6-14-2023

Working Paper No. 79, On the Emergence of and Failures of Cybernetics in The Soviet Union

Leah Herrera

Citation Details

Herrera, Leah. "On the Emergence of and Failures of Cybernetics in The Soviet Union, Working Paper No. 79", *Portland State University Economics Working Papers.* 79. (14 June 2023) i + 44 pages.

On the Emergence of and Failures of Cybernetics in The Soviet Union

Working Paper No. 79

Authored by: Leah Herrera

A Contribution to the *Working Papers* of the

Department of Economics, Portland State University

Submitted for: EC460, "History of Economic Thought" and

EC 447 "Economics of Transition"; 14 June 2023; i + 44 pages

Prepared for Professor John Hall

Abstract: This inquiry seeks to establish that despite potentially offering significant efficiency gains leading to an era of intensive economic growth, cybernetics in the USSR fell short in being implemented because of a) lack of coordination between competing ministries; b) inadequate policies; and c) insufficient funding. Though the structure of government in the USSR appeared to be centralized and hierarchical, with economic and government plans and policies traveling from the top down, in practice, ministries acted more like *heterarchies,* leading to ministerial competition over the large cybernetic projects meant to reform the administrative command economy—from the mid-1950s through to the late 1980s. This ministerial competition led to inadequate policies being suggested for cybernetic reforms, with ministries stalling, avoiding, denying resources, or withholding approval for implementing cybernetic projects. Finally, as ministries sought to secure their own positions, cybernetic institutional proposals were denied sufficient funding to implement the nationwide projects that would have represented the development of intensive economic growth in the Soviet Union.

Journal of Economic Literature **Classification Codes:** B24, P31, P41

Key Words: Cybernetics, Economic Planning, Planning Reform, Socialism, USSR

This inquiry seeks to establish that despite potentially offering significant efficiency gains leading to an era of intensive growth, cybernetics in the USSR fell short in being implemented because of a) a lack of coordination between competing ministries, b) inadequate policies, and c) insufficient funding. The Union of Soviet Socialist Republics, or USSR (1922-1991), displays a long and complex relationship with the field known as "cybernetics” , an interdisciplinary field concerned with communication and control in machines or living things. A simple example of a cybernetic system would be a thermostat responding to changes, effectively maintaining a set temperature. However, the internet is arguably the most famous cybernetic system with its networked computers.

The USSR's administrative command economy was structured in a manner that meant it was in a unique position to benefit from the application of cybernetics. In addition, the Soviet Union was the birthplace of "economic cybernetics," in which Soviet cyberneticians sought nothing less than to apply cybernetic models, tools, methods, and thinking to optimize and automate the USSR's planned economy. The use of cybernetics in economics is a frequently overlooked topic in the literature of transition economies such as the USSR underwent beginning with the Khrushchev thaw. Economic cybernetics was presented as another way to reform economic planning without appearing overly political, an assumption that would prove faulty.

This inquiry shall discuss how cybernetics went from being viewed with suspicion and mocked as pseudoscience, to being lauded as the ultimate planning solution; with detailed proposals being developed and presented by top Soviet scientists, only to languish through becoming mired in bureaucratic infighting as ministries jockeyed to preserve their own positions and funding. Indeed, the decline of Soviet cybernetics also offers key chapter for the story of the USSR's demise.

Soviet Scientists Embrace Cybernetics

Cybernetics as a paradigm has existed since at least Ancient Greece, if not earlier. One of the earliest written mentions of the term cybernetics is attributed to Plato's *Republic* ([375 BCE]), where the Ancient Greek word κυβερνήτης (kubernḗtēs) appears. The root, κῠβερνάω (kubernáō), means "I steer, drive, pilot, or guide," and adding the ending -τηϛ translates roughly to one being a good helmsman, steersman, captain, navigator, or pilot of a ship. However, there is also a figurative meaning: to be a "governor" or leader of a state or region. Plato (428/427-348/347 BCE) uses κυβερνήτης both ways, as in guiding a ship and figuratively, as in the art of guiding men in society. Indeed, the English term "ship of state" emanates from the often-cited metaphor Plato expounded on in *Republic, Book VI: The*

Philosophy of Government ([375] 488a-489d), which likens governing a city-state to commanding a ship.

The term cybernetics reappeared in the year 1834 in the work of French physicist André-Marie Ampère who referred to "kubernētikē" which became "cybernétique" in the French language. Ampère used *cybernétique* figuratively to mean the science of government when he categorized areas of human knowledge. In the French tradition, the field of cybernetics consistently references both Plato and Ampère, which contrasts with the American tradition.

Following Ampère, in 1947, the term was rediscovered and adapted by Norbert Wiener, an American mathematician often credited with founding cybernetics as a field in the American tradition. Wiener used the term in his book *Cybernetics or Control and Communication in the Animal and the Machine* (1948). Though Wiener ([1948] 1962, 11-2) identifies the original Greek as "χυβερνήτης"—he was known to have spoken 34 languages, including Greek and Latin—he does not explicitly credit Plato's use of the term, nor are there references to Ampère. Wiener instead anglicized the term to cybernetics, citing James Clerk Maxwell's article *On Governors* (1868) as his inspiration, with the word "governor" being a corrupted Latin form of χυβερνήτης. Maxwell's governors controlled the speed of steam engines; however, for Wiener, they are a clear example of an essential cybernetic term borrowed from control engineering called "feedback." Oddly, despite Plato's exclusion, Wiener ([1948] 1962, 12) still refers to the steering mechanisms of ships as one of the clearest, earliest forms of a feedback mechanism.

Wiener's book popularized cybernetics as a field in America and was well-received there. However, Wiener had previously authored the article *Behavior, Purpose, and Teleology* (Philosophy of Science, 1943) with Arturo Rosenblueth and Julian Bigelow, based on work Rosenblueth had performed on living organisms in Mexico. In addition, Warren McCulloch and Walter Pitts authored *A Logical Calculus of the Ideas Immanent in Nervous Activity* (Bulletin of Mathematical Biophysics, 1943), foreshadowing American cybernetics' emergence. Years 1946-1953 saw these articles followed by a series of trans-disciplinary conferences funded by the Josiah Macy, Jr. Foundation, commonly called the Macy Conferences. The years 1949-1958 saw the emergence of cybernetics in the U.K. under the Ratio Club, where experts from various fields met informally.

These conferences and clubs represented the "first wave" of cybernetics in the 1950s when it was primarily a technical discipline. However, by the 1960s, cybernetic thought shifted toward the social sciences and philosophy while still grounding its insights in biology. The rise of "management cybernetics" is a "second wave" cybernetic trend, with the best example being that of Stafford Beer, who—in his effort to automate the Chilean economy between 1971 to 1973 in what is known as "Project Cybersyn"—relied upon his cybernetic Viable System Model which was inspired by the central nervous systems in living beings. The "third wave" of cybernetics has been ongoing since the 1990s as the early first wave cybernetic work on neural networks and predictive language models have experienced renewed interest with the rise of artificial intelligence and machine learning.

