A Century of Vicissitudes: Building the Foundation of Science and Technology—Russia' s (Including the Soviet Union' s) Path to Becoming a Science and Technology Power (Postprint)

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Abstract

The ability to utilize scientific and technological strength to defend national sovereignty, protect national interests, and maintain world peace constitutes the essential attribute of a technologically powerful nation. Since the time of Peter the Great, from the late 17th century to the late 20th century, the heads of state of Russia (including the Soviet Union) have consistently pursued the goal of building a powerful nation, planning and selectively developing science and technology. Through the implementation of "nationalization" initiatives, they established a nationalized science and technology system with distinctive Russian (Soviet) characteristics, thereby securing a position among the world' s technological powers. This nationalized science and technology system operates as a top-down structure of strict control and rapid information feedback, directly led by the head of state, and features a rigid, integrated "politics-military-industry-science-education" five-in-one framework. It serves to consolidate national comprehensive strength, safeguard national security, effectively respond to crises, and contribute to global scientific and technological advancement, representing a crucial guarantee for achieving the status of a technological power. However, this system suffers from inherent deficiencies: it lacks innovation elements driven by interests and capital, and requires the weakening or sacrifice of individual freedom among community members as a prerequisite for its effective operation. Following the dissolution of the Soviet Union, Russia' s nationalized science and technology system sustained severe damage, placing its status as a technological power in grave jeopardy. Nevertheless, Russia was not entirely defeated, owing to its nearly 300-year accumulation of Russian scientific culture. Presently, Russia is actively adjusting its science and technology strategy, restoring its nationalized science and technology system, implanting innovation elements into the "fertile soil" of Russian scientific culture, and cultivating a science and tech-

nology innovation ecosystem with endogenous dynamism to rebuild itself as a technological power. By contrast, the "soil quality" of China' s scientific culture remains relatively impoverished, necessitating further profound accumulation and cultivation to realize the objective of becoming a technologically powerful nation.

Full Text

Building the S&T Foundation for Hundreds of Years –Russia' s (Including the Soviet Union) Path to a Major S&T Power

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The essential character of a science and technology power is the ability to use S&T strength to defend state sovereignty, protect national interests, and maintain world peace. Since Peter I, from the late 17th to late 20th century, Russian (including Soviet) heads of state have consistently pursued the goal of building a powerful nation through planned, selective development of science and technology. Through the implementation of "nationalization" projects, they created a nationalized S&T system with distinctive Russian (Soviet) characteristics, elevating Russia into the ranks of world S&T powers. This nationalized S&T system, under the direct leadership of the head of state, is a rapid information feedback system with strict top-down control, featuring a rigid "politics-military-industry-science-education" five-in-one nationalized structure. It plays a crucial role in consolidating national comprehensive strength, maintaining national security, effectively responding to crises, and contributing to global S&T development, serving as an important guarantee for achieving S&T power status.

However, this system has congenital defects: it lacks innovation elements driven by interests and capital, and it weakens or sacrifices the individual freedom of community members as a prerequisite for its effective operation. The collapse of the Soviet Union severely damaged Russia' s nationalized S&T system, placing its status as a major S&T power in jeopardy. Yet Russia was not completely defeated, thanks to its nearly 300-year accumulation of Russian scientific culture. Currently, Russia is actively adjusting its S&T strategy, restoring the nationalized S&T system, implanting innovation elements into the "fertile soil" of Russian scientific culture, fostering an endogenous technological innovation ecosystem, and reconstructing its status as a major S&T power. In contrast, the "soil quality" of Chinese scientific culture is relatively poor and requires further accumulation and cultivation to achieve the goal of building a major S&T power.

Keywords: major S&T power, Russia (Soviet Union), nationalized S&T system, Russian scientific culture, S&T innovation ecosystem

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If Space Engineering Demonstrates Comprehensive National Strength and S&T Levels

If we accept that space engineering is an important symbol of comprehensive national strength and scientific-technological capability, and that entering space represents humanity' s proudest achievement of the 20th century, then the Soviet Union—which first established a national-level space technology research institution (1933), launched the first artificial Earth satellite (1957), completed the first manned space flight (1961), and achieved the first human spacewalk (1965)—undoubtedly deserves to be recognized as a major power of science and technology.

