Tech-Politik

Historical Perspectives on Innovation, Technology, and Strategic Competition

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THE ISSUE

Technological innovation represents a central arena of great power competition that demands policy action informed by historical perspective. The speed of today's technological progress and nature of the competition makes historical comparison seem daunting, but several critical periods in twentieth century science and technology policy can offer insights on the value of government investment, technological exchange, and centralization.

Technology is becoming the most complicated and central challenge of U.S.-Chinese strategic competition, with implications for military, political, and economic power. The capacity to harness emerging technology for military purposes has an important impact on the balance of military power. Innovation drives the modern economy and serves as the foundation of national power. Innovation and scientific breakthroughs provide tangible metrics of progress in the competition between systems and are symbols of national vitality in any ideological contest for the hearts and minds of the world's people. Navigating economic cooperation and competition with China—particularly in high tech sectors with deep interdependencies and strategically important secrets—will pose vexing problems for policymakers as they weigh economic opportunity and strategic risk.

From the U.S. perspective, trendlines in the competition are worrisome. China has made substantial gains driven by centralized strategic planning, massive infusions of government spending, and selective participation in the liberal international system, including purchasing, investing in, and stealing intellectual property from non-Chinese companies.[1] In contrast, the U.S. federal commitment to basic research and development and support for science and technology (S&T) has been on a steady downward trajectory since before the end of the Cold War.[2] There is now a realistic prospect of the United States falling behind in critical innovation sectors with defense implications.[3]

Meanwhile, a deep set of interconnections between Chinese researchers and U.S. academia and commercial firms has developed even as the strategic rivalry deepens.[4] Today, the U.S. government and American industries are re-examining the costs and benefits of close technological and economic ties to China as it becomes a peer competitor.[5] Having been dominant for decades, and slowly realizing its own investment gaps, the United States is now considering a series of large-scale investments in emerging technology while also struggling to imagine what an interdependent relationship with a strategic competitor entails.[6]

IN SEARCH OF HISTORICAL PERSPECTIVES

In the fall of 2019, CSIS's Project on History and Strategy (PHS) held a series of private roundtables to explore historical perspectives on innovation and technology in the context of strategic competition, hosting Dr. Emily Gibson of the National Science Foundation, Dr. Michael Gordin of Princeton University, Dr. William Hitchcock of the

University of Virginia, Dr. Ian Johnson of the University of Notre Dame, and Dr. Margaret O'Mara of the University of Washington. The five historians were asked to shed light on: the strategies, tactics, public policy decisions, and politics at the nexus of technology and national security; how states incentivize and build an innovation ecosystem; and how strategic competitors balance economic and strategic risk and reward in technology trade and cooperation.

There are no perfect analogies that capture the current techno-strategic competition between the United States and China. However, specific dimensions of the contemporary strategy challenge do lend themselves to the search for historical clarity on, for example, state involvement in innovation and the galvanizing effects of a "Sputnik moment." Analogies are usually an attempt to assert that a present challenge is similar enough to a previous one to draw lessons, but they are also useful to sharpen contrasts, to show what a current competition *is not*. As Princeton historian Michael Gordin suggested in his PHS seminar, examining just how dissimilar the early Soviet-U.S. scientific competition is to today "illustrates what is distinctive about the problem."[7]

In an effort to think through the current technological competition, PHS has explored the following series of questions:

- How do governments pursue innovation when driven by strategic concerns? More specifically, how did the United States build its S&T ecosystem during the early Cold War?
- How do other political systems—namely authoritarian or one-party governments—approach technology? What are the strengths and weaknesses in their approach?
- Can strategic competitors find a basis for technological cooperation? What have past technological relationships looked like between geopolitical and ideological competitors beyond the Cold War? And if competitors do cooperate, how do they weigh risks and rewards across economic and strategic considerations?

