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Advancing Soviet Technologies: Influence of the Management Environment

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A Research Paper

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SOV 87-10054
September 1987

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Advancing Soviet Technologies: Influence of the Management Environment

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A Research Paper

This paper was prepared by analysts of the Defense Industries Division of the Office of Soviet Analysis. Comments and queries are welcome and may be directed to the Chief, Defense Industries Division, SOVA 25X1

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Advancing Soviet Technologies: Influence of the Management Environment 25X1

Summary

Information available as of 17 August 1987 was used in this report.

General Secretary Gorbachev has singled out several key production technologies—microelectronics, computers, telecommunications, and automated machine tools and robotics—to pace the revitalization of the Soviet economy. In an effort to narrow the technology gap with the West, he has exhorted the scientific and industrial establishments to expand the supply of these key technologies and to move them more rapidly into industry. 25X1

In the West these information-based technologies have raised the quality and performance of both civil and military products and increased automation and efficiency, thereby accelerating the pace of change in industrial operations and technology development. These technologies have also made heavy demands on industrial management. Their development and application are highly interdependent, with advances in one technology field required for and in turn spurring advances in another. Sustaining this interaction has blurred the traditional boundaries between engineering disciplines, industries, and countries and has required dramatic increases in the information that flows across organizational lines. 25X1

In contrast with the broad front of accelerating and frequently chaotic development in the West, Soviet management has tended to produce spurts of growth toward a predetermined target—frequently supported by heavy doses of Western technology—followed by periods of stagnation. Soviet and Western analysts have thoroughly documented general Soviet problems in fostering dynamic and innovative development in critical production technologies:

- A Byzantine network of state organizations that allows local managers little flexibility and minimizes direct contacts between producers and consumers. For example, 30 different ministries are involved in the development and production of personal computers.
- A rigid decisionmaking structure that effectively discourages initiative from below—the source of most innovative ideas. Many enterprises that attempt to implement new ideas are blocked because their requests are not part of an authorized plan.
- The tendency for planners to seek compromise and standardization for the sake of planning efficiency, not production efficiency or product utility.
- A relationship between suppliers and customers that protects suppliers and discourages consumers—just the opposite of the West, where the customer decides if a product is useful. 25X1

[redacted] 25X1

[redacted] considerable differences in the relative 25X1
importance of various factors in the two countries, [redacted] 25X1
[redacted] reflect the attention or time that a manager must devote to 25X1
a particular ingredient of technological innovation:

- Obtaining and applying information—market and technical—consumes much of a US manager's day. He responds to customer requirements and has reliable suppliers.
- Assuring a reliable supply of equipment, materials, and labor is the principal challenge confronting a Soviet manager. He responds to a centrally dictated plan and sees little need to obtain feedback on customer needs. [redacted] 25X1

Our analysis indicates that sustained technological development must be underpinned by a strong supply system, a responsive infrastructure of services, and above all by institutions and incentives that allow or force managers to concentrate on improving product utility. The information that Western managers seek, and that Soviet managers frequently ignore, fuels technological advance. [redacted] 25X1

Gorbachev has adopted a two-pronged strategy to improve Soviet technological performance. He has demanded impressive gains in performance in the target areas and has announced a massive infusion of investment resources to support his goals. Although this strategy is likely to produce some improvement in performance, Gorbachev's statements, and those of other officials, reveal an appreciation of the implications of our interviews—that sustaining rapid technology development depends critically on stimulating initiative at the enterprise level, developing a strong linkage between customers and suppliers, and enabling managers to quickly shift resources to the most productive applications. The Soviets have introduced several reform initiatives to realize these objectives; expanded self-financing, increased enterprise autonomy, and decentralized wholesale trade are among the more promising. None, however, have proceeded far enough to permit a firm judgment on how effective they will be. [redacted] 25X1

The Soviets are likely to struggle in their effort to be competitive in advanced industrial technologies. They will eagerly copy Western advances and will master high-volume production of standardized equipment, but they will probably fall short of developing the kind of efficient, flexible

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manufacturing capability that will allow them to take full advantage of the benefits of advanced technologies. The centralized Soviet approach will serve better in areas such as telecommunications and basic computer equipment, where standardization provides some advantages. It will fall short in fostering innovative applications of the core microelectronic and computer technologies and of software, the glue that binds the system together. 25X1

Prospects for more efficient development and use of these technologies would improve with structural reforms targeted at the free flow of information and more decentralized management, but the outlook for such change is highly uncertain. Sticking to the current blueprint for technological progress may cause the Soviets to lose ground to the industralized West and perhaps to even newly industralized nations. Current Soviet reforms and investment plans focus primarily on those factors central to sustained technology development that concern Western managers the least—namely the dependability of supply of inputs to production. Shortfalls in inputs may extend into the military arena, where cost-effective manufacture of high-performance weapon and support systems depends increasingly on information technologies. 25X1

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Background

Industrial modernization is the cornerstone of General Secretary Gorbachev's strategy to revitalize the Soviet economy. The program he has outlined aims at bringing the quality of Soviet products and the efficiency of Soviet industry up to world standards by the year 2000 and is to be achieved through accelerated technological development, innovation, and renovation of industrial capital. Modernization also promises the image of vitality and strength that Soviet global prestige demands and provides the means to strengthen the industrial base needed to compete economically and militarily with the West. [redacted]