How did Russia (including the Soviet Union) embark on the path to becoming a major S&T power? What insights can we gain from this experience? What lessons can we draw? This paper seeks answers by examining the 300-year developmental trajectory of Russian science, technology, and culture.

The First Century on the Path to a Powerful Nation: From Peter I' s Goal to the Decembrist Event

Russia is a complex and contradictory nation. Geopolitically situated on the Eurasian continent, it has experienced cultural impacts from east and west (Mongol and Byzantine) and north and south (Slavic and Scandinavian). Over eight centuries, it has experienced four typical state regimes: the Rurik Dynasty (c. 862–1598), the Romanov Dynasty (1613–1917), the Soviet Union (including Soviet Russia, 1917-1991), and the Russian Federation (1991-present). From the 11th to early 17th century, under the protection of the Orthodox Church, Russia "promoted spiritual isolation and fostered national pride and egoism" [3]. Tsarist Russia relied primarily on traditional experience and technology for civilizational self-perpetuation, neither cultivating modern science nor establishing a civic education system, essentially remaining in a state of "gazing across the river" at the new civilization of Western Europe.

Peter I' s "Break Window into Europe" Strategy Western European countries generally established university education before creating modern scientific institutions. Following Leibniz' s advice , Peter I decided to first build a national academy in Russia, which lacked a foundation in civic education. This was because universities "cannot lay a scientific foundation for production development" [4], whereas an academy "can not only bring glory to the state and prosper contemporary science, but also benefit future national education" [5]. To achieve this goal, Peter I personally formulated the basic framework of the

"Draft Charter of the Academy of Sciences and Arts" (hereinafter referred to as the "Draft Charter"). The Draft Charter stipulated that the Petersburg Academy was a Russian state institution funded by the government (Figure 1 [Figure 1: see original paper]); employed personnel were directly under "the management and protection of the Emperor" ; scientific research constituted state action (Figure 2 [Figure 2: see original paper]); and research results belonged to the state[6].

On February 8, 1724, Peter I issued an imperial decree establishing the "Petersburg Academy of Sciences and Arts" (abbreviated as "Petersburg Academy" or "Petersburg Academy of Sciences" , later known as the "Russian Academy of Sciences"). Regrettably, Peter I passed away on February 8, 1725, before he could see the launch of his designed Russian scientific vessel.

The 18th-century Petersburg Academy was not large in scale, comprising 110 scientific researchers, 75% of whom were foreign scientists[7], primarily from Germany or German-speaking countries. These scientists fully utilized superior research conditions to establish academic journals and completed two Kamchatka scientific expeditions (1725–1730 and 1732–1743), making important contributions to world navigation, geography (including cartography), zoology and botany, as well as ethnology and Oriental studies. In an academic atmosphere far removed from Western Europe, they rapidly expanded research fields, establishing Russian schools of mathematics-mechanics (represented by L. Euler), astronomy, and experimental physics. In 1745, Lomonosov became the first Russian-born academician, signifying Russia' s entry into a period of scientific indigenization. From the 18th to early 19th century, the Petersburg Academy was "synonymous with Russian science" [8].

In addition to conducting research, scientists at the Petersburg Academy also shouldered the tasks of cultivating Russian scientific talent, implementing civic education, and carrying out cultural enlightenment. This special "science-education integration" model both promoted the deepening of scientific indigenization in Russia and continuously improved the Russian national education system. The successive establishment of state universities (Moscow University in 1755, St. Petersburg Normal University in 1797, Kazan University in 1807, among others) cultivated a new generation with scientific and humanistic literacy.

The Decembrists Initiate a New Era in Russian Culture Russia' s victory in the Russo-French War of 1812 marked the transformation of Peter I' s dream of a powerful nation into the reality of "breaking the window into Europe." However, Russian aristocratic officers who had defeated Napoleon' s army began to recognize the essential difference between Russian imperial rule and Western European democratic systems. They believed that only by overthrowing the monarchy, abolishing serfdom, and establishing a republic could true happiness be brought to the Russian people. On December 24, 1825, their uprising was brutally suppressed. Nevertheless, they left behind the revolutionary spirit of the "Decembrists," awakening the consciousness of more Russian citizens.