THE CHALLENGES OF BUILDING AN INNOVATION ECOSYSTEM: THE FEDERAL ROLE IN AMERICAN S&T IN THE EARLY COLD WAR

The early Cold War experience with the creation of a federal and national commitment to innovation has become a symbolic touchstone in the call to action for the United States to take China's rise seriously, make new investments in research and education, and frame science and innovation as competitive races. The realization that the high-water mark of federal investment in research and development (R&D) occurred more than 50 years ago, at the height of the Cold War, has led many to conclude that the United States must replicate that commitment given the magnitude of today's strategic challenge.[8] Some have lamented the absence of, and need for, some frightening technological breakthrough by China to spur another generation of American innovation, education, and far-sighted investment.[9] Others have noted the central role played by federal, and more specifically defense, funding and research during the Cold War in spurring many of the civilian applications that have revolutionized the modern world.[10]

In this contemporary discussion, the political will, budgetary commitment, and organizational development, exemplified by the story of the establishment of the National Science Foundation (NSF), represent an experience worthy of emulation in the new tech race. But we should not underestimate the difficulty of building support for S&T even in that "golden age."[11]

The growth of federal investment in science and education in the early Cold War was neither quick nor inevitable. World War II had forged unprecedented and crucial S&T relationships between the federal government and universities, private foundations, and industry.[12] As the war came to an end, many in Washington realized that continued partnership and funding would be just as beneficial for civilian purposes as it had been to the Allied victory.[13] The leader of the wartime Office of Scientific Research and Development, Vannevar Bush, at President Roosevelt's request, drafted a study called *Science: The Endless Frontier*.[14] In it he proposed the continuation of the effort to develop science above and beyond military applications in service of national health, prosperity, and security. He also cautioned that without concerted effort the United States would face a serious deficit in scientific personnel for teaching and research to drive a new scientific agenda.

The creation of the NSF in 1950 represented the key civilian bureaucratic and policy innovation of this period. Its early history is a reminder of just how hard it is to create, fund, and sustain any new federal S&T initiative. Despite witnessing the extraordinary impact federal support could have for science in wartime, recognizing the promise for peacetime application, understanding the gaps in expertise, and adding the new threat of competition with the Soviets, the effort to build and fund the federally supported science and education infrastructure was slow, contentious, and episodic. Major bureaucratic innovations

and significant funding took years to begin (and in some cases more than a decade).

DOMESTIC POLITICS AND POLITICAL PHILOSOPHY SLOWED GROWTH

Five years passed between the publication of Vannevar Bush's landmark study and proposal for federal support and the establishment of the NSF. Congress first introduced a bill in 1947, but it was not fully negotiated and signed into law until 1950, despite widespread support for federal investment in S&T. The mission outlined by Congress was unobjectionable: "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." Implementation, however, was stymied by deep disagreements over the geographic distribution of potential grants, debates about patent ownership, questions about the relationship between social science and a new foundation, and the issue of who would actually exercise administrative control over the new entity. Even after the NSF was established, the debates continued to constrain its work and severely limit its budget until the mid-1950s.

DEFENSE STILL DOMINATED

The creation and impact of the NSF must be given context. This government investment in basic research and long-term civilian science was dwarfed by the massive increase in the defense budget and military research. The NSF was established with a budget of $3.5 million in 1952; the defense budget at the time was approaching $50 billion. From the defense budget, $1 billion, or 90 percent of all federal R&D funding, was spent by the newly established Department of Defense on its own research projects. This original NSF budget was barely enough to staff its building, let alone issue research grants and scholarships.

MOBILIZING FOR ACTION THROUGH SPECIFIC DATA

The Cold War technological competition rapidly became the defining feature of debates about the NSF. However, even the looming Soviet threat and Cold War atmosphere were insufficient to expand the NSF beyond its embryonic organizational state in its first five years of existence. Key congressional figures, including the chairman of the House Committee on Appropriations, viewed the NSF's educational mandate as a dangerous threat to local education, calling it a "federal takeover." Congress was not persuaded that national security imperatives for fully funding the NSF should trump concerns about federalism until the NSF produced a study of Soviet progress, titled *Soviet Professional Manpower*, in 1955.[15] The precise, data-driven analysis of Soviet educational and scientific progress framed the NSF's educational mission in a competitive ledger. After the study was published and it became clear exactly what the Soviets were doing in education, Congress appropriated $40 million to the NSF budget and increased the foundation's educational budget for S&T eight-fold.