According to Wiener, cybernetics is an interdisciplinary field concerned with the communication and control of animals and machines. As an area of study, cybernetics birthed, intersected with, or accelerated the development of other technical fields, including artificial intelligence, information theory, computer science, communications, and associated branches of mathematics. Likely, the closest one can come to cybernetics today would be found in systems science. Cybernetics was more than a field; it was a way of thinking about complex, dynamic systems and understanding the processes that drove them.

However, despite the field's richness, cybernetics has fallen out of modern usage. Wiener ([1948] 1962, vii-viii) provides insight into why this should be the case in the preface to the second edition, where he explains that cybernetic ideas, such as feedback, control theory, automation, communications, and statistical methods, came to be integrated into fields that have been extensively developed to the point that the latest progress is best seen by specializing in one of them; the fragmentation of cybernetics created splinters that became fields in their own right.

A cybernetic system should be capable of automation and be made to respond to feedback to bring itself back to a set equilibrium. This may be accomplished by mathematics, computers, a mechanism, or whatever method or combination permits it, even if the process is not fully understood, as in the case of the human brain. A simple cybernetic system is that of a thermostat maintaining a set temperature. Today a complex cybernetic system relied heavily upon is the internet with its networked computers. In addition, artificial intelligence models, including Large Language Models (LLMs) such as ChatGPT, have recently taken the world by surprise, generating seemingly human-like intuitive responses to complex questions creating massive interest. All these innovations are the results of government-funded projects and private civilian and academic research. They represent intensive growth that has occurred in this area, a trend seen especially clearly in the United States. However, it is not commonly understood that a common source of these technologies primarily grew from, intersected with, or was inspired by the field of cybernetics, specifically during the Cold War.

In the Soviet Union, cybernetics had an inauspicious beginning, as presented by Wiener and the American press. Benjamin Peters, author of *How Not to Network a Nation: The Uneasy History of the Soviet Internet* (2017, 30-2), teaches in his chapter "A Global History of Cybernetics" that there was a chilly initial public reception to Wiener's book in the 1950s USSR where the response was to remove it from public library circulation while secret military libraries retained access. In addition, Wiener himself was maligned in the top Russian publication *Literaturnaya gazeta* which ran articles calling him an "obscure" figure and referring to cybernetics as a ridiculous "pseudoscience."

Despite publicly mocking Wiener's cybernetics as a pseudoscience, Russia already had a preexisting parallel school of thought. The Russian polymath Alexander Aleksandrovich Bogdanov (1873-1928) had anticipated Wiener and other cyberneticians, creating the field and term "Tektology" in his book, *Tektology: Universal Organization Science*, published between 1912-1917. Bogdanov conceived of a universal science of the sciences in which all the social, biological, and physical sciences were unified and viewed as systems of relationships. *Tektology* is often considered the forerunner of systems science and is related to synergetics. Bogdanov is further credited with developing blood transfusions and multiple cybernetic contributions. However, Bogdanov's theory contrasted with the Marxist dialectical materialist view foundational to the USSR. Consequently, Vladimir Ilyich Ulyanov (1870-1924) or Lenin vehemently opposed Bogdanov, accusing him of idealism in his book *Materialism and Empirio-Criticism* (1909). Besides the philosophical differences, Bogdanov was viewed as a political rival to Lenin as he had co-founded the Bolsheviks in 1903. Therefore, as Lenin gained power within the Bolsheviks and successfully led the formation of the USSR, Tektology was suppressed and faded into the background. This theme would continue under his successor Ioseb Besarionis dze Jughashvili, better known by his chosen *nom de guerre,* Vissarionovich Stalin (1878- 1953).

Cybernetics was publicly mocked in the early 1950s-Soviet Union, and was somehow viewed as threatening before attitudes towards the nascent science thawed. Still, the issues Bogdanov encountered reappeared once more when Soviet philosophers—the people responsible for interpreting and disseminating correct Soviet ideology to the masses—encountered American cybernetics, as discussed by Wiener. In his book, *From Newspeak to Cyberspeak: A History of Soviet Cybernetics,* author Slava Gerovitch (2004, 125) reveals that a person going by the pseudonym "Materialist" used Marxist terminology and rhetoric to point out what they perceived as a flaw in cybernetic thinking: that mechanistic processes were being *idealized*. In addition, Materialist believed that man and machine were so qualitatively different that few parallels likely existed between them, meaning cybernetics was bound to fail.

The Cold War, beginning on the heels of World War II on 12 March 1947 and lasting until the fall of the Soviet Union in 1991, marked a time when the United States and the USSR were in an arms race. This situation resulted in the

Soviet military privately reconsidering the merits of cybernetics. By 1949, the Soviet Union proved capable of detonating atomic bombs and was known to have developed long-range aircraft capable of reaching the United States via an Arctic route. However, by 1950, the United States Semi-Automatic Ground Environment (SAGE) system was developed and was, by design, cybernetic. Said to be the first computer network, the system used telephone lines, supercomputers the size of rooms, and many networked radars to identify, track and assist in bringing down enemy aircraft. Such a useful defensive system contrasted severely with the idea of cybernetics as a pseudoscience, and Wiener's ideas of feedback, control, and communication, along with the mathematics associated with these, now seemed prescient to those in the Soviet military, especially as Wiener had offered his assistance to aid in the development of such systems. Therefore, this early public criticism of American cybernetics represents an instance where the dismissal of a new approach contributes to a lack of development and delayed response in one's nation. In addition, under Stalin, the Soviet Union developed the field of covert operations extensively, which proved invaluable during the Cold War. The USSR was, therefore, sensitive to the American response to their military achievements. Whether obtained covertly or otherwise, knowledge of SAGE impelled the USSR to reevaluate cybernetic systems even when the field was under public disapproval.

Year 1953 would mark the death of Stalin and his death also marks an inflection point for Soviet cybernetics. At high costs, between 1922 and 1953, Stalin’s leadership helped to transform the USSR from a largely agrarian nation behind its capitalist neighbors technologically, socially, and economically, into one of the world's great powers. This was achieved with his emphasis upon uneven growth and prioritizing the advancement of heavy industry that included capital goods. Thereafter, the USSR occupied a unique spot as one of the few nations representing an alternative to capitalism and a world power. Stalin was known to be quite concerned with the USSR's relative defensive position given its repeated history of, and vulnerability to, invasions to the point of paranoia—a justifiable stance,however, one taken to extremes. His death further changed the sociopolitical climate so that even cybernetics was open to public reconsideration, especially as it had proven helpful in national defense.

In 1956 Nikita Sergeyevich Khrushchev (1894-1971), successor to Stalin, gave his famous "secret speech," shocking the world by denouncing Stalin and referring to him as a "cult of personality" However, Khrushchev specifically opened the door to Soviet economic cybernetics—an often overlooked point. Peters (2017, 33) teaches us that Khrushchev particularly described the desire to automate economic planning, factory production, and technological processes using cybernetics. Khrushchev, advocating as he did for “deStalinization”, wanted to try new approaches to the administrative command economy and was even willing to look at cybernetics, the field that had been developed by the USSR's most significant rival.