From Peter I' s reforms in the late 17th century to Nicholas I' s suppression of the Decembrists in 1825, the first century of Russia' s path to power traced a trajectory of negation of negation: Peter I top-down implemented the "Break Window into Europe" strategy, "using barbaric struggle methods against barbarism to compel barbaric Russia to accelerate its emulation of Western European culture" (Lenin)[9]. The embryonic "politics-military-industry-science-education" five-in-one nationalized S&T system began to emerge, cultivating a group of new Russians with scientific knowledge who embraced Western democratic ideas and opposed the nationalized system. Russian scientific culture quietly grew from within the nationalized system, forming an emerging internal tension that resisted the system.

The Second Century on the Path to a Powerful Nation: Metrology System–Siberian Railway–Commission for the Study of Natural Productive Forces

State Metrology Institution Construction and Government' s Institutional Selection of Scholars Metrology is the intermediary of commodity exchange and the guarantee of social fairness. Before the mid-19th century, Russia had no national metrology system and lacked unified measurement standards across the country, severely limiting the scale of Russian industrial output and foreign trade. To expand exports, Nicholas I issued the "Decree on Russian Weights and Measures System" in 1835 and approved the establishment of Russia' s first national-level metrology institution–the "Weights and Measures Repository" on June 16, 1842. This was a top-down institutional construction process. The Russian government recognized the relevance, necessity, and complexity of national standardization practices and metrology development, and decided to select scientists to serve as directors of the Weights and Measures Repository (as government officials). The first director was Academician Kupffer of the Russian Academy of Sciences, and the second was Professor Glukhov, a physicist and metrologist. These two directors completed the early construction of the Repository from 1842 to 1892, but failed to fundamentally improve Russia' s chaotic situation lacking unified standards. On November 19, 1892, the renowned chemist Mendeleev was appointed as the third director, ushering in the "Mendeleev Era" (1892–1917) of Russian metrology.

To better exercise governmental functions, the government accepted Mendeleev' s proposal to rename the Weights and Measures Repository as the Main Directorate of Weights and Measures and to increase salaries for staff (who were also metrology researchers). Mendeleev vigorously promoted publicity campaigns to establish branch offices nationwide, raising public awareness of metrology to advance the work of unified weights and measures and new standards across Russia. To prevent nationwide chaos, he adopted a "step-by-step" approach: first unifying Russian measurements nationwide to prepare for full implementation of the international metric system; purchasing and storing international measurement standards; calibrating national clocks (which played an important role in promoting Russian railway development); and establishing a metrology research center within the Main Directorate to store a national standards database at an international level. However, due to political upheavals in Russia and Mendeleev' s death in 1907, Russia failed to implement the international metric system before the October Revolution.

After the October Revolution, the Bolshevik regime continued to advance the work of unifying weights and measures. On September 14, 1918, Lenin signed the "Decree on Unifying Weights and Measures," and on October 4, 1918, issued the "Decree on Using the International Metric System,"completing the important task of replacing Russian measurements with the international metric system[11]. This fully demonstrated the Bolshevik Party' s strength in implementing new nationalization. Today, the Russian Main Directorate of Weights and Measures has been renamed the "All-Russian D.I. Mendeleev Institute for Metrology," serving as Russia' s metrology research center.

The Siberian Railway and Russia' s Industrial Development The railway transportation industry can drive the development of steel manufacturing, mining, telegraph, telephone, signaling, and railway 沿线 facility construction and maintenance, 集中 reflecting industrialization achievements and serving as an important indicator of national power in the 19th century.

Russia' s railway transportation industry began in the 1830s. By 1861, approximately 1,600 kilometers of railway lines had been laid within Russia. Compared with Britain (16,000 kilometers of railway lines) at that time, Russia remained in a backward state. The Russian Emperor regarded railway development as a breakthrough for revitalizing Russian industry, fully leveraging the control functions of the nationalized system. In the late 1890s, Russia launched a second railway construction 高潮, successively building the Transcaucasus, Trans-Caspian, and Siberian railways.