THE GROUNDWORK IN PLACE FOR THE LEGISLATIVE MOMENT

While Sputnik has rightly been credited with expanding the U.S. innovation ecosystem, key aspects, such as the National Defense Education Act of 1958 (NDEA), had deeper history. As noted above, the NSF received a meaningful budget (though not the hundreds of millions per year it would later receive in the 1960s) in the federal budget for fiscal year 1958, before Sputnik launched. The NSF already had an Office of Education developing a policy framework, and a notional plan from the administration and draft bills already existed to expand STEM education. Sputnik created the policy window, but many of the policy ideas for student loans, grants for STEM studies, foreign language training, expanding graduate fellowships, and funding to improve science facilities in schools were already under development and ready to be consolidated in the NDEA. Indeed, even NASA existed in almost all but name.

As these examples suggest, institutional movement and smaller organizational contributions can precede political will. Indeed, they likely must in order for leadership to be prepared when the political moment arrives to translate ideas into action.

WAITING FOR SPUTNIK? THE LEADERSHIP AND THE POLITICS OF S&T INVESTMENT

Amid concern about how the United States can protect its technological advantages, spur a new era of innovation, and maintain its economic and military edge, one often hears the yearning for another "Sputnik moment." The Soviet satellite—the first "artificial moon," in the parlance of the era—sparked a celebrated "golden age" of government-driven innovation that has become a touchstone in contemporary policy discussions. As the former chairman of the Joint Chiefs of Staff stated earlier this year, "In my view, it's not an overstatement to say that we're at another Sputnik moment. And you could argue that the stakes are much higher than they were in the late 1950s and early 1960s."[16]

The Soviet satellite launch transformed the political landscape and shifted long-standing debates about the proper role of federal funding for science and education. However, the conventional narrative we tell ourselves about

Sputnik—that it "shocked" the nation, galvanized bipartisan support, and represented the height of American greatness in the face of fear—is too simple. It casts Eisenhower's missile technology accomplishments as failures, and it obscures the important political and bureaucratic dynamics that made the "Sputnik moment" out of an ambiguously meaningful news story.

A POLITICAL AND LEADERSHIP CHALLENGE

In its proper context, the "Sputnik moment" should be viewed not as the signal of a new existential threat to the United States but rather as a political crisis for a president also under pressure from an economic recession, a health crisis, and his recent decision to integrate a school in Little Rock, Arkansas by force.[17] The Soviet launch was neither a surprise—at least to anyone paying attention—nor a paradigm-shifting technical achievement. Both the Americans and the Soviets had announced their intention to orbit a satellite within the year and had serious programs in place. American national security officials marveled at Sputnik's weight and lamented the propaganda loss but were not daunted by the demonstrated capabilities. They certainly did not suddenly perceive a decisive Soviet strategic advantage.

The United States could have orbited a satellite a year before the Soviets did, had that been a presidential priority.[18] Nearly all U.S. investment in rockets was in the military realm, where U.S. missile programs were more advanced than the capabilities demonstrated by Sputnik. Eisenhower had judged that while a satellite program would necessarily involve a successful rocket technology program, it would be more efficient for national security purposes to focus on rocket technology's application for carrying weapons. In fact, given that Eisenhower was preoccupied with establishing the neutrality of space as a scientific research domain, the peaceful Soviet launch supported his long-term goals for international space policy.

Soviet workers and engineers in the Space Race. Sputnik, the first artificial Earth satellite, was launched into space in 1957, and Yuri Gagarin was the first human in outer space in 1961. This later image indicates Soviet intentions to reach the moon.

Photo by Culture Club/Getty Images

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Eisenhower failed initially to account for the public relations consequences of being second in space. Sputnik became such an impactful event because, in a hyper-partisan moment marked by intense debate over the size of government, it offered Eisenhower's political opponents an opportunity to blame his thrift for a Soviet "win." To make things worse, Eisenhower was slow to react, true to his conviction that the orbiting sphere was nothing more than a propaganda victory. It was only after he realized that Sputnik had taken on a life of its own, as a referendum on his leadership and the nation's power, that he moved to drive the narrative toward missile investment, Department of Defense reorganization, basic research, and STEM education. Eisenhower remained rueful, convinced that politics and pushy education advocates and scientists were using a meaningless event to force open the government purse-strings. As he said, of the "Sputnik psychology," "One had only to say 'moon' or 'missile' and everyone went

berserk."[19] Eisenhower chose not to waste the opportunity, but it was not an opportunity he had hoped for.