Khrushchev's secret speech legitimized cybernetics, opening up the topic to positive public discourse; however, Soviet societal attitudes may have already been primed to accept such a transition. Indeed, the military privately continued to look into the field. Peters (2017, 35) reveals that Anatoly Kitov, a top Soviet military researcher, discovered Wiener's 1948 book on cybernetics in a secret military library in 1952. Gerovitch (2004, 176-7) teaches that Kitov was also responsible for writing the first book on Soviet computing and headed Computation Center I for the Ministry of Defense. Due to his familiarity and expertise in these areas he immediately grasped the importance of Wiener's book and shared what he learned with his teacher and mentor, Aleksei Lyapunov. Gerovitch (2004, 173-4) reveals that Lyapunov, who is often referred to as the father of Soviet Cybernetics, was an influential Soviet mathematician who was interested in the intersection between biology, computers, and mathematics and who had developed military applications for Soviet computers. Therefore, like in the United States, Soviet cybernetics was first considered from a military standpoint. The pair would later hold important positions that enabled them to promote cybernetics outside the military and to a broader academic audience which they did until the dissolution of the USSR.

Even as secret Soviet military applications sought to use cybernetics in computing, it took some time to spread cybernetics to the Soviet civilian academic sphere. Slava Gerovitch (2004, 103) teaches that when Volume 20 of *The Great Soviet Encyclopedia* was published in 1953, it did not include the word "cybernetics." *The Great Soviet Encyclopedia* was more than an encyclopedia—it legitimized, defined, and described acceptable terminology applicable to Soviet society and, as such, was practically required reading in order to avoid being accused of working against the Party. Even so, as early as 1954 six scholarly critiques appeared in Warsaw titled *Dialogues on Cybernetics.* These scholarly articles were quickly followed in 1955 by two articles in *Voprosi Filsophii*, or what in English translates as the *Problems of Philosophy*, a Soviet journal written in Russian.

These early articles, lectures by Kitov and others, along with small groups carefully renamed or reworded Wiener's ideas to avoid criticism before Khrushchev's speech permitted cybernetics to be more freely discussed. For example, if drawing a cybernetic parallel between animal and machine, the term "theory" was used heavily to demonstrate that the authors were not asserting animals were *materialistically* similar to machines, which would have been anti-Marxist, but merely *theoretically* similar.

One of the most enduring forms that cybernetics would take in the civilian sphere was directed mainly at reforming the USSR's administrative command economy, as indicated by Khrushchev’s secret speech. The administrative command economy of the USSR during the 1950s underwent significant changes, with the Communist Party experimenting with different approaches to economic planning. Unlike the economies of capitalist nations where markets primarily consisted of private firms, the USSR's "enterprises" were owned by the government or "State." Therefore, enterprises relied on plans or "commands" from Gosplan, the state planning ministry, which detailed what would be produced and the quantities. The plans were carried out by "Gosnab," which attempted to source the materials and enact the plans. However, though the state appeared to have fine-grained control over the economy on paper, this did not mean that things always went according to the plan or that all economic activity was captured by it.

Soviet-type planning was not open to public scrutiny for much of the time it was used, so relatively few descriptions exist detailing the exact planning process. One of the few examples describing how it was done in practice was authored by John Michael Montias in his article *Planning with Material Balances in Soviet-Type Economies* (The American Economic Review, 1959) and remains the best source to explore the topic while it was still occurring. Montias (1959, 965-6) teaches that, by 1957, the planning process had undergone substantial reform at

Khrushchev's behest. Rather than Gosplan and Gosnab being responsible for all planning, Khrushchev shifted power to the regional and enterprise level. Accordingly, 18,000 enterprises were supervised by about one hundred Economic Councils responsible for distinct regions. In addition, after the reformation, the number of balances to be calculated was between eight hundred to one thousand—apparently, this was a significant decrease made possible by aggregation. This reformation is essential for several reasons. First, it reveals a system that shifted from a strict centralized hierarchy to a multi-level heterarchy. Second, regions holding power came to be in competition with each other. Third, this change foreshadows the beginnings of bureaucratic infighting and inadequate policies that would result in the languishing of the Soviet internet, computing, and the associated economic cybernetic plans. Lastly, the intensive growth that a fully automated economic cybernetic system would have signaled never arrived despite great success with extensive growth in the early decades of the USSR.

The system of material balance planning used in the USSR must be understood in more detail for the advantages of economic cybernetics to be revealed. Paul R. Gregory and Stuart authored the definitive textbook *Russian and Soviet Economic Performance and Structure* (1994, 74-6), where they teach us that Gosplan would establish "control figures" which dictated how much was to be produced while "promfinplans" detailed how the enterprises would meet the control figures. Next, the *promfinplans* were brought into alignment with the control figures. Materials were then allocated accordingly using the balance system, which revealed sources and stated the uses of the materials permitted. The plans covered five years but could serve as standalone guides annually. This material balance planning process, originating with the USSR itself, was more or less the planning system used the entire time the USSR existed, with slight changes in organizational structure and modifications to the centralization of power. In practice, there was much back and forth between planners and enterprise managers. Montias (1959) also describes enterprises working autonomously as they waited for plans to arrive or when errors triggered recalculations that could result in delays while the corrected plans were made. Therefore, though the economy was planned, plans were adapted to suit those involved and the situation.

Intriguingly, much more efficient methods of economic planning than material balance planning were created and existed within the USSR yet were, as far as is known, never openly attempted. Peters (2017, 68-9) reveals that a 1923-4 input-output analysis was completed by talented economists and statisticians working for Gosplan, which had captured the balance of the USSR's national economy. However, in 1929, Stalin dismissed it as a "numbers game." Such innovations did not further Stalin's ambitions and, according to Gerovitch (2004, 269), put the method's developers at risk of being purged. Indeed others, such as

Wassily Leontief (1905-1999), would gain recognition, a Nobel Prize, and public approval for presenting this method outside the USSR. Montias (1959, 967) reveals that planners in the USSR, Hungary, and East Germany considered programming their process to encompass the entire national economy. However, they reported that such experiments did not "harmonize." Such a report is intriguing, considering that the development of linear modeling was completed by the Soviet economist and mathematician Leonid Kantorovich (1912-1986) by 1939. Given minimal information, linear modeling permits one to input competing resources as variables, along with their associated costs, to determine the optimal distribution depending on the eventual selling price. Kantorovich was also awarded a Nobel Prize in 1975. Therefore, though the USSR certainly had world-class talent with top-level skills who invented sophisticated mathematical techniques directly applicable to economic planning, pursuing these was discouraged until the end of the Stalin era when Khrushchev's thaw allowed these concepts to be revisited.

Even the necessary simplifications in the planning process often caused headaches for planners. By the early 1960s, sound theories and tools had been developed inside and outside the USSR that held immense promise. Some of these ideas ironically reentered the USSR after their inventors fled from possible Stalin-era purges only to be rewarded richly elsewhere, where they were free to publish their findings. By the Khrushchev era, new possibilities for cybernetics to be used with input-output analysis, linear programming, and networked computers permitted serious consideration.

