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Fallen Behind: Science, Technology, and Soviet Statism

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Abstract
Why, despite the overwhelming enthusiasm from the state for science and technology, did the Soviet Union fail in its project of modernization? This essay argues that the fundamental reason behind the Soviet Union's technological lag, and its consequent catastrophic decline, is the incompatibility between the logic of *statism* and the demands of 21st century *informationalization*. The damaging logic of Soviet statism manifested itself in five key areas: 1) the extensive military-industrial black hole exhausting the Soviets of key resources; 2) the ideological capture of science; 3) bureaucratic logic, risk aversion, and structural disincentives against innovation; 4) technological conservatism and a dependence on the West; 5) the dominance of vertical structures in closed information loops at the expense of horizontal linkages.

Introduction
The USSR, as envisioned by Soviet revolutionaries, was poised to chart the course for a new modernity characterized by secularism, rationality, and a supranational enlightenment. In the revolutionaries' technocratic vision, science and technology were vaunted as a means to providing the material basis for Soviet global dominance and for reaching the highest point of modernity. In 1957, the Soviet Union surprised the world by successfully launching Sputnik, the first artificial Earth satellite, and then consolidating itself as a superpower by achieving nuclear parity with the United States in the early 1970s. The Soviets were, by most measures of technological capability of the time, in real competition with the United States. By the 1980s, however, the USSR had been relegated to the technological periphery as the United States catapulted itself to the frontier of the information revolution. The yawning technological gap slowly discredited the Soviet model. By 1991, the Soviet Union's collapse had become a textbook case of "imperial overstretch" (Kennedy, 2002).

Why, despite the overwhelming enthusiasm from the state for science and technology, did the Soviet Union fail in its project of modernization? In what ways have science and technology shaped the Soviet project of modernity, and what do the failed attempts at reform mean for present-day efforts to modernize Russia? Here, I argue that the fundamental driver of the Soviet Union's technological lag and subsequent catastrophic decline is the incompatibility between the logic of *statism* and the demands of 21st century *informationalization*.

Missing the Information Revolution

That the Soviet Union would lose the technological race was hardly inevitable, contrary to popular belief. After all, there was a time when American and Russian science and technology were competing in lockstep. The launch of Sputnik in 1957 left U.S. leaders quite unnerved by its implications: the Soviets had won the first leg of the Space Race. The fall in confidence in American science and technology that followed prompted the United States to place a new national priority on research science. The Soviets arguably enjoyed technological parity with the United States and, for at least a while in the 1960s, enjoyed technological superiority in the domain of space exploration.

The economic conditions for technological development in the USSR were not unfavorable in the years that followed Sputnik. By most measures of industrialization, Soviet economic achievement from 1928 to 1987 was an extraordinary success. Its centrally-planned economy was meeting the ambitious targets that leaders set out to achieve, and by the 1980s, the Soviet Union had outpaced the United States in heavy-industrial production, producing 80% more steel, 78% more cement, and 42% more oil than the United States (Walker, 1986). The Soviets had built for themselves, in record time, an industrialized economy that could have served as the foundation for later technological advancements. Furthermore, state support for scientific and technological development was so strong that, by the 1980s, the Soviet Union had more scientists and engineers, relative to the total world population, than any other major country in the world (Fortescue, 1986). With the major exception of the biological sciences—which had been devastated by Lysenkosim—the Soviets were competitive in most sciences, including math, physics, and computer science. The Soviet Union, in short, had no lack of human capital, resources, or political will to maintain its technological parity with the U.S (Thomas and Kruse-Vaucienne, 1977).

It is no small puzzle, then, that the PC revolution that catapulted the United States to the forefront of the information revolution in the 1980s would bypass the Soviet Union completely. Despite its lead in heavy industries, the Soviet Union was 20 years behind the U.S. in the domain of computing by the late 1980s[1]: in 1986, the U.S. had about 1.3 million mainframes and minicomputers, and the Soviets had only 10,000 (Longworth, 1986). The aggregate peak performance of Soviet machines in the 1991 was over two orders of magnitude less in computer power than

[1] Physicists in the Soviet Union were working with computers analogous to the CDC-6600, which U.S scientists were using 20 years before (Longworth, 1986). The research institutes of Siberian Branch of Academy of Sciences in Novosibirsk in 1990 were 20 years behind the American or Japanese industry (Kuleshov and Castells, 1993).

the supercomputers designed by Cray Research in the U.S. (Wolcott, 1993). By the 1980s, the technological gap between the Soviet Union and the West had become impossible to overlook.