The Siberian Railway stretches west from Moscow to Vladivostok in the east, spanning a total length of 9,288.2 kilometers, making it the longest railway 干线 in the world to date[12]. The most significant importance of this railway lay in achieving military objectives: shortening the distance between European Russia and East Asia, ensuring that Russian forces could mobilize troops in the Far East and transport military materials during wartime. To construct this railway, Russian politicians and scholars learned from Western Europeans about large-scale financing concepts and methods; selected, developed, and built railway equipment adapted to Siberian climate and geographical conditions. With the completion of the Siberian Railway, Russia cultivated a group of experienced managers, engineers, and technicians, familiarized itself with capital and technology operation methods, and added knowledge, capital, and management elements to the nationalized S&T system. In 1913, Russia possessed 70,000 kilometers of railway, becoming the world' s second-largest railway nation (USA: 250,000 km, Germany: 63,400 km, France: 40,800 km, UK: 38,100 km)[13].

The "Commission for the Study of Natural Productive Forces" and Scholars' Proactive Participation in State Governance The outcome of Russia's defeat in the Russo-Japanese War of 1905 severely undermined Emperor Nicholas II's confidence. Around 1912, Europe was covered by war "dark clouds." The Russian government urgently needed to adjust its development strategy to stabilize domestic political situations and respond to external political and economic pressures.

On January 21, 1915, Vernadsky proposed the establishment of the "Commission for the Study of Natural Productive Forces" at a meeting of the Physics-Mathematics Division of the Russian Academy of Sciences. The "primary task of the Commission for the Study of Natural Productive Forces is to collect and organize information on Russia' s natural resources and productive forces status, produce systematic scientific research reports, and accurately assess and evaluate the nation' s productive forces level based on existing literature," with the purpose of comprehensively investigating, preserving, and developing Russia' s natural resources and transforming them into productive forces, preparing to cope with brutal wars and future post-war reconstruction work. This proposal immediately received positive responses from scholars and affirmation from the government. The "Productivity Commission" established specialized research subcommittees including asphalt, clay and refractory materials, platinum, salt, and a publications subcommittee for *Russian Natural Productive Forces*; involving 10 scientific societies, professional associations, and 5 government departments. In 1918, building on previous work, the "Productivity Commission" formally established the Institute of Physicochemical Analysis, the Institute of Platinum and Other Precious Metals, and expanded existing subcommittees into 20 research divisions including rare elements and radioactive substances, salts, platinum ores, hydrology, and optics, while simultaneously establishing a map library. The "Productivity Commission" had 139 members (in 1917), the vast majority being professional scientists from the Academy, with a few government officials, entrepreneurs, and university teachers, focusing primarily on theoretical research and scientific expeditions. In 1916 alone, the "Productivity Commission" dispatched 14 scientific expeditions across Russia. Between 1916 and 1923, the "Productivity Commission" successively published *Research Documents on Russian Natural Productive Forces* and the six-volume *Russia' s Natural Productive Forces* [15].

The "Productivity Commission" was Russia' s first new-type organization spontaneously formed by scientists. It united elites from government, enterprise, universities, and social organizations, scientist-led, patriotism-oriented, and technology-based nation-building as its goal, organized according to academic community rules, employing capital operation methods and management approaches, integrating scientific research, finance, and production management. Although a non-governmental organization, it could exercise supra-governmental functions in some aspects, capable of convening scholars from different fields according to government needs to jointly solve urgent problems involving Russian military industry and national economic production. "It played a major role during the critical moments of World War I" (Vernadsky)[16].

The Third Century on the Path to a Powerful Nation: "Mobilization" Research Management Model–Nationalized S&T System–S&T Innovation Ecosystem

From the mid-1920s to early 1930s, the economic "Great Depression" in Western capitalist countries such as the United States provided favorable international political conditions for the Soviet Union' s rise. The Soviet Communist Party seized this opportunity to implement plans including strengthening the Soviet Academy of Sciences, overcoming economic difficulties in a short period and rapidly elevating the scientific and technological level of the entire population.

