1990s, with the Cold War' s end, the U.S. promoted military-to-civilian or dual-use technology development, and defense R&D began declining and stabilizing. After the 2008 economic crisis, as strategic focus shifted to economic growth, defense R&D investment declined, falling below 50% after 2017 when the U.S. initiated the "tech war." Non-defense R&D includes all funding categories except DOD and the National Nuclear Security Administration (NNSA), primarily comprising health, space, energy, general science, natural resources, and other fields. Overall, the U.S. employs a point-and-surface combined funding model for non-defense domains [40]: on one hand, to protect the ecological environment, enhance public welfare, and encourage scientists to conduct non-utilitarian research, federal funding covers all scientific fields including health, general science, and natural resources; on the other hand, around national S&T strategic orientation and core S&T competition areas, the federal government strongly supports R&D in relevant fields. For example, during the 1960s space competition with the Soviet Union, space R&D funding rose sharply; in the 1970s, to alleviate the global energy crisis, energy R&D funding experienced a growth period.

2.5 Disciplinary Layout of Federal R&D Investment

The disciplinary classification of U.S. federal R&D investment includes eight categories: life sciences, psychology, physical sciences, environmental sciences, mathematics and computer science, engineering, social sciences, and other sciences [Figure 5: see original paper]. Changes in disciplinary R&D investment closely relate to international competition environments and S&T strategic layouts. By investment share, life sciences constitute a major component of the federal R&D portfolio, accounting for over half of total federal R&D funding, with NIH undertaking most life sciences research covering biology, biomedicine, and health sciences. The second-largest field is engineering, including aerospace, chemical, electrical, mechanical, and materials sciences. Due to U.S.-Soviet competition, this field maintained high R&D investment before the 1990s, but declined after the Cold War. In recent years, as U.S.-China chip competition has intensified, materials science has gradually become an engineering focus, with R&D investment trending upward again. Physical sciences, the third-largest field, saw significant R&D investment decline after the Cold War. Notable R&D growth has occurred in life sciences, mathematics, and computer science. Worth highlighting is that U.S. mathematics and computer science R&D investment has grown significantly since the 1990s, primarily due to the Clinton administration' s 1993 "Information Superhighway" strategy, which dramatically increased computer science R&D investment. By 2017, computer science R&D investment was nearly triple that of mathematics, positioning the U.S. information economy at the world forefront.

Through this multidimensional analysis of U.S. federal R&D investment, we find that federal R&D investment proportions closely correlate with national S&T strategic priorities. However, significant fluctuations in R&D investment shares across core departments, non-defense domains, and different disciplines occurred before the 21st century, remaining relatively stable since. This may indirectly indicate that U.S. S&T policy has merely been inertially developing and functioning over the past two decades, without breakthrough or transformative S&T strategic policies.

3. Evolution Logic and Characteristics of U.S. S&T Policy

Examining S&T policy and R&D investment evolution reveals an underlying direction (internal logic) guiding U.S. S&T policy development: maintaining global leadership, enhancing national S&T strength, and defeating competitors. The U.S. believes it has faced competitive crises historically: in 1957, the Soviet Union' s Sputnik launch prompted rapid major changes in U.S. S&T policy and R&D investment layout, mobilizing all forces for space competition; in the 1980s, economic competition with Japan led the U.S. to expand federal funding usage and develop measures encouraging cooperation among federal agencies, universities, and private enterprises to promote technology transfer; in the 1990s, the Cold War ended with U.S. victory, and the "Information Superhighway" led information industry S&T, enabling the longest peacetime economic growth in U.S. history. In the first decade of the 21st century, U.S. S&T policy functioned inertially. Since 2008, especially after 2018, intensifying international competition and the rapid rise of China and other emerging economies have challenged U.S. S&T status, creating another historic moment for policy transformation, termed the "China' s Sputnik moment" [42]. In recent years, to maintain global leadership and enhance competitiveness, U.S. S&T policy has made major adjustments in four areas.

3.1 Reforming the National Innovation System and Strengthening Innovation Institutions

Since 2005, following the National Academy of Sciences' *Rising Above the Gathering Storm* report, U.S. scientific and policy communities have widely recognized threats to national S&T innovation capacity and leadership. Federal agencies, S&T think tanks, and other policy institutions have reflected on U.S. S&T development and the national innovation system. For example, the Information Technology and Innovation Foundation (ITIF) released *Understanding the U.S. National Innovation System* in 2020 [43], noting that facing China's development and declining U.S. government R&D investment, the national innovation system was in crisis requiring rebuilding. The Council on Competitiveness' 2020 report *Competing in the Next Economy: The New Age of Innovation* [44] warned that America' s historical position as world innovation leader was threatened, offering 50 specific recommendations as a roadmap for national innovation. Since the Obama administration' s three releases of *A Strategy for American Innovation*, the U.S. has continuously emphasized S&T innovation importance, with numerous domain innovation strategies and competitiveness acts at the national level. Recently, the federal government has begun emphasizing inter-system cooperation among national innovation actors, mobilizing whole-of-society forces to promote S&T innovation through a "whole-of-government approach" including multi-agency cooperation, civil-military fusion, and public-private partnerships.