It soon became clear that the real prize of the 21st century information age was not pig iron and steel, but silicon. In focusing all their energy on meeting industrial targets, the Soviets missed the revolution in information technology that had taken shape in the world during the mid-1970s. Success in industrialization did not bring about success in informationalization. Whereas industrialization relied on heavy physical inputs, informationalization was a new mode of development in which the main sources of productivity came from optimizing use of factors of production on the basis of knowledge and information (Bellows, 1993). In failing to adjust to the new information environment that emerged during the 1980s, the Soviet Union increasingly fell behind in the information revolution that was ushering in a modernity with new metrics for developmental success.

The Crisis of Soviet Statism

Why did the Soviet Union fall so far behind in only twenty years? If this lag was not due to a lack of physical resources, scientists and engineers, or political will, what did the West have that the Soviets did not? Much scholarship has attributed the fall of the Soviet Union to imperial overstretch and the internal contradictions of a centrally commanded economy (Lundestad, 2000; Beissinger, 2002). What has been less discussed, this paper contends, is the damaging logic of statism in the Soviet variant of industrialization, which held the Soviet Union back from a much-needed transition from an industrial society to an information society.

This hypothesis was first put forth by Manuel Castells in the final volume of his trilogy on the information age (Castells, 2010). A statist social system, in Castells' description, is one "organized around the appropriation of the economic surplus produced in a society by the holders of power in the state apparatus" (Castells, 2011). Whereas a capitalist society maximizes profits, a statist society aims to maximize the power of the state apparatus. In the Soviet case, this manifested in the total control exerted by the party over the state, and by the state over society, via a centrally planned economy underscored by Marxist-Leninist ideology. The following discussion examines how the Soviet modernization project fell victim to its own system and statist logic, sliding into a gradual technological recession that would precipitate the collapse of the Soviet Union.

1. The Military-Industrial Black Hole

One attribute of a statist system that assigns absolute priority to the power of the state is the militarization of its economy, for the sake of consolidating and preserving the state's power, both domestically and abroad. This logic was borne out to its logical extreme in the Soviet case, in which the "national-security state" subordinated civilian economic interests and political and civil society to the security imperative. The securitization of the state necessitated the elevation of defense technology to the top of the agenda, and science and technology was put in complete service to state security (i.e., the military).

The result was a massive military-industrial black hole that continuously exhausted state resources. In the 1980s, the industrial-military complex accounted for two-thirds of industrial production and received 15-25% of GNP; this was several times higher than defense expenditure in the United States, which—at its height in 1987—peaked at 6.6% of GNP. Approximately 40% of industrial production was related to defense, and production of enterprises engaged in the military-industrial complex reached about 70% of all industrial production (Loren and New, 1992).

The primacy of the military-industrial complex as a driver of scientific and technological research meant that skills and inventions were directed solely towards military ends. The sheer concentration of science and engineering talent dedicated to the military-industrial complex was staggering: it was estimated that the anti-missile institute alone had 10,000 scientists at its service, and numerous science parks across the country bore scientists and engineers who worked solely on military defense technology (Longworth, 1986). The only client for Soviet technologies was the defense ministry, which had extremely specific requirements for military hardware and little incentive to declassify technologies for development outside of the military-industrial complex (Castells, 2011). Over-classification of innovations kept military technologies cordoned off from public view, minimizing spin-offs from military technology to civilian economy. As a result, most innovations were locked in laboratories, contributing meager improvements to the civilian economy. In directing all of its research capacities toward the extremely narrow goal of making the Soviet Union a total war machine, the Soviet military-industrial sector became a black hole that sucked away massive productive and creative energies from the Soviet economy.