The USSR underwent a variety of attempts at reform, beginning with the Khrushchev era. Gregory and Stuart (1994, 245-55) assert that modifications made to the Soviet economy during this period can be broken down into organizational change, planning reform, and decentralization. Organizational change refers to the restructuring of the hierarchical nature of the Soviet economy. Planning reform involves changing how the administrative command economy achieves its goals in determining and allocating resources. It would include process changes (such as how calculations were made and reported) or modifications to tools and techniques. Finally, decentralization involves devolving decisions to a lower level of the hierarchy. In a decentralized network, information is dispersed more widely. The benefit of outsourcing concepts is that there is a broader knowledge base for issue resolution. Economic cybernetics, in its most robust imagined visions, would have required all three types of reform: organizational change, planning reform, and decentralization, something that led to resistance to adopting cybernetic planning reform later.

Cybernetics is a term that never appears in *Russian and Soviet Economic Performance and Structure*; however, Gregory and Stuart (1994, 247) reference it indirectly, stating instead that a "computerized information system" was pursued but never developed. They also definitively reveal the conditions in the USSR that made economic cybernetics using networked computers especially attractive. For example, the amount of information required to plan the economy "increased dramatically," according to the authors. The Khrushchev reforms also had the effect of increasing bureaucracy even when desiring to streamline it. This argument reflects one cited by Peters (2017, 63), who teaches us that one of the most famous Soviet cyberneticians, Viktor Glushkov, calculated that by the year 1980, if the paper-based methods used by Soviet planners remained unchanged, planning bureaucracy would increase nearly forty-fold. If unabated, the entire Soviet working-age population would have been required to work in planning!

To ease the immense calculation burdens and bureaucracy inherent in the Soviet economic planning process, computers and networks utilizing cybernetic approaches were considered by many to be an ideal solution. It was imagined that such a system could calculate, adjust, and make planning decisions autonomously and continuously. In a nation that relied upon five-year plans with mistakes triggering arduous recalculations automating this process was extremely attractive. As discussed in the next section, gathering data directly from the enterprises would have represented a significant advancement in terms of accuracy, impact, efficiency and importance. Overall, Party openness to changes in material balance planning reaffirmed the idea that cybernetics could specifically be applied to the economy leading to the origination of the term and field of Soviet economic cybernetics.

With cybernetics now publicly approved and introduced by leading military researchers into the wider civilian academic sphere the Soviets went from mocking the field to popularizing it. By the late 1950s and early 1960s, institutions were created to apply cybernetics to nearly every academic field. Cyberneticians had risen to important societal positions—cybernetics went from being distrusted to trendy and now they supplanted philosophers by interpreting ideology in cybernetic terms. A key theme of Gerovitch's (2004) book is that appending the word cybernetic to a formerly "taboo" field allowed it to receive political approval and support; cybernetics allowed researchers to sidestep political and bureaucratic barriers. For example, "cybernetic biology" was the code name for the field of Mendelian genetics, which had previously been under attack for years by the politically powerful and influential Trofim Lysenko, who did not believe in Mendelian genetics and promoted his pseudo-scientific ideas known as "Lysenkoism." To circumvent Lysenko, *cybernetic biology* allowed researchers to do Mendelian genetic research by framing their work in cybernetic terms.

Even experiments relating to capitalism could be discussed in positive terms if framed cybernetically in the USSR. Gerovitch (2004, 225-6) reveals that Mikhail Tsetlin created a game demonstrating that when finite automata were given a pay function and simple rules, they could develop individual strategies that did not require them to be centrally directed. Each automaton minimized its interactions with others and the system's environment in favor of pursuing its individual goal. Surprisingly, though operating independently, this resulted in expedient solutions for the system as a whole. Though this experiment was intended to demonstrate how the human brain and nervous system might function as described by Gerovitch or Tsetlin, the results speak of how individuals in capitalist societies are said to behave—in a decentralized manner as if guided by an "invisible hand" to an efficient outcome. In addition, it appeared that the language of cybernetics, couched as it was in mathematics, computation, and science, evaded politics and associated bureaucracy—an assumption that would prove faulty. Indeed, Slava Gerovitch (2004, 253) teaches that early critics of cybernetics translated Wiener's term for "control" to the Russian "kontrol," meaning to check, examine, or monitor something without directing it. However, those who championed cybernetics chose the word "upravlenie," which is a type of control more closely related to managing, directing, regulating, or governing something—all concepts that involve policy-making or taking actions that affect the thing being controlled.

In summary, a confluence of factors led the Soviet Union to embrace cybernetics after initial resistance and open skepticism. Having witnessed what happened to those such as Bogdanov—whose similar field of tektology challenged

Party power to his detriment—Soviet society was wary of venturing into such topics again. However, a new, more open political environment facilitated a positive public discourse surrounding cybernetics for the first time. In addition, the Soviet economy was undergoing significant reforms intended to improve its performance, and better technology and new techniques made a cybernetic economic approach a potentially practical reform in light of the new technology such as computers and networks. In addition, the Cold War stoked the perennial Soviet fear of being overtaken by capitalists. The United States had achieved intensive growth in computation, cybernetics, and associated areas, by opening up what was initially military technology to the academic and civilian population, who contributed significantly to continued development. The USSR, by contrast, had achieved extensive economic growth; however, the development of ideas that could have led to its intensive growth in the same fields was, by turns, discouraged politically, viewed as threatening, or failed to be appreciated fully. All this ensured that cybernetics first had to evolve from a field whose language, ideas, and technology were viewed as belonging to the enemy to one that was co-opted and adopted in service of the Soviet system. Unfortunately, cybernetics would be used not to improve the Soviet system but to reinforce and enshrine the bureaucratic and political status quo ensuring the promised efficiency gains were never realized.

Instead, by contrast, the USSR's existing bureaucratic and economic problems grew.

Leading Soviet Economic Cybernetic Plans

A pattern emerged in the development of Soviet cybernetics; however, it is one that is not immediately apparent. It comes from information gathered by Slava Gerovitch (2004, 261) in his sixth chapter, "Cybernetics in the Service of Communism." Data, in the form of a table, were gathered from the Cybernetics Council under the direction of Aksel' Berg in 1966 and appear in Gerovitch's book. This data has been recreated with the rows and columns switched (see Table 6.1).