Test pilot Lawrence Clousing boards a Lockheed P-80 aircraft for a test flight at the NASA Ames Research center in Mountain View, California, with a NACA logo visible in the background, 1960. Image courtesy NASA.

Photo via Smith Collection/Gado/Getty Images

A MOMENT FOR POLICY ENTREPRENEURS WITH PROPOSALS READY

As noted above, virtually all of the organizational innovations spurred by the reaction to Sputnik had been formulated prior to the Soviet launch. Some were wallowing in bureaucratic purgatory, existed in draft form in Congress, or had been floated in the private sector, while others existed in all but name already. Sputnik represented the quintessential policy window when ideas, action, and funding came together, but the ideas themselves were already under development.

THE POWER OF PUBLIC-PRIVATE PARTNERSHIP: THE MAKING OF SILICON VALLEY

A NEW MODEL?

Because the balance of power between the American government and private sector has shifted in favor of private industry, S&T mobilization is now a different challenge than it was during the Cold War. The most substantial difference in public-private partnerships between the rise of the Cold War and today is the diminishing importance of federal dollars—particularly defense dollars—in driving the innovation sector. The best data scientists in America used to be distributed similarly between government and private employment; now they are almost all concentrated in the private sector. Spinning-off commercial enterprises from defense-funded projects has yielded to spinning-in commercial innovation for government applications.

THE AMERICAN WAY

This new model would seem to be justified by the "American" way of innovation, starting up in a garage without government involvement. Silicon Valley stands as the perfect example of capitalism at work, thriving with self-starting, independent entrepreneurs who (these days) often scorn national security applications. By contrast, "throwing money at the problem" is too top-down of an approach, reminiscent of the Soviet way of doing things; Americans let the free market foster the best innovation.

A careful look at the history of Silicon Valley reveals a different narrative.[20] In fact, Silicon Valley would not exist as it does today without the Cold War-era tsunami of federal defense contracts. Not only did the U.S. government provide vast sums of money to develop computing technologies across various small "startup towns," it also stood as a ready customer long before these technologies were commercially viable. Silicon Valley, therefore, was built on a foundation of private defense contracting. For example, Lockheed Martin was the largest employer in the valley from the mid-1950s to the late-1980s.

In the mid-1960s, because of the space race, federal funding went into overdrive as the nation worked to send humans into space. To land on the moon, the critical component needed was light, powerful transistor technology—exactly what the Santa Clara valley specialized in. At the center of what would be called Silicon Valley, Santa Clara rose to the top of the transistor field because of the focus that the private, forward-thinking Stanford University placed on earning these federal contracts for itself and the community. Its provost, Fred Terman, had focused the university on science and engineering, built a sprawling academic research park, and convinced nascent computing companies to relocate there. But the U.S. government provided the seed capital; as a striking example of the lasting impact of that model, the original Google search engine developed by Larry Page and others as graduate students was done with a grant by the Defense Advanced Research Projects Agency (DARPA) and the NSF.

LARGESSE WITHOUT CENTRALIZED MANAGEMENT

The model for this funding was decentralized and privatized, distributed via Stanford and local subcontractors. This

fostered entrepreneurship, as did a host of state and federal policies, such as the 1958 Small Business Investment Act, which provided tax breaks to the kind of startups that were flourishing in Silicon Valley, and the Hart-Celler Act of 1965, which increased immigration from non-European countries and prioritized high-skilled applicants.[21] Immigrants would have a large impact on the industry, for example, going on to lead more than half the companies founded in Silicon Valley between 1995 and 2005. California's ban on non-compete clauses was also critical, allowing innovation to spread and flourish more easily than it could in other parts of the country.