The Soviet Academy of Sciences and the "Mobilization" Research Management Model To leverage the reputation of the Russian Academy of Sciences in the world scientific community, the Soviet government grandly celebrated the Academy' s 200th anniversary in 1925, simultaneously renaming the Russian Academy of Sciences as the "Soviet Academy of Sciences," highlighting the nationalization of science. From 1925 to the eve of World War II, the Soviet Academy of Sciences was incorporated into the direct jurisdiction of the Soviet government (1933); its headquarters moved from Leningrad to Moscow (1934); an Engineering Sciences Division was established (1935) to drive basic scientific research through military research and improve the overall level of military research and defense production ; Communist Party members and defense industry managers were recommended as academicians; and the number of research institutions, scientific personnel, and research funding was substantially increased . Under the leadership of the Soviet Communist Party, the Soviet Academy of Sciences gradually became the "general headquarters" of Soviet science.

However, simultaneously, Soviet Communist leaders persecuted and suppressed intellectuals through the establishment of "Sharashka" institutions and the "Great Purge," aiming to eliminate dissent and severely dampening intellectuals' patriotic enthusiasm.

The "Mobilization" research management model (Figure 3 [Figure 3: see original paper]) relied on an efficient social organization and management network integrating "politics, military, industry, science, and technology," uniting the entire nation and ultimately winning the war. In this system, Stalin held absolute command authority, exercising strict top-down control over all levels of institutions and rapidly obtaining information feedback through the KGB intelligence system. Scientists directly participated in important military research projects within the system, establishing a symbiotic relationship with those in power.

The "Mobilization" model was built upon lessons learned from Russia' s participation in World War I (such as the "Productivity Commission") and Russian scientific culture, dependent on the Soviet Union' s powerful comprehensive industrial national strength and centralized system. In a state of war mobilization, it served to uniformly allocate national resources, respond to challenges with scientific and technological achievements, and strengthen national interests.

Space Achievements and the Nationalized S&T System After 1945, Stalin and subsequent Soviet leaders maintained and expanded the "Mobilization" model, incorporating computer and atomic energy R&D and comprehensive utilization, as well as the space sector, into priority development strategic domains, forging a nationalized S&T system with a rigid structure integrating "politics, military, industry, science, and education" five-in-one. This system achieved breakthrough scientific and technological progress in a short period, attaining the goals of comprehensively developing basic research and protecting the defense industry and national security.

Soviet space research originated from Tsiolkovsky' s ideas on using rockets for space flight proposed in the late 19th to early 20th century. During the 1920s–1930s, Tsiolkovsky' s ideas were widely disseminated in the wave of socialist construction, stimulating great Soviet public interest in space endeavors. In 1924, the Soviet Union established the world' s first space flight research organization—the Interplanetary Communications Section. Between 1930–1933, the Soviet Union developed the first batch of liquid rocket engines and the world' s first electric thermal rocket engine. In 1933, the Soviet Military Commission approved the establishment of the world' s first national-level rocket technology research institution—the Jet Scientific Research Institute. This marked the incorporation of Soviet rocket research from scientists' and engineers' personal interests into the national military-industrial research system, receiving state funding. However, precisely because of the nationalization of military research, Soviet rocket research nearly stagnated[18] following the wrongful execution of its leader, Marshal Tukhachevsky, in the "Great Purge." During World War II, Nazi Germany developed the world' s first ballistic rocket, the V-2. After WWII, although the Soviet Union failed to "seize" top German scientists, it attracted a large number of outstanding German engineering and technical personnel with generous 待遇. After five years of study and nearly 3 billion rubles of R&D investment, the Soviet Union for the first time independently designed and developed the P-2 rocket (an improved version of the V-2), the world' s first nuclear weapon delivery vehicle P-5M rocket, and the first intercontinental ballistic missile P-7. Possessing the P-7 meant the Soviet Union had the capability to directly launch nuclear weapons onto U.S. territory, thereby changing the political and military 格局 of U.S.-Soviet 博弈. However, Korolev was less concerned with directly launching missiles at the United States and more focused on the peaceful development of space. He successfully used the P-7 to launch the world' s first artificial Earth satellite (1957) and achieve the first manned space flight (April 12, 1961), pioneering the human space age.