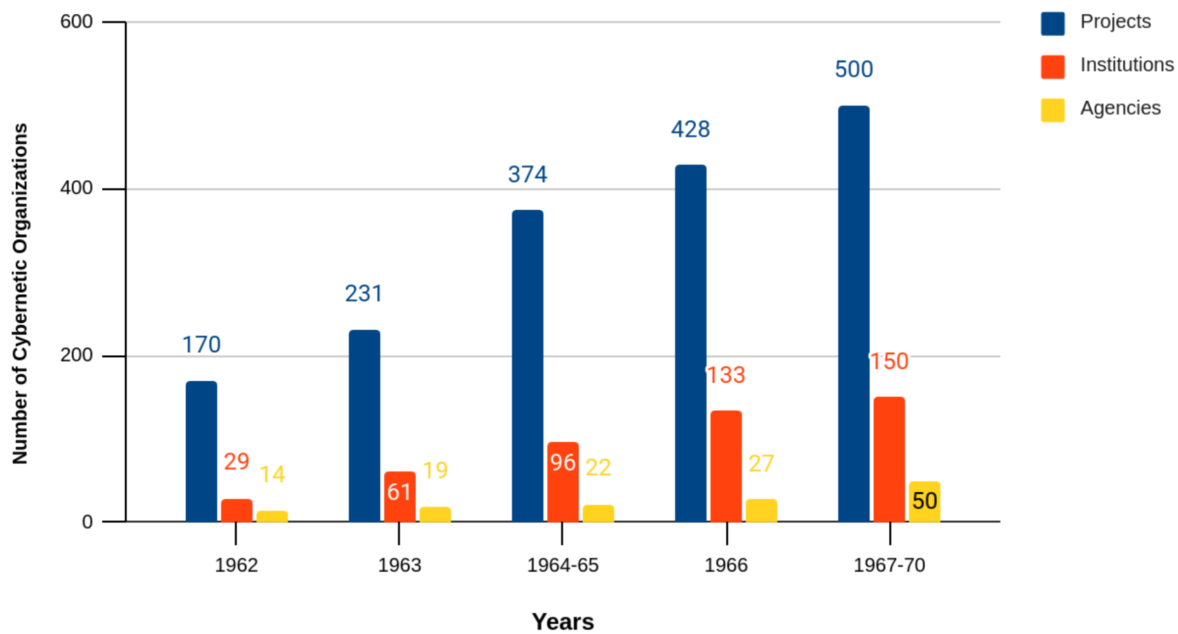
Table 6.1 recreated from Gerovitch (2004, 261)

Years	Projects	Institutions	Agencies
1962	170	29	14
1963	231	61	19
1964-65	374	96	22
1966	428	133	27
1967-70	500	150	50

As is borne out in the data in Table 6.1, the number of cybernetic projects, institutions, and agencies has been enumerated from the years 1962-1970. Merely looking at the change in the numbers for each organization does not immediately reveal the path cybernetics took in the USSR. For that, one needs to interpret the numbers, so a visual has been created from this data, which shows what these numbers look like in the form of a bar chart (see Graph of Table 6.1).

Graph of table 6.1

Data from the Cybernetics Council obtained by Gerovitch (2004, 261)



What the graph suggests is the pattern by which cybernetics emerged. Instead of viewing the number of organizations year over year, looking at the percent change is more revealing. The first thing to flourish once cybernetics had been legitimized in the USSR was the emergence of institutions. This institutional boom can be seen in 1962 when 29 institutions grew to 61 by 1963, the most significant percent increase at 210%. Next, the number of projects proliferated. In 1963 there were 231, which grew to 374 in 1964-5, representing an increase of about 162%.

Finally, agencies grew from 27 in 1966 to 50 in 1967-1970, which is 185%, however, keeping in mind the longer time frame.

Overall, the pattern is that institutions experienced greater growth first, followed by projects, and lastly, agencies. Such a pattern is likely general rather than specific to this context, and therefore would be applicable to areas far beyond cybernetics in the USSR. Logically, institutions serve as the nurseries where prototypes are developed. The resulting projects follow from this initial thriving of institutions. Lastly, agencies supporting the continuation of the projects occurs as agencies service and maintain them. Applying this pattern in this manner, to see the first hints of a significant advance being actively developed in a nation, the first sign might be a large jump, or percentage increase, in the concentration of institutions, focused on a similar field. In any case, this is the path taken by Soviet cybernetics and demonstrates that by the early 1960s, cybernetics was fully accepted and in the process of being applied. As each institution can create multiple projects, the institutions themselves have a more powerful impact than can be appreciated by their number alone which the data bears out as there were many more projects by number than institutions.

The organizational pattern just described dovetails with the overarching theme of cybernetics in the USSR. There was initial excitement and enthusiasm as cybernetics became acceptable. This enthusiasm enabled capable people to organize and develop multiple projects in institutions. However, the growth of the actual projects was less robust percentage-wise than the institutions themselves. When agencies were in on the action, enthusiasm was muted, cybernetics grew slowly, and significantly fewer agencies were needed. As shall be discussed, proposals for projects were subject to Party approval and so frequently ran into issues with bureaucratic infighting and political barriers. Ministries wanted to preserve their funding or positions, a fact that saw Soviet cybernetics implemented piecemeal. Finally, as agencies are frequently the servicers and maintainers of completed projects, this indicates, by 1970, cybernetic projects in the USSR were not so numerous or in demand as to warrant the creation of many new ones as, even over a more extended period, not many new agencies were created.

The emergence of institutions focused on cybernetic research may have appeared first; however, they emerged from a group of people. In the USSR, this was an elite group of Soviet mathematicians who were among the world's best. Peters (2017, 34-5) reveals that Andrei Markov Jr, Andrei Kolmogorov, Sergei Sobolev, Aleksei Lyapunov, and others coalesced to advance Soviet Cybernetics. In 1957, the preferred location was known as Akademgorodok in Novosibirsk, Siberia, which was a town created to foster more than 65,000 scientists with an atmosphere as close to intellectual freedom as one might hope to find in the USSR.

Academics had been prepped for the about-face by which cybernetics came to be acceptable when multiple articles, lectures, and other events were carefully introduced by top Soviet mathematicians and others with access to outside sources, usually due to a military connection. Another tactic to circumvent censorship was to use sources from neighboring countries such as Warsaw's *Dialogues on Cybernetics* discussed earlier. Sobolev, Lyapunov, and Kitov authored an article titled *The Main Features of Cybernetics*, in which cybernetics was rendered distinctly Soviet by removing the man-to-machine analogies and incorporating dialectics. Peters (2017, 40) teaches that an article by Ernest Kolman came next and fully brought cybernetics into the Soviet academic sphere. The article itself, *Chto takoe kibernetica?* translating to *What is Cybernetics?* in English was not significant so much for what it said (although it did further transform American cybernetics into a very Soviet one) but for who Kolman was—a conservative, orthodox figure known to attack non-orthodox mathematicians viciously. His article was a stamp of approval few expected, yet fully legitimized the field.

With institutions being created and associated publications accepted and published, it was time to reintroduce cybernetics to the public. In 1959 the esteemed Soviet engineer and military General Admiral Aksel' Berg created the statewide institution called the Council for Cybernetics. From 1960 to 1961, a series of lectures aired, *Cybernetics: In the Service of Communism*, which triggered alarm in the United States. Peters (2017, 44-5) teaches that some Americans believed that if the Soviets succeeded in automating their economy using cybernetics, it might be the weapon Khrushchev had once referred to when he said the Soviet Union would "bury the West." As such, a special branch of the United States Central Intelligence Agency (CIA) was created to watch the development of Soviet cybernetics, especially Soviet economic cybernetics. Since then several of these reports have since been declassified.