3.2 Increasing R&D Funding and S&T Talent Investment to Consolidate Innovation Foundations

U.S. S&T policy transformation also manifests in increased government financial and human resource investment. Financially, increasing federal R&D investment, especially in basic research, has become a policy focus. For example, the Biden administration has highly prioritized S&T development since taking office, continuously emphasizing substantial increases in federal R&D investment, with the *CHIPS and Science Act of 2022* allocating considerable resources to S&T. In talent cultivation, the U.S. has elevated STEM education to national strategic importance. Since the 21st century, the U.S. has issued a series of STEM education policies [Figure 6: see original paper], forming a relatively complete STEM education system. The Trump administration strictly restricted visas and immigration conditions for STEM international students. The Center for Strategic and International Studies (CSIS) noted [45] that without major STEM immigration policy reforms, the U.S. would not stay ahead of China in future talent competition. In 2022, the Biden administration enacted new policies relaxing employment and immigration requirements for STEM professionals to restore U.S. attractiveness to top talent.

3.3 Implementing National Industrial Policy to Control High-Tech Industrial Chains

While the U.S. has long advocated free-market economics with minimal government intervention in industry formation and development, since the 2008 financial crisis, the federal government has increasingly emphasized its important role in S&T development. Through implicit industrial policy intervention to achieve high-quality employment and economic recovery goals, the U.S. has formed a modern industrial policy framework centered on "advanced manufacturing" [46]. The Trump administration introduced the concept of future industries, releasing *Recommendations for Strengthening American Leadership in Industries of the Future* [47] and, in January 2021, *Industries of the Future Institutes: A New Model for American Science and Technology Leadership* [48] to promote advanced manufacturing, artificial intelligence, and quantum information. ITIF' s January 2022 report *Computer Chips vs. Potato Chips: The Case for a U.S. Strategic-Industry Policy* [49] argued that only through strategic industrial policy identifying key industries and technologies for national security and economic development could the U.S. sustain its innovation and production capacity. In recent years, the U.S. has broken from traditional market economy concepts, strengthening government roles in promoting S&T industries through "industrial policy" to revitalize key S&T sectors, exemplified by the *CHIPS and Science Act of 2022* signed into law on August 9, 2022, aimed at incentivizing domestic advanced semiconductor production and controlling advanced semiconductor supply chains to support cutting-edge applied science.

3.4 Containing China' s S&T Development to Maintain Global S&T Leadership

As China has risen in S&T fields such as 5G communications, artificial intelligence, and quantum information, rapidly narrowing gaps with the U.S. in patent numbers [50], highly-cited publications [51], Global Innovation Index [52], and total R&D investment [53], American circles have been filled with anxiety about "being comprehensively surpassed by China," viewing China as a major competitor. The 2022 *U.S. National Security Strategy* [54] states that "the next ten years will be the decisive decade of competition with China," with persistent strategic competition between the two countries in high-tech fields. In recent years, the U.S. has intensified efforts to contain China' s S&T development through strict and precise export controls. Taking the Bureau of Industry and Security' s *Entity List* as an example: the Trump administration attempted to suppress China' s S&T development in key areas such as semiconductors and artificial intelligence through technological "decoupling," with Chinese entities on the *Entity List* increasing significantly after 2018 [55]. The Biden administration has continued this containment tendency, escalating restrictions on high-tech exports to China. In October 2022, the Bureau of Industry and Security released *Implementation of Additional Export Controls: Certain Advanced Computing and Semiconductor Manufacturing Items* [56], further restricting China' s ability to purchase and manufacture high-end chips. This demonstrates the U.S.' s clear attitude toward suppressing China, with containing China' s S&T development becoming an important driver of its S&T policy transformation.

4. Main Conclusions and Policy Implications

4.1 Main Conclusions

Since the 21st century, a new round of S&T revolution and industrial transformation has accelerated, with emerging countries' S&T developing rapidly and the global S&T innovation landscape showing multipolarization trends. The relative weakening of America' s global S&T leadership and competitiveness, apart from S&T globalization factors, is closely related to its recent governments' lack of effective S&T policy innovation and reform, as well as declining government R&D investment. U.S. S&T policy development over the past two decades can be divided into two stages.