A MORE HONEST AND NUANCED DEBATE

The reality of this historical moment forces us to think in a more nuanced way about the difference between entrepreneurial and state-run systems of technology and innovation. Of course, "throwing money at the problem" involves waste in the short term. But in the long term, and at greater scale, the billions that the U.S. government invested in Silicon Valley have been returned to the American economy many times over, as have the billions invested in the space program.

Properly understood, the growth of Silicon Valley becomes an argument in favor of massive federal spending, not against it. We should shift the debate away from whether to throw federal money at the problem and toward how best to foster the innovation and return on investment that federal money can enable. The story of Silicon Valley demonstrates the success of a modified "American" model—one where local government and institutions provide a well-equipped sandbox where the federal government pours substantial funding before getting out of the way of innovation.

A COMPARATIVE PERSPECTIVE: SOVIET SCIENCE AND THE CENTRALIZATION MODEL

While the United States federally funded S&T during the Cold War, that funding was distributed through universities and contracting; in other words, it was a decentralized system often driven by private enterprise. The rise of Soviet science represents a very different approach to developing S&T for strategic competition.[22] The fall of the Soviet Union allows us to imagine that the Soviet model's failure was always clear, but that assumption prevents us from understanding the strengths of the Soviet approach. The Soviet system and specific developments posed formidable challenges to the U.S. system and exceeded U.S. innovation in some sectors. Soviet mathematics in particular was

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sophisticated and continues to leave a mark on university departments around the world. In terms of scale, by 1991 the Soviet Union had the largest scientific community in the world and as many as half of the world's engineers.

Examining the Soviet model also provides broader insights into the strengths and weaknesses of a large, state-directed effort to build modern research and development infrastructure using a top-down authoritarian approach. The Soviet model worked very well in areas such as mathematics and geology and for large-scale engineering projects, such as building rockets, but utterly failed in others. For example, political interference debilitated the work of geneticists, and in the field of computing hardware, over-centralization directed research pathways in the wrong direction.

A LONGER TRADITION

The Soviet Union had a long and successful scientific tradition that predated the launch of Sputnik in 1957 and their first atomic bomb test in 1949. Scientists in imperial Russia created the modern periodic table, and early Bolshevik leaders were deeply interested in science and engineering, sometimes to the detriment of other economic necessities. They undertook huge projects in the 1920s and 1930s, including electrification of the countryside and the development of chemical fertilizers, with great success, though at phenomenal human cost. By 1940, the Russian language was the second most widely used in global scientific publications.

In other words, the Soviets' Cold War investment was in many ways a continuation and acceleration of a trajectory set in previous decades and was not driven primarily by competition with capitalism or the United States. Understanding a competitor's investments in a historical context may help create a sense of proportion and drain some of the alarmism from contemporary debates around seemingly revolutionary and rapid progress.

SEPARATING RESEARCH AND TEACHING

The Soviets separated teaching from research in an effort to limit the ideological danger posed by innovators. Most of the best scientists and researchers were holdovers from the