In the CIA report *Computers in the Soviet Economy* (1966), a detailed critique of the state of Soviet economic cybernetics proves useful not for its information about what the Soviet Union was capable of doing at that time but for listing the flaws the CIA's authors believed their approach contained. Later, when cybernetics was applied to the Chilean economy between 1971 to 1973 in Project Cybersyn, the issues faced by Soviet cyberneticians that the CIA raised in this report were so effectively addressed by Cybersyn's British creator, Stafford Beer that it almost appears as if he read the CIA's 1966 critiques. Unfortunately, though Project Cybersyn surpassed even the Soviet attempts to automate the economy—as the Chilean team did manage to gather, transmit, analyze, and respond to economic data nearly real-time directly from their state-owned enterprises—the Project was said to be destroyed in 1973 when the democratically elected Marxist President Salvador Allende was killed in a CIA-backed coup d'etat.

The first economic cybernetic proposals came from cyberneticians employed in the Soviet military. Slava Gerovitch (2004, 264-7) reveals that in 1959 Berg, Kitov, and Lyapunov sent information on computing to the Party Central Committee and Berg was given a commission by the authorities. Soon, the Central Committee and the Council of Ministers were involved and encouraged economic cybernetics to be developed. Kitov and others proposed a national network that could be used by the military by day while performing economic calculations nightly when the system would likely otherwise be idle. However, as the benefits promised by economic cybernetics directly undermined or threatened the bureaucratic hierarchy, funding, and authority, the military began to suppress it. The Chief Political Directorate took an active role by limiting the functions of the computing center and only allowing individual military projects. Kitov was expelled from the Army and, temporarily, from the Communist Party. He was later hired by Viktor Glushkov—arguably the most famous Soviet cybernetician.

Viktor Glushkov (1923-1982), in 1962, served as the director of the Institute of Cybernetics of the National Academy of the Science of Ukraine in Kyiv. He was a top mathematician who Aleksei Kosygin, then prime minister, asked to submit a proposal to apply cybernetics to the Soviet planned economy. Kosygin is best known for what Gregory and Stuart (1994, 249-25) call the Kosygin reforms beginning in 1965. He believed that mathematical programming, computers, and organizational change could improve the planning process. Given this, it is surprising that academic literature frequently overlooks that Kosygin was a supporter of economic cybernetics and a powerful one. Ultimately, the Kosygin reforms were tried as they could be implemented with the stroke of a pen rather than requiring extensive computers or networks. However, in 1957 power was re-centralized as Kosygin shifted it to the ministries and away from regional economic councils—national ministries were once again dominant over regional councils. Gregory and Stuart (1994, 253) point out that bureaucracy increased 60% from 1966 to 1977 which was one of the very issues economic cybernetics was meant to address and which Glushkov had foreseen.

Glushkov has been called the father of information technology in the Soviet Union, a background evident in his ambitious economic cybernetic proposal. Glushkov introduced what is known as the National Automated System for Computation and Information Processing (OGAS) which was to be a nationwide networked system of computers that could entirely automate Soviet planning. If adopted, such a system would have allowed money to be eliminated from the economy—a feature that Glushkov thought might be attractive to those who envisioned living in a Marxist communist society in its futuristic form. Unfortunately, a moneyless economy was viewed by his advisors as one step too far, and they recommended Glushkov leave this possibility out of the proposal. The system would have had computers installed at every enterprise, linking to 200 regional centers and then to Moscow's central Computing Center. It was a heterarchical pyramid by design. Each enterprise was on the same level as others, overseen by the next level of regional centers and, finally, the State for a total of three levels. Glushkov wanted to enable access to OGAS remotely—an early precursor to modern day cloud computing.

Initially, the 1964 OGAS proposal by Glushkov appeared successful, yet it ultimately became a victim of its own success. Glushkov was given more resources and more institutions involved in planning were established to automate management. Of these, the Academy of the Sciences set up the Central Economic Mathematics Institute (CEMI). The State Planning Committee created the Main Computation Center, while the Central Statistical Administration set up the Scientific Research Institute. Gerovitch (2004, 272) teaches that CEMI and the Council of Cybernetics with Berg became a focus of cybernetic economic development.

CEMI, under Nikolai Prokof'evich Fedorenko, and Glushkov's Institute for Cybernetics shared an early alliance. Peters (2017,140-2) reveals that both received funding and support largely thanks to Kosygin who viewed their solutions as an alternative to his own reforms. However, by 1970 CEMI under Fedorenko began pursuing more conventional economic projects centered at the microeconomic level. The reason for this as Peters (2017,144) teaches us may lie in the fact that when Glushkov and Fedorenko approached the Ministry of Defense in 1965 hoping to secure their support in the OGAS project—which could be joined to the military's own network—they were denied just as Kitov had been previously. Bagramyan, the Minister of Defense, was concerned his funding from the State would flow to a project that did not benefit his ministry directly. Cooperation, therefore, would decrease his own funding for military networks if these were to cross into the civilian sphere. At that time, Glushkov and Fedorenko did not have funds to compensate for this loss. This denial appears to have resulted in Fedorenko, and CEMI, shifting away from nation-wide projects and to a microeconomic mathematical focus. Fedorenko's leading cybernetic plans took the form of individual enterprises where computers with accounting capabilities were installed. His ministry thrived, completing many projects. However, this approach ultimately resulted in a patchwork of incompatible computer networks and software which Peters (2017, 142-3) suggests may have facilitated the failure of the USSR to reform the administrative command economy. Indeed, Fedorenko's approach *enshrined* ministerial power rather than reforming it—effectively siloing ministries from each other and preserving and petrifying their bureaucratic hierarchy.

Economic cybernetics became inundated with the very ministries that would be impacted by it, with concerned bureaucrats desiring to control how it was implemented. Increased bureaucratic involvement had the effect of forestalling development entirely. The organizations created to facilitate nation-wide projects like OGAS began to hijack the process to reinforce their ministry's bureaucratic structure and hierarchies. These hierarchies consisted of intricate connections with political tones. As an example, Barry Clark, author of *The Evolution of Economic Systems* (2016, 231), teaches that managers of enterprises would cultivate close relationships with planners to meet quotas for which they could receive a bonus. In addition, Clark (2016, 232) reminds us that managers did not depend on sales meaning that once quotas were met, selling into the black market was more beneficial than utilizing the official route for which they would gain nothing extra.

A series of inadequate policies were often suggested or put forth as requirements to protect their ministries from shrinking, losing authority, or being eliminated by economic cybernetics. One example of these was the insistence that economic cybernetics be done on the local enterprise level first, which would impact a lower level of the hierarchy and was, therefore, less threatening. The United States CIA noted this in their report *Enterprise-level Computing in the Soviet Economy* (1987). In a twist, Eden Medina teaches us in *Cybernetic Revolutionaries* (2014) that enterprises need not have computers specifically to gather the needed data, which can instead be gathered by older technology and then be directed to a location where a mainframe computer exists. Stafford Beer used such an approach on Project Cybersyn—the cybernetic economic system that was more developed than the Soviet projects before Chile's violent political overthrow. Cybersyn's enterprises used Telex machines (simpler than computers, these resemble a cross between typewriters and faxes) to send data directly from the factory floor to a mainframe computer for processing. Yet, Gerovitch (2004, 276-7) teaches that Soviet cyberneticians such as Glushkov resisted, insisting that economic optimization had to be done nationwide before it could be done locally. Other ministries began to ignore or delay progress on OGAS, and enterprise managers joined bureaucrats in resisting computerization.