2. Ideological Capture of Science

Emerging from a revolution that rejected the old in favor of a blank new slate, the Soviets believed that they were ushering in not only a new epoch in human history, but also a new intellectual world. As a result, Soviet science lived in the revolutionary and exceptional ethos under which the USSR was born. Forgoing scientific objectivity, it sought to distinguish itself from the "bourgeois science" of the West by extending Soviet exceptionalism to science itself (Graham, 1990). The trouble was that where revolution is based on discontinuity, science relies on continuity. While the Soviets could recast art, literature, and history in Marxist terms, it was pernicious to do the same with physics and biology.

However, science was not spared from ideological capture. The rejection of Western scientific theories as “bourgeois” became a political reality when Stalin supported the rise of Trofim Lysenko, a poorly educated agronomist who rejected the study of Mendelian genetics in the West and perpetuated his own scientifically unsound theories, leading all of agricultural sciences and biology to slide into falsehood. Likewise, Einstein's theory of relativity was dismissed as “bourgeois, reactionary, and incompatible with Marxism-Leninism,” until—ironically—the imperative of building a nuclear bomb forced Soviet scientists to accept Einsteinian physics (Vucinich, 2001).

Paralleling many facets of Soviet life, ideological dogmatism and a commitment to Soviet exceptionalism undermined scientific rationality and closed off Soviet scientists from the rest of the global scientific community. The Soviets believed they could live in autarky and self-sufficiency not only in the sphere of natural resources, but also in the realm of ideas. This led to a kneejerk rejection of all science foreign or antithetical to Marxist-Leninist ideology, with disastrous consequences for Soviet scientific advancement.

3. Bureaucratic Logic, Risk Aversion, Structural Disincentives

Because technological progress proceeds from trial-and-error, innovation necessarily entails the risk of failure. The Silicon Valley mantra “fail faster, fail often, fail better” rightly embodies the “learning-by-doing” logic of innovation: technological innovation is an evolutionary process in which progress comes in spurts that generate accelerating returns. Under the logic of accelerating returns, positive feedback loops make each iterative process more effective, creating the potential for exponential growth (Kurzweil, 2001). Specific paradigms, methods or approaches to solving a problem (e.g. shrinking transistors on an integrated circuit to make more powerful computers), drive exponential growth until the method exhausts its potential and gives way to a new one through what has come to be known as *paradigm shift* (Kuhn, 2012).

The Soviet imagining of innovation was, in many ways, antithetical to an evolutionary, iterative process of technological growth. The Soviet Union sought innovation in the same way that it pursued industrialization—that is, in a way that circumscribed innovation within a linear model in which x amount of factor input yields $c(x)$ amount of innovative output, where c is a positive constant. The same bureaucratic logic that was used to run the command-and-control economy was applied to scientific and technological development, largely ineffectually. Five-year plans were handed down from bureaucratic managers who exercised central direction but lacked the technical know-how to make reasonable expectations and goals. This bureaucratic logic also came with pervasive risk-aversion, and risky projects were often eschewed for their uncertain upside rewards and huge downside risks (Pakulski, 1986).

However, this systemic risk-aversion did not reflect a lack of ambition. At a time when the West was transferring technological innovations from the sphere of defense to the domain of consumer goods, Soviet engineers were preoccupied with massive engineering projects directed by the state, often in service of the military-industrial complex. Much the Romans, who accomplished engineering feats like the Roman aqueducts, the Soviets enthusiastically pursued large-scale engineering feats to reverse tides (Northern River Projects), harness hydroelectric power, and build canals. However, outside of the mammoth projects dictated by the Politburo, scientists were systematically discouraged from risky ventures. Technological change was largely directed by the state; outside of that realm, independent scientific ventures were piecemeal and *ad hoc* at best.

More deleterious were the structural disincentives to innovation that came with a command-and-control economy. Consider, as a case-in-point, the *val* accounting system used by the Soviets to measure gross value of production per unit (Goldman, 1983). Under this system, the value of output included the value of all inputs, and bonuses of workers and managers were paid out according to gross output rather than according to the profit margin. Predictably, such a system could not translate productivity increases into higher value added, and there were no incentives to adopt or invent better technology or management practices that could lower production costs. On the contrary, enterprises that adopted new technologies and increased outputs were given higher targets to meet in the next round of production.