(1) Early 21st century: No breakthrough or transformative S&T strategies, merely "inertia" at work. After the Cold War ended, the U.S. lost a competitor of equal magnitude, becoming the world' s top S&T power by the end of the 20th century with minimal S&T policy changes, merely "inertial" development. Specifically: First, the S&T governance system remained largely unchanged. After the Soviet Union's dissolution in the 1990s, the U.S. gradually lost its sense of crisis, with minimal changes to its national innovation policy system and inertial S&T policy driving development. Entering the 21st century, political and academic circles recognized competitive crises, with the Bush and Obama administrations developing strategic plans and legislation to address challenges, but without fundamental improvements or transformations. Second, U.S. federal government R&D investment continuously declined. Since 2000, federal R&D investment intensity has decreased significantly. Federal R&D investment proportions complement national S&T strategic priorities, yet since the 21st century, R&D investment shares across departments, fields, and disciplines have shown no significant fluctuations, further confirming inertial S&T policy development. Third, the strategic leadership of S&T plans has weakened. While the U.S. established initiatives such as the "National Nanotechnology Initiative," "Advanced Manufacturing Initiative," "National AI Initiative," and "National Quantum Initiative," their influence has been relatively ordinary, failing to achieve the long-term strategic significance and global S&T leadership of major projects like the "Manhattan Project," "Apollo Program," or "Information Superhighway."

(2) Since 2018: Heightened sense of crisis and competition, accelerated S&T policy adjustments with enhanced competitiveness. As global S&T competition intensifies and China and other emerging economies rise, America' s S&T competitive consciousness has been reawakened. Recent U.S. S&T policy has gradually strengthened, manifested in three aspects. First, integrated development of S&T innovation policy. U.S. political circles recognize that an efficient "innovation system" is key to maintaining global leadership, enhancing S&T competitiveness, and resisting economic and pandemic crises, continuously driving national innovation system reform. For example, the Obama administration highly emphasized S&T innovation importance, releasing *A Strategy for American Innovation* three times. Second, increasingly "explicit" S&T industrial policy. The traditionally market-mechanism-oriented U.S. has gradually revealed government roles, strengthening support for industrial S&T, clarifying frontier technology development priorities, and releasing numerous strategic plans and S&T reports. The *CHIPS and Science Act of 2022* represents three years of legislative effort. Third, explicitly identifying China as a major competitor. Since the Trump administration launched the "tech war," the U.S. has identified China as its primary competitor, with strategic competition against China becoming the theme and trend of U.S. S&T policy development. Simultaneously, the U.S. actively expands multilateral S&T diplomacy, forming alliances with countries sharing similar ideologies and interests to comprehensively contain and suppress China' s S&T development.

4.2 Policy Implications

The historical evolution of U.S. S&T policy and R&D investment demonstrates that S&T powerhouses are not built overnight but result from long-term national S&T strategic orientation, steadily increasing R&D investment, and accumulated major S&T innovation breakthroughs. These historical experiences offer important implications for China' s S&T policy formulation, strategic layout, and S&T powerhouse construction.

(1) S&T development is a long-term strategic undertaking requiring stable, efficient S&T governance systems and long-term strategic policy guidance. Since WWII, over 70 years of persistent and vigorous S&T development established the U.S. as the world' s top S&T power. However, inertial S&T policy development and declining federal R&D investment since the 21st century, combined with emerging countries' rise, have challenged U.S. global S&T leadership. Therefore, in building a S&T powerhouse, China should establish a sustained, stable mechanism supporting S&T development, deploy national strategic S&T forces with long-term vision, and continuously deepen national S&T governance system reform. First, continuously and stably increase R&D investment, maintaining long-term emphasis on frontier basic research and STEM education to provide momentum for S&T development. Second, formulate leading S&T industrial policies from national strategic heights, encouraging enterprises to tackle key core technologies and enhance corporate innovation capacity. Third, continuously strengthen top-level S&T development design and macro-level coordination to improve national innovation system efficiency and risk resistance.

(2) S&T development is a highly competitive undertaking, where significant S&T policy competitiveness helps support S&T competitive advantages. U.S. S&T development levels continuously improved through competition with the Soviet Union and Japan, enabling America' s comprehensive S&T capabilities to achieve unparalleled global status in the early 21st century. As a new round of S&T revolution and industrial transformation accelerates, international S&T competition has become unprecedentedly fierce, with increasingly nationalized and corporatized S&T development characteristics [57]. Therefore, while rapidly enhancing S&T capabilities and international status, China should maintain competitive and risk awareness, prospectively planning S&T policy strategic layouts. First, coordinate international S&T competition and cooperation, clarify national interest orientation in S&T, and combine high-quality S&T self-reliance with high-quality open innovation. Second, focus on strategic high-tech fields, develop important strategic and forward-looking national S&T plans or projects to enhance core national S&T competitiveness. Third, attend to high-quality S&T talent competition, optimize education resource allocation, and intensify cultivation and attraction of world-class talent urgently needed in strategic emerging technology industries and key scientific fields.

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