Programmers have a famous saying: "Garbage in, garbage out," which refers to how lousy input yields wrong output. A cybernetic economic system would only have been accurate if the data entered was correct and fully reflective of reality. Informal "gray" or "black" markets were tolerated, even relied upon, in the USSR by many for multiple reasons. Peters (2017, 75) teaches that "tolkachy" were fixers who could make things happen outside the plan. Soviet citizens at every level relied upon them, with estimates of up to 24% of yearly spending going to tolkachy between 1968-1990. At the Gross National Product (GNP) level, the estimates from the informal economy range from a lower limit of 17% to a stunning 40%

over the same period. There were mulitple reasons for this. For example, if an enterprise did well, that set the "base" for the next year, leading high-performers to, at times, struggle to fulfill the plans. In addition, it would sometimes take so long to obtain services or goods that there were incentives to jump the line by providing a favor. If using computers, mathematical models, and cybernetics in economic planning, the informal economy posed problems as this activity would either be revealed or risk extreme inaccuracies system-wide.

Another significant barrier to the implementation of OGAS was due to insufficient funding. The USSR, occupying vast territory, would have been extremely expensive to network, and the lines that did exist were only rarely the needed quality or speed to support a network like OGAS. Gerovitch (2004, 278) discloses that Glushkov admitted significant barriers to implementing OGAS. According to him, the cost was more than the atomic project and the space program combined. In addition, as revealed by the Minister of Defense Bagramyan, ministries would choose to use funding for themselves and were unwilling to commit portions of their funds to facilitate a nationwide project, though they would do so for a system that they controlled completely.

The design of the USSR's nation-wide networks differed in a significant way from those in the US. The network, as visualized by Glushkov, drew its cybernetic inspiration from a nervous system. Glushkov created maps showing the enterprises, regional centers, and Moscow showcasing the similarity. However, in Glushkov’s OGAS, the “brain” of the nervous system was Moscow, specifically the Central Computing center. By contrast, in the US, the cybernetic inspiration was also a nervous system, however the entire nation was the brain with people being akin to neurons. The US version, consisting of a distributed network whose brain consisted of the people of the nation, was capable of routing around and resisting a nuclear attack which was successfully implemented, while the pyramidal heterarchy of the USSR was never created as planned. A major theme of Peters’s (2017) book is that the USSR did not operate hierarchically in practice, but only on paper. Therefore OGAS—as a pyramidal heterarchy with Moscow as the brain—did not map onto Soviet reality and resulted in an abstract structural dissonance.

In summary, the proposals submitted for an automated economic cybernetic network threatened the very system, as it existed, that it was meant to reform. Networks are often described as linking machines together. However, they really link the people behind them, which was the more significant issue to overcome in Soviet economic cybernetics. Without the consent and support of the people in the Soviet system, that system could not be improved. The pressure was stronger to uphold the bureaucracy, even as it undermined itself because to do otherwise would be to act against one's self-interests. In the service of bureaucracy, policies were weaponized to forestall progress. In this way, Peters (2017) argues that the communists behaved more like capitalists even as the capitalists worked cooperatively to successfully build a network everyone could eventually participate in and contribute information to—the American Internet. In addition, though both nations began cybernetic projects, computing and networks in the military, the United States allowed civilians to participate nearly from inception, while the USSR kept a technological iron curtain between the military and civilian sectors.

The sharing of information and resources between the military and civilians eventually culminated in the internet as we know it today, a result that could have been achieved in the USSR but was not. Sharing extensive, expensive infrastructure with a larger population facilitates its use and development, as was the case for the American Internet. Such cooperation also engenders intensive rather than just extensive growth as more people come to depend upon, develop, and adapt the technology, allowing it to become embedded in wider society. Indeed cybernetic systems are integral to nearly every facet of life, yet many today are unfamiliar with the term or its history. However, despite the success, even the most beautifully designed cybernetic system cannot suit every individual's preferences. Therefore, allowing more people to use and change it to suit their situation has always been a key to any technology's adoption from the bottom-up which is what engenders its continuance on a massive scale. It is clear that military networks in the USSR were top-down, however the bottom-up portion of this is missing and is an important aspect needed for achieving intensive economic growth.

Intensive growth would have been required to perpetuate the continued existence of the USSR, and the proposed nation-wide economic cybernetic systems—such as those proposed by Glushkov and Kitov—were capable of enabling this possibility had they come to fruition. The failure to develop OGAS or similar projects is also the failure of intensive growth as it would have represented a doubling down—or "leaning in”—on the socialist planned economy. Finally, insufficient funds were an issue that even the most strident cyberneticians could not overcome.

Failure to Launch: The Decline of Soviet Cybernetics

Unlike the Soviet Space program, as OGAS stalled and failed, so did the Soviet economy. Authors Gregory and Stuart (1994, 256) assert that from 1964 to 1982, the USSR's economy underwent what is known as an "era of stagnation"—a term coined by the Soviet leader Mikhail Gorbachev (1931-2022). Gorbachev attributed the stagnation era to the leadership of Leonid Ilyich Brezhnev (1906-1982), who emphasized pragmatism in governance and was careful to obtain widespread agreement within the Communist Party before initiating changes. The timing and causes of this Brezhnevian stagnation are controversial. However, one standard view cites a lack of progress and innovation resulting from the need to secure widespread support for proposed initiatives: a few naysayers could stall most proposals.

The failure of the Soviet Union to develop OGAS saw a return to the old centralized planning system of material balances. Khrushchev had split the planning process into regions which may have helped the economy initially. However, Khrushchev was forced to resign in 1964 and was succeeded by Brezhnev and Alexei Kosygin. Clark (2016, 234) reveals that the two leaders reinstated much of the old planning system as the Khrushchev reforms had created rivalries between regions. In addition, managers and planners colluded to manipulate planning targets. Rather than try to continue trying something new, the Soviet Union went back to its familiar centralized planning process. The Kosygin-Lieberman reforms attempted to introduce the concept of profit into the Soviet planning system, with enterprise managers gaining more control in decision-making. However, this had a different effect. Comparing itself to the West and trying to use Western approaches in a system so unused to the concept of profits was out of character for the Soviet Union. An extended period of vacillation between introducing markets and planning proceeded, and the economy, by the

1980s, was in fast decline. By now, none were considering, or able to fund, any cybernetic economic system.

The same tactics applied to the planning system in the Soviet Union were also applied to the OGAS proposal. In the end, incompatible individual networks that could not talk to each other were established in enterprises and ministries. The computers did little but become bookkeeping systems for individual enterprises or regional centers. In this way, the only economic cybernetics ever employed reflected the same problems besetting the Soviet economy and society. What was meant to be a unified network that everyone could see, contribute to, and benefit from became shattered into individual silos that isolated enterprises and ministries further by hard-coding incompatibility. Bureaucracy, the policies it lived by and perpetuated, and the results were solidified rather than broken down and reformed.