Thus, for both workers and managers, it made sense to adopt a *satisficing* strategy, which meant to do no more than meeting planned targets. This effectively discouraged productivity-enhancing technologies from being produced and adopted, because it simply did not pay to be more productive. Sheltered from both domestic and global competition, Soviet firms felt no pressure to innovate faster than was needed in the view of the planners of the defense ministry. The result was an economy that was very effective in mobilizing resources to meet priority targets but also exceedingly rigid. Such rigidities would put the Soviet system on an unfavorable footing in coping with a global economy that was increasingly complex, networked, and organizationally diversified.

4. Technological Conservatism, Copycats, and Dependence on the West

Perpetually in a Cold War mindset—in which everything is viewed through the prism of a zero-sum game—the Soviet planners had been over-eager to follow the West in lockstep. This was a logical characteristic of a reactive Cold War mentality ("whatever the West has, we must have too"), and the implications of such a mindset were far-reaching. In their over-eagerness to bridge what was initially a marginal gap between Soviet and Western computer science, they made decisions that practically locked themselves in a path of dependency on Western technology.

The history of Soviet computing is particularly instructive in that regard. Since the 1940s, the Soviets had been designing their own computers. The MESM, the first prototype developed by a group of computer scientists in Kiev, was completed just four years after the first American computers. Developments in computer design continued, spawning a family of mainframes that achieved considerable success. By 1958, the BESM-6 was capable of 800,000 operations per second and set the industry standard for many years to come. However, this line of development came to a halt when the Soviet government, under pressure from the military, decided to adopt the IBM model 360 as the core of the Unified Computer System for the Council of Mutual Economic Assistance (Agamirzian, 1991). From then on, IBM models became the norm, Soviet designs were sidelined, and the Soviets shifted from building their own computer systems to importing Western technologies, or copying them outright.

The Soviet model of innovation was arguably one of KGB-led innovation: open and covert technology transfer in both software and hardware became the main source for the information technology revolution in the Soviet Union. The KGB became notorious for its extensive industrial espionage and operations aimed at smuggling computers and technical know-how from the West, which Soviet scientists then reverse-engineered. However, reverse-engineering Western technology took time, and because they were constantly chasing the tail-ends of technology, the Soviets were always several steps behind state-of-the-art technology. By the 1980s, they had become so dependent on the West that it was estimated that, without Western technology, the Soviet Union's annual output of microelectronic devices would be reduced by 25% for discrete semiconductor devices, 75% for small and medium scale Integrated Circuits (ICs), and more than 90% for large scale ICs (Office of Scientific and Weapons Research, 1986). Technological conservatism had locked the Soviets into a technological trajectory that severely inhibited Soviet research into computers.

5. Closed information loops and the state vertical

"*Informationalization*," Castells explains, "is a mode of development in which the main source of productivity lies in the qualitative capacity to optimize combination and use factors of production on the basis of knowledge and information" (2011). Extending this logic, it is not difficult to see that the free flow of information is an essential prerequisite for any economy that wants to be part of the information revolution. For the Soviets, however, the transition into this new mode of development came too late, and was fraught with insurmountable impediments. At a time when Apple in the U.S. was producing personal computers designed for consumers in the mass market, computers were subject to unusual restrictions in the Soviet Union.[2] Such consumer-oriented products were also inaccessible because of their high price. Agat, the Soviet copy of Apple II, cost about $3600, three times more than it did in the U.S., and was not affordable for most in USSR (Longworth, 1986). Hampered by inaccessibility and excessive state control, the Soviet's entry into the computer economy was followed quickly by a drift toward the technological periphery.

Statist as it was, the Soviet state was by no means static. In a way, the history of Russia since the Bolsheviks took over had been one *perestroika* after another: first the New Economy Policy in the 1920s, then Stalin's dramatic restructuring in the 1930s, Khrushchev's revisionism in the 1950s, and Kosygin's economic reforms in the 1960s. The leaders of the Soviet Union were not oblivious to changing external conditions, and did not sit by watching history leave the Soviet Union behind. Gorbachev's *glasnost* (openness) reform was, in fact, a surprisingly bold attempt that responded squarely to the new context of the networked information society. By ending the most draconian censorship policies and introducing new freedoms in the sphere of political discourse, it was hoped that the Soviet Union would break out of the strangling state control on science, culture, and the very social fabric of Soviet society. Yet, like all previous attempts at reform and modernization, *glasnost* could not overcome the structural incapability of the statist Soviet Union to adapt to informationalism.