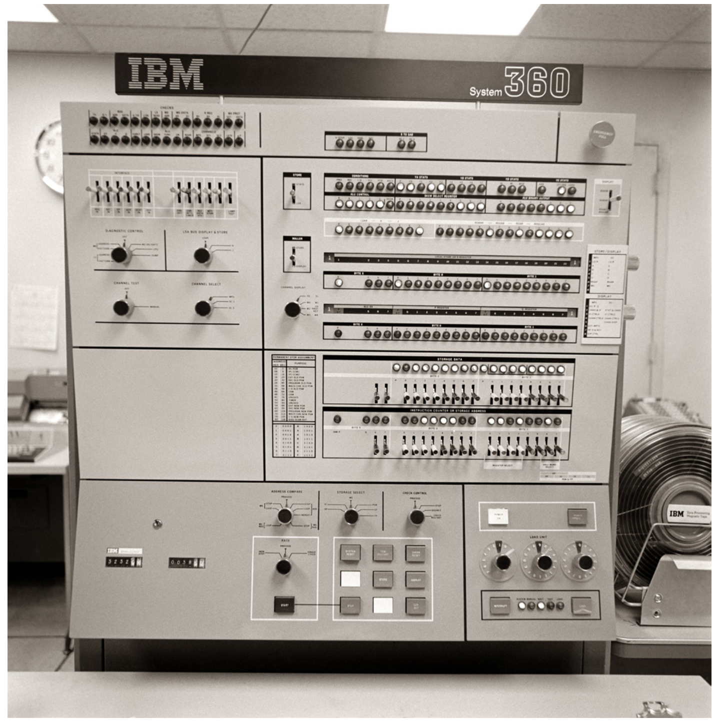
pre-Soviet era, and even younger Russian scientists tended to hold liberal views. This represented an inconvenient problem for the Soviet leadership, who desperately needed and valued their expertise. The solution was to create a distinction between teaching universities and the Academy of Sciences, where the ideologically suspect innovators could serve the state without tainting the next generation. These "bourgeois specialists" were also given privileges as a reward for their cooperation with the regime. The Soviets refined a triangular system designed to accelerate scientific progress while thwarting dangerous political ideas. This system was comprised of the Academy of Sciences for research, universities for teaching, and branch ministries for specific military applications at the national level and in all 15 republics.

THE BENEFITS OF CENTRALIZATION

Unlike the rigorous and decentralized peer-review structure used in the United States and other parts of the West for grant funding and research publication, in the Soviet Union these decisions were made centrally. The reward system emphasized prizes and perks, not patents. One strength of this approach was that it allowed for high-risk, low payoff "unpopular" research to proceed for long periods of time if a scientist could convince a central funding body, or a politically connected sponsor, of its worth. An even greater competitive advantage of the Soviet model was the ability to mobilize the nation's capital and mass slave labor for large projects, such as building a nuclear bomb or a space program. The Soviets could forcibly relocate expertise from around the empire to build scientific incubators, as well as reallocate funding from other sectors of the economy, sometimes with dire consequences for consumers.

THE DEVELOPMENTAL COSTS OF CENTRALIZATION

The Soviet centralized S&T system also produced misguided decisions that could not easily be unwound or circumvented, even once their damage was clear. In 1948, for instance, the Soviets banned genetic research; this had devastating effects on their ability to benefit from molecular biology and the hybrid crop revolution. Moreover, a downside of the state's ability to mobilize for huge projects without meaningful dissent was the propensity to make big bets on the wrong trajectory of innovation. For instance, during the 1950s the Soviet computing sector was leading in some areas, such as machine translation; in the early-1960s, the Soviets concluded that they were falling behind and decided the best use of resources would be to clone and reverse engineer IBM's 360 design. In shifting their computing



A control panel for an IBM 360 computer system.

Photo by H. Armstrong Roberts/ClassicStock/Getty Images

technology apparatus wholly away from broad research toward replication, they wrongly assumed that a linear historical rate of innovation would apply to computers as it had to past technology. The consequence was to debilitate their own computing sector, with profound implications for national security and economic development.

WEALTH, POWER, AND SCIENTIFIC DEVELOPMENT

The computing example illustrates one of the seemingly obvious but often overlooked elements of the Cold War: an extreme disparity in resources. At a very basic level, even below that of political structure and philosophy, economics shaped the Soviet approach. The Soviet innovation model was determined by deep resource constraints and the realization that the USSR had to place concentrated bets. Unlike the United States, they did not have the economic might to diversify research pathways and adequately fund broad fields of research and development.

SHORTCOMING IN THE ANALOGY WITH U.S.-CHINESE COMPETITION

The Soviet-U.S. scientific competition does not precisely map to the current technological competition between the United States and China because autarky and state-directed, large-scale endeavors of the Cold War have been replaced by a globalization of science driven by the relatively free movement of scientists and private-sector investment. The

U.S.-Soviet exchange of scientists was limited and looks nothing like the deep interconnections between U.S. and Chinese academic and private-sector researchers. By some metrics China has been the United States' largest bilateral scientific partner for decades.