Soviet rocket technology and space flight R&D "experienced a process from expert spontaneity to top-level government decision-making" [19], representing the Soviet Union' s strategic selection and integrated construction of basic science, applied science, natural resources, human resources, and technical equipment by mobilizing the entire nation's strength. This demonstrated the systematic, informational, and rapid superiority of the "politics, military, industry, science, and education" five-in-one nationalized S&T system, marking an important symbol of the Soviet Union' s ascension to the pinnacle of major S&T powers.

The Chernobyl Disaster and Russia' s S&T Innovation Ecosystem The Chernobyl nuclear power plant explosion that occurred in the Soviet Union in the early morning of April 26, 1986, was "the greatest technological disaster of the 20th century" [20]. The Soviet government, leveraging the superiority of a socialist state, adopted numerous emergency measures. However, it also fully exposed the sharp contradictions between state reputation and national interests, and between state commitments and uncompensated personal material and spiritual losses. "Chernobyl" became the "last straw that broke the Soviet Union" [21].

After the dissolution of the Soviet Union in 1991, the Russian Federation assumed nearly 86% of Soviet 遗产. The period from 1991–1999 marked Russia' s transition from a planned economy to a market economy, representing an important transitional phase of "de-nationalization" and "strong capitalization" in the third century of Russia' s path to a powerful nation. During this process, the original Soviet nationalized S&T system, having lost the support of the centralized system, could not 发挥其优势, greatly weakening Russia' s comprehensive national strength.

During social transformation, as the nation' s basic science stronghold, the Russian Academy of Sciences lost 100% of its state budget support and suffered severe damage. However, Russian scientists strove to overcome difficulties including severe shortages of research funding, abrupt declines in social status and living standards, 坚守科研岗位, and preserved research capabilities in many fields.

In recent years, the Russian government has adopted multiple measures to vigorously revive its status as a major S&T power. For example: formulating the "National Science Law" and a series of policies aimed at enhancing national S&T potential; opening previously "secret" science cities; strengthening research cooperation with universities; advocating the introduction of market mechanisms; expanding sources of research funding; integrating with international standards and participating in international market competition; explicitly proposing to jointly build international S&T innovation systems with other countries. Particularly since 2013, top-down reforms of the Russian Academy of Sciences have been promoted, striving to create a national innovation system. This demonstrates that in the torrent of global development, Russia has not stopped advancing toward becoming a major S&T power.

The Nationalized S&T System and Russian Scientific Culture

The "nationalized S&T system" proposed in this paper refers to a top-down, individual-command-driven system encompassing political, military, industrial (engineering), scientific, and educational nationalization, featuring a rigid "politics-military-industry-science-education" five-in-one structure and a self-contained system. This system possesses advantages including resource concentration, system integration, interconnectedness where one move affects the whole, and rapid upward-downward transmission, facilitating complementary advantages, leveraging strengths while avoiding weaknesses, and concentrating resources to accomplish major tasks. However, this system has inherent defects—it operates on the premise of reducing or sacrificing personalized factors within the system, contradicting individual freedom development and lacking innovation drivers. Russia' s (including the Soviet Union' s) S&T system represents a concentrated manifestation of the nationalized S&T system.

"Russian scientific culture" is a new concept[22] that emerged after Peter I' s "Break Window into Europe" strategy, representing a unique, continuously growing subculture of the Russian nation with multiple sources and rich connotations. It 主要包括 five sources and basic 内涵: the core of individual rational thinking and the drive for knowledge, namely modern science (natural sciences and humanities) and methods; the spiritual source of the collective, namely the Orthodox cultural spirit of salvation, forbearance, contempt for material wealth, and willingness to sacrifice; the secular character and life attitude of boldness, openness, unconstrained freedom, and pursuit of natural beauty, determined by Russia' s natural geography; the collectivist and submissive behavioral norms formed by social conditions such as the village commune system; and the exquisite Russian language system with complex logical structures that carries and expresses thought. Russian scientific culture is endogenously generated within the nationalized S&T system and plays a role in either outward expansion or inward cohesion for that system. Since culture depends on cultural subjects, the inheritance and 变迁 of scientific culture depend on the composition and changes of scientific culture subjects. The subjects of Russian scientific culture are Russians (or foreigners who speak Russian and understand Russian traditional culture) educated in modern science and Western Enlightenment. In different periods, Russian scientific culture forms different proportions of connotations due to changes in subject composition, thereby exhibiting different manifestations and exerting different effects on society.