This problem could be traced back to the dominant vertical structures inherent within a statist environment, which came at the expense of horizontal linkages. Coupled with the tight control of information flow, this made for a toxic combination pernicious to innovation. The whole Soviet economy was, according to Professor Sergei Medvedev,[3] a gargantuan piece of machinery moved by the vertical administrative decisions of a massive bureaucracy with countless planning institutions, ministries of execution, and production units. As a result, few horizontal links existed across agencies, and exchanges were pre-established by respective parent administrations.

In the R&D sectors, the strict vertical separations imposed by this institutional logic meant that basic science, applied research, and industrial production took place within closed circuits, with little cross-pollination of ideas. The Academy of Sciences was isolated from industry and facilitated little cross-faculty or cross-ministerial cooperation. Foreign fears of espionage, and the Soviets' own skepticism towards foreign scientific

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[2] This inhibition is discussed in the documentary "How Good is Soviet Science?" produced by Martin Smith Productions. Seen as subversive instruments and threats to state power, tools like typewriters, computers and photocopying machines were subject to tight control of the state.

[3] This point was heard during a lecture by Prof. Sergei Medvedev during the author's time in Moscow, Russia.

developments, also meant that Soviet scientists worked in relative isolation from the rest of the world.

This system is in stark contrast with R&D culture in the U.S., in which the free flow of information and people among agencies, government agencies, and research created a research-industry synergy that was missing in the Soviet case. Although the government also played a major role in financing research in Silicon Valley, research institutions like the Stanford Electronics Research Laboratory operated in close collaboration with defense contractors and private enterprises (Leslie, 1993). Compared to the excessive security restrictions governing public access to technological innovations in the Soviet Union, scientists and engineers in the U.S. had relative freedom to commercialize technological innovations and to start their own companies with private capital. This had the corollary benefit of spreading the risks of innovation, creating the space necessary for "learning by doing" through an iterative process of trial-and-error.

Soviet authorities were by no means blind to the flaws in their system. Khrushchev, upon his return from the United States, tried to recreate similar horizontal links and pro-innovation conditions in the Soviet Union by constructing Akademgorodok, a major scientific center that emulated the American university campus model. Concentrating its best researchers, professors, and students, Akademgorodok saw many scientific institutions operating on the cutting edge of their disciplines (Josephson, 1991). Nevertheless, the lack of synergies and horizontal linkages between research and industry kept the Soviets far from the technological center. Furthermore, Akademogorodok could not survive the political tightening of the Brezhnev years, and soon returned to a bureaucratically-controlled, ideologically-conservative science that was reminiscent of the Stalinist era. Party officials favored buying or stealing Western technology over creating their own. As Josephson (1998) argued, the promising Siberian science city became "just another cog in an increasingly creaky Soviet industrial machine."

In retrospect, the state vertical was not something that could be easily overcome by a scientific and technological center, far off in a Siberian birch forest and disconnected from the larger economy.[4] For the aforementioned reasons, Soviet industrial firms were not interested in state-of-the-art technology due to structural disincentives embedded within a quota-driven production system. An additional impediment had to do with an economic model that could not accommodate the disruptions caused by creative destruction, a process in which new innovations continually displace old practices or technologies. Economic growth in the

[4] Paradoxically, had the Academy of Sciences not developed separately from the central command economy, it would have been encumbered by the state vertical; but being detached from industry also meant that it was not responding to industry demands, and had little prospect of "modernizing" the Soviet economy, as Khrushchev had intended to do through this project.

Soviet economy proceeded largely from Gosplan's mathematical models and calculations; incorporation of new technologies was slow, and largely avoided due to its potential to upset the meticulously planned command economy.

Overcoming the state vertical that had hamstrung Soviet innovation would have an entailed a fundamental change in the economic structure, which could not have been accomplished without seriously undermining vested interests in the state's bureaucracy and the party's *nomenklatura*. The Soviet Union was stuck in a gridlock in which changes that were necessary for the system's longevity would, paradoxically, undermine it. This logic was borne out, eventually, in a series of desperate reforms that ended up failing under the burden of Soviet statism, precipitating the collapse of the entire system.

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