Other differences include the contrast between the economic systems in China and the Soviet Union. Both economies were built to a great extent on command and control, forced labor, and sacrifice—but China's system eventually developed into a truly competitive and dynamic economy, albeit one constantly manipulated for state purposes. China's S&T ecosystem takes place in a freer, more prosperous context. In Stalin's era, Communist ideology allowed him to sacrifice consumer welfare in favor of research; it remains to be seen whether Chinese nationalist ideology would be equally powerful and its people similarly forgiving. Finally, China currently faces some economic constraints, but China's economy appears capable of continuing its expansion and overcoming these obstacles. The privilege of being able to "throw money at a problem" could allow even a centralized system to make huge mistakes and still achieve equally huge successes.

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A COMPARATIVE PERSPECTIVE: MILITARY AND TECHNOLOGICAL COOPERATION BETWEEN THE SOVIETS AND GERMANS IN THE INTERWAR YEARS

For the sake of comparison, PHS sought one case study removed entirely from the Cold War and American contexts that could shed light on the complicated intersection of technology and strategic competition. Soviet-German cooperation in the interwar period provides an extraordinary example of two states with antithetical ideologies and divergent strategic interests nevertheless finding a military and technological basis for developing cooperative ties.[23] Despite enormous ideological hostility, the Soviets helped Germany violate its commitments under the Versailles treaty by producing German aircraft, artillery, chemical weapons, and armored vehicles on Soviet soil in exchange for industrial parts, shared intelligence, and technological know-how. The cooperation extended to extensive military-to-military cooperation and training.

In part, the strange bedfellows had been driven together by their shared antipathy for the post-World War I international system, which left both as aggrieved outsiders. Just as importantly, each state possessed resources the other needed in their ambition to rebuild national power. Germany, which was forcibly demobilized after the war, needed a place to develop, test, build, and train the German military, largely in secret and contrary to its international obligations. The Soviets, in turn, were eager to access German technology and German capital for their own economic development and to build a modern military.

The arrangement allowed the two pariahs to bypass economic controls imposed by the West.

The relationship produced significant results in a compressed period of time. With German assistance, Soviet aircraft production jumped from zero to supplying the largest air force in the world within 15 years. As many as 55 percent of Soviet tanks depended on parts from German factories. A total of 255 German firms, including most major companies, conducted military-related business with the Soviet Union that had been forbidden by the Versailles Treaty. The relationship permitted the Germans to build strategic industrial depth as they shifted production of key military industries to Soviet soil in production sectors ranging from aircraft and conventional military equipment to chemical weapons.

Technological and industrial exchange was augmented with direct military-to-military cooperation and the creation of shared Soviet-German bases where the two sides tested new technology, developed operating concepts, and conducted joint training maneuvers. An entire generation of German officers trained in the Soviet Union, and thousands of Soviet officers trained with the Germans (many of whom were subsequently killed in Stalin's purges).

When Hitler came to power, the relationship stopped, in part because the Germans judged they had regained enough strength and capacity that they no longer needed an ideological foe to help them hide their violations of the Versailles treaty. When the Germans and Soviets briefly resumed cooperation after the Molotov-Ribbentrop Pact in 1939, the sinews of cooperation developed during the previous decade provided the foundations for the rapid resumption of some aspects of military, economic, and technological cooperation.

THE STAGES OF INTEGRATION

The risky cooperation proceeded quickly but cautiously. Initially the relationship was focused on trade and production of dual-use goods with an economic focus. As that line of effort deepened, the caution started to lift, and cooperation grew to include aircraft and artillery production before proceeding into full military cooperation, including joint training and shared bases.

THE WEAKNESS OF THE INTERNATIONAL COMMUNITY

German-Soviet cooperation was limited only by the perceived risks and rewards of the bilateral relationship, not because of international pressure. Despite what amounted to egregious violations of the Versailles treaty, the Soviet-German military relationship proceeded at a scale and depth that was difficult to hide. The British and the French expressed little appetite to confront either side for the violations, even though the conspiracy was ultimately driven by the German army's determination to rearm and reclaim lost territory in France and Poland. While the West did enforce export controls from their own territories, they made no attempt to enforce controls between the Soviet Union and Germany.