Centuries of Journey, Building a Powerful Nation' s System

From the late 17th century to the present, Russia' s path to becoming a major S&T power has spanned 300 years. In the first century (late 17th century–1725–1825), Russia traced a trajectory of negation of negation: to learn from Western European culture, it top-down promoted and implemented the "Break Window into Europe" strategy, creating the Petersburg Academy and forming a prototype of the "politics-military-industry-science-education" five-in-one nationalized system. Within this system, Russian scientific culture with inherent tension against the nationalized system emerged bottom-up. In the second century (1915–1917–1925), Russian scientific culture flourished vigorously, promoting the process of "strong capitalization" and "de-nationalization." Intellectuals proactively participated in national development activities, driving industrialization. Changes in the international political 格局 broke Russia's internal balance. The socialist construction goal of "Soviet plus electrification" and the governance philosophy of "de-capitalization" and "strong nationalization" laid the ideological foundation for consolidating the "politics-military-industry-science-education" five-in-one nationalized system. In the third century (1917–1925–2018), the Soviet Union fully established the "politics-military-industry-science-education" five-in-one nationalized S&T system, won WWII, initiated humanity' s space age, and ascended to the pinnacle of major S&T powers. After the Soviet Union' s dissolution, the nationalized S&T system lost its advantages, while Russian scientific culture has played and continues to play a cohesive role. The Russian Federation bears the heavy responsibility of reviving its status as a major S&T power.

Russia' s path to becoming a major S&T power exhibits the following characteristics: clear "powerful nation" goals; top-down promotion; gradual formation of a "politics-military-industry-science-education" five-in-one nationalized S&T system; endogenous Russian scientific culture; and lack of innovation elements that protect national personal interests and drive capital.

The S&T Innovation Ecosystem and Its Implications

Russia still possesses the basic conditions for being a major S&T power: abundant natural resources; partially preserved original nationalized S&T system structure; unique Russian scientific culture; gradually strengthening social innovation consciousness; and innovation-driving capital expanding in both quantity and scale. History proves that Russia, a nation with special geopolitical positioning and complex cultural origins, cannot simultaneously satisfy national interests and citizens' happiness by moving to any extreme. Russia' s challenge lies in how to fully absorb the lessons from its 300-year history as a powerful nation, learning from but not copying other countries' models, and drawing on their strengths while compensating for its own weaknesses. Science and capital can provide unlimited growth space for human groups and individual development, capable of combining national reputation with individual citizen interests —two indispensable innovation-driving elements for moving from a large country to a powerful one. Russia needs to concentrate national strength to protect the Russian Academy of Sciences as the stronghold of basic scientific research, transform and utilize the rigid structure of the nationalized S&T system, promote the expansive and cohesive functions of Russian scientific culture, add innovation elements (adjusting policies, opening markets, integrating capital), and employ the regulation of scientific and capital elements to establish a "S&T innovation ecosystem" that is vibrant, open, capable of self-regulation, and cyclically developed.

Compared with Russia, China possesses a similar "nationalized S&T system" and does not lack innovation-driving elements such as capital and markets. We need to cultivate Chinese scientific culture subjects who possess both scientific rationality and inherited traditional culture, accumulate and nurture fertile soil, and create an ecological atmosphere for Chinese scientific culture. China' s goal of building a major S&T power featuring "national prosperity and citizen strength" can only be truly realized when a vibrant S&T innovation ecosystem is constructed. Thus, we have bright prospects, but the task is arduous and the road is long, requiring difficult journeys, earnest study, and continuous climbing.

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Note: Figure translations are in progress. See original paper for figures.