Economic cybernetics within the Soviet Union was threatening due to its realistic, powerful potential. The threat posed by economic cybernetics can be seen externally—in the form of the concern shown by the CIA—and internally by the inadequate policies and bureaucracy with the subsequent lack of funding within the Soviet Union. This Soviet system defied any attempts at serious reformation. Various Soviet bureaucrats did not wish to see a computer supplant what may have taken them years of social strategizing to attain—a high position in their department, enterprise, or ministry, the Communist Party, and the attendant social benefits that entailed. Though the Soviet economy did not have the same kinds of incentives that wages offered to workers in capitalist economies, this did not erase the perennial self-interested nature of the Soviet bureaucracy. Instead, competition and self-interest merely took on a different form. Evidence of this self-interested behavior can be found by examining the roles key figures held and the departments they oversaw that resisted the development of economic cybernetics in the USSR. Departments that would see a decline in resources by implementing economic cybernetics either ignored or resisted those who sought to apply cybernetics to the economy. The same rule applies to those who advocated for its use, noble though their intentions may have otherwise been.

Economic cybernetics, in its most robust imagined form, would have required all three types of reform: organizational change, planning reform, and decentralization, a reality resulting in resistance to its adoption. Despite these barriers, the potential of the Soviet Union to successfully create the system they imagined was high. Some of the world's top mathematicians, scientists, and thinkers were actively working with world-class ideas that would have permitted significant improvements in the Soviet Union's planned economy. No technological or scientific barriers likely prevented the cyberneticians from achieving their goal had the financial, ministerial, and political support existed. However, the bureaucrats' strength and ability to weaponize policy and withhold funding were obstacles that not even the best problem solvers could overcome. As a result, Soviet cybernetics, unlike their rockets, failed to launch.

Conclusion

This inquiry sought to establish that despite potentially offering significant efficiency gains leading to an era of intensive growth, cybernetics in the USSR fell short in being implemented because of a) a lack of coordination between competing ministries; b) inadequate policies; and c) insufficient funding. Cybernetics is an interdisciplinary field concerned with communication and control. Popularized by the American mathematician Norbert Wiener in the summer of 1947 and published in his book in 1948, it aims to automate complex processes in machines or living things. Cybernetics is a paradigm that, when applied, birthed many theories and specialties that became fields in their own right. Communication theory, the concept of using feedback as input into the system, self-organization, and more are examples of ideas and fields emerging from cybernetics. The internet, artificial intelligence, and SAGE are all examples of cybernetic systems.

The Soviets first saw cybernetics as a pseudoscience created by a Cold War rival, yet eventually embraced it, creating the field of economic cybernetics, which was extensively developed before falling into decline as the USSR did. The story of the decline of economic cybernetics is also the story of the decline of the USSR as a political and economic system. Economic cybernetics experienced rapid initial growth, with many new institutions and academic work created to develop it. Nevertheless, this widespread involvement helped splinter the field before a coherent nationwide economic planning system was i. Instead of economic cybernetics optimally automating planning, it enshrined the bureaucratic and political status quo as affected parties weaponized policy and withheld support or funding to preserve their ministries.

Ironically, while cybernetics was being splintered and halted internally in the USSR, externally, the CIA was carefully watching the development of this new grand experiment, possibly recognizing this attempt as the serious indicator of intensive economic growth it could have been. Indeed, the talent, technology, and techniques existed to make OGAS possible. A switch from material balance planning to linear programming using input-output analysis in combination with networked computers is relatively easy, and is utilized by firms and developed nations. These techniques were often invented or at least developed extensively by Soviet economists or mathematicians yet their insights and methods were discouraged in the Soviet Union itself at the highest levels. Outside the USSR, these insights garnered Nobel Prizes, and other nations utilized them to achieve yet more intensive economic growth while the USSR's economy stagnated. Wassily Leontief—developer of input-output analysis—for example, later held a position at the National Bureau of Economic Research (NBER) in the United States. In addition, techniques developed by both Leontief and Kantorovich are used today by Walmart, Amazon, and are applied in some countries nationally to maximize profit or improve economic planning. The adoption of these methods in the US by large private firms demonstrates that rational planning methods facilitate intensive economic growth, even—or especially—in capitalist nations. From this it is clear that ideas that facilitated intensive economic growth were abundant within the USSR. However, the appropriate policies, funding, and ministerial cooperation and support needed to be improved to make them a reality.

Bibliography

Barry Stewart Clark (2016). *The Evolution of Economic Systems : Varieties of Capitalism in the Global Economy*. New York: Oxford University Press.

Bogdanov, A. (1980). *Essays in Tektology*. University of California.

Gregory, P.R. and Stuart, R.C. (1998). *Russian and Soviet Economic Performance and Structure*. 6th ed. Boston: Addison Wesley, Cop.

McCulloch, W. and Pitts, W. (1990). A Logical Calculus of the Ideas Immanent in Nervous Activity. *Bulletin of Mathematical Biology*, 52(1-2), pp.99–115. doi:https://doi.org/10.1016/s0092-8240(05)80006-0.

Medina, E. (2014). *Cybernetic Revolutionaries : Technology and Politics in Allende's Chile*. Cambridge, Massachusetts: The MIT Press.

Montias, J.M. (1959). Planning with Material Balances in Soviet-Type Economies. *The American Economic Review*, [online] 49(5), pp.963–985. Available at: http://www.jstor.org/stable/1813077 [Accessed 18 Nov. 2022].

Peters, B. (2017). *How Not to Network a Nation: The Uneasy History of the Soviet Internet*. MIT Press Ltd.

Plato (2007). *The Republic*. Translated by D. Lee. London: Penguin Books Ltd.

Rosenblueth, A., Wiener, N. and Bigelow, J. (1943). Behavior, Purpose and Teleology. *Philosophy of Science*, 10(1), pp.18–24. doi:https://doi.org/10.1086/286788.

Slava Gerovitch (2004). *From Newspeak to Cyberspeak : a History of Soviet Cybernetics*. Cambridge, Mass.: MIT Press.

United States Central Intelligence Agency (1966). *Computers in the Soviet Economy | CIA FOIA (foia.cia.gov)*. [online] www.cia.gov. Available at: https://www.cia.gov/readingroom/document/cia-rdp79t01049a003200140001-0 [Accessed 22 May 2023].

United States Central Intelligence Agency (1987). *Enterprise-level Computing in the Soviet Economy | CIA FOIA (foia.cia.gov)*. [online] www.cia.gov. Available at: https://www.cia.gov/readingroom/document/cia-rdp08s01350r000401300001-9 [Accessed 22 May 2023].

Vladimir Il′ich Lenin (1938). *Materialism and empirio-criticism : critical notes concerning a reactionary philosophy*. London: Lawrence & Wishart.

Wiener, N. 1948 (1962). *Cybernetics or Control and Communication in the Animal and the Machine.* 2nd ed. S.L.: MIT Press.