A MILITARY INITIATIVE

From the German side, the impetus, action, and business relationships were initially structured by the military without the knowledge of the German government. Only after the connection to the Soviets was developed did the military bring the civilian government into the scheme. Fundamentally, the German military was driven by the singular goal of rearmament and the Soviets by the desire to modernize the Red Army and access German capital and industrial capacity to build their military power. While hundreds of major German firms ultimately participated in the effort, the driver was very much the German military and its determination to rebuild and modernize despite the crippling limitations imposed by the postwar settlement.

CULTURAL BIAS INHIBITING KNOWLEDGE TRANSFER

The Soviets were eager to learn from the Germans and, if necessary, steal German technology. It was not uncommon for the locks on German facilities in the Soviet Union to be found broken in the morning after a night of Soviet espionage. The Germans, by contrast, were less interested in the Soviet intellectual contribution to the cooperative relationship. For instance, they expressed little interest in the Soviet development of the T-34 tank, which proved to be a crucial factor in World War II.

TAKEAWAYS FOR CURRENT POLICY

This case study demonstrates the difficulty in predicting and understanding how actors perceive strategic risks and tradeoffs in competition. Much like when the U.S. armed the Afghan mujahideen, in order to achieve a proximate benefit, actors can contribute to strategic long-term risk in the form of empowering a future adversary.

It also highlights the dangers of excluding several states from the international order, even if their ideological differences and long-term strategic interests seem to reduce the likelihood of their cooperation. Because both the Soviets and the Germans were excluded, it was less likely that trade between them could be effectively policed. The exclusion also provided an external common enemy that overpowered their ideological and strategic rivalry and drove them to empower each other.

CONCLUSION AND INSIGHTS

Because of the growing strategic importance of technology in war and national security, great powers must develop their S&T base with some degree of government involvement and public investment. The question is often how to balance government and private endeavors, how to focus on the right problems, and how to take advantage of international cooperation while retaining national advantages. These debates play out today not just in federal S&T investment, but also in university admissions, intellectual property protection, trade negotiations, cyber espionage, and international telecommunications standards. With that in mind, the following general historical takeaways may be useful:

- As a solution, "throwing money at the problem" is underrated. In order to make great strides in the kinds of basic research that lead to enhanced economic growth and technological revolutions, taxpayer funding may be essential. The crucial element of successful American money-throwing is its decentralized research and innovation model, in which the government provides competition-enhancing regulation, long-term investment, and a market to acquire and use the emerging technologies.
- American narratives of technological mobilization and greatness are, in general, overly simplified. Silicon Valley is not a counterexample to government-funded research, and the Sputnik moment was not a pure story of sincere threat perception and artless reaction. Self-congratulatory narrative is not uncommon, but in order to replicate successful strategies, one must work with

as unvarnished an understanding as possible of what really happened.

- In order to meet the challenges of great power competition, we must study not only high politics but low politics: the bureaucratic and party politics of the moment may be as important as an overarching national interest.
- Eisenhower's reluctance to invest the nation's financial well-being in a crash space and education program should challenge the unspoken narrative we rely on when we hope for another Sputnik moment with respect to China. Eisenhower's fear that the investment was misplaced and would threaten the American economy might have proven prescient if the 1958 recession had not ended quickly. More importantly, the missile competition at the time favored the United States, and it seems clear in retrospect that the Soviet system would have deteriorated and collapsed quite independently of American S&T progress. We should invest in S&T education and R&D because they enhance the nation's economic fundamentals, not because the American space program led to the end of the Cold War.
- Ideology is not everything. When a state has various conflicting and powerful motivations, as Germany and the Soviet Union did during the 1920s to 1940s, cooperating for mutual benefit with a rising adversary may not be an irrational decision. We see this playing out in the realm of Chinese foreign investment; even liberal democratic states are choosing to enhance their local economies by incorporating Chinese investment and technology that come with leverage and political influence. These states' leaderships would generally not prefer to be part of a Chinese sphere of influence or a Chinese-led international order, but they enable the growth of Chinese power and influence through partnership. We should plan for a continuation of this pattern far longer than seems rational. ■

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