Since assuming leadership of the Soviet Union, Gorbachev has exhorted the scientific and industrial establishments to expand the supply of key technologies and to move these new technologies more rapidly into industry. His program emphasizes development of the high-technology sectors that provide the advanced equipment and processes needed for industrial and military modernization, especially microelectronics and instrumentation; computer equipment and software; telecommunications; and machine tools, robotics, and flexible manufacturing systems. The supporting industrial base for these information technologies resides in the favored machine-building and metalworking sector of the economy. [redacted]

This paper assesses the influence of the Soviets' planning and management system on Gorbachev's prospects for wringing benefits from these technologies to the degree that has been realized in the West. It outlines the reasons these technologies are deemed essential for the continued development of advanced economies. It reviews the conditions that have fostered Western technological development, [redacted] and compares these conditions with those traditionally prevailing in Soviet industry. The paper then contrasts the relative importance attached to various factors involved in innovation by US managers, [redacted] managers in the Soviet Union, and Western experts on Soviet industry. It concludes by assessing Gorbachev's prospects for transforming the Soviet economy into an engine of technological advance and the implications of this assessment. [redacted]

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The Promise and Challenge of Advanced Technology

In the West, applications of these information-based technologies have raised the quality and performance of both civil and military products, created a vast service industry, and increased automation and efficiency in manufacturing:

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- Since 1975 US high-technology industries as a group had a rate of growth of real output more than twice that of total US industrial output. Nine of the 10 fastest growing US industries since 1975 have been high-technology industries.[1]

- The rate of price increase for high-technology industry products during the 1970-80 period was only one-third that of the overall inflation rate in the United States.

- During the 1970s, average labor productivity of the industries in the high-technology group grew six times faster than that of total US business.

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- The high-technology industries accounted for more than 60 percent of total private industrial research and development in the United States, although they represented only 13 percent of the value of manufacturing product shipments. [redacted] 25X1

The Promise

Application of these advanced technologies (see inset for thumbnail descriptions of the leading technologies) 25X1
can have profound effects on the cost, quality, and 25X1

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[1] For purposes of this paper we define high-technology industries to be microelectronics, computers, software, telecommunications, and machine tools and robotics. [redacted] 25X1

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Key Technologies for Industrial Modernization

Microelectronics: Integrated Circuits or Chips
An integrated circuit consists of many transistors and other electrical components linked by conductor segments and fabricated on thin wafers of silicon or other insulating material. Each wafer, containing many ICs, is separated into chips that are packaged separately.

Computers
Mainframe. *Large, general purpose, multiuser computers possessing dozens of terminals and disk drives and several printers. Mainframes can have word lengths of 32, 48, or 64 bits and can accommodate as many as 300 to 400 users.*

Minicomputer. *A computer anywhere in size between a mainframe and a micro with word lengths of 16, 24, or 32 bits (superminicomputer). Minicomputers often operate in distributed systems as data collection points. They also serve as dedicated computers, often handling communications protocol responsibilities in computer networks.*

Microcomputer. *Small microprocessor-based computer containing a central processing unit, memory chips for storing programs and data, and input-output interfaces for exchanging data with peripheral devices. Also known as the personal computer.*

Telecommunications
Analog Transmission. *A process in which the information content of each communications channel is represented by a continuously varying smooth waveform. This process is suited to transmission of a continuously varying input, such as voice traffic, but subject to distortion of the information content by common types of noise.*

Digital Transmission. *A process in which the information content of each communications channel is represented by combinations of pulses in an on-off format. The process is suited to the transmission of various types of information—voice, teleprinter, computer data—and is particularly compatible with the use of integrated circuits. It is less susceptible to distortion by most forms of noise than analog transmission.*

Advanced Machine Tools and Robots
Numerically Controlled (NC) Machine Tool. *An automated machine tool whose movements and functions are recorded on paper tape, punch cards, or magnetic tape. Readers convert this information into signals that operate servomotors that move the machine along each of its axes.*

Computer Numerically Controlled (CNC) Machine Tool. *An advanced NC machine tool in which a computer is substituted for the command portion of the machining tool's control system. Advantages are online program revision, automatic correction of machine inaccuracies, and the elimination of tape or card handling. A computer may control several machines and incorporate them into an integrated manufacturing system.*

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performance of producer and consumer goods, supporting their diffusion throughout the economy. Mass production of inexpensive, general purpose integrated circuits (ICs) and automated production of custom ICs have caused the cost of memory and logic functions to plummet, fueling an unprecedented explosion in the use of microelectronics-based computing and communications by the military, industry, medicine, and the public. For example, in the last 15 years the selling price per bit of information has fallen by a factor of 1,000, and the number of transistors per chip has risen by a factor of 100,000. Although advances in power, speed, and efficiency of large mainframe computers were fairly predictable, the surge in the use of minicomputers and personal computers was largely unforeseen 10 years ago. Today, a modestly priced personal computer can perform many of the functions of a large, costly, mainframe computer of the type used as recently as a decade ago. 25X1

Manipulator. *A device that moves material, parts, or tools through limited, preset motions to perform simple tasks, such as single-point spot welding and simple materials handling (stacking, point-to-point transfer).*

Industrial Robot. *A reprogrammable multifunction manipulator that moves material, parts, tools, or specialized devices through variable programed motions to perform a variety of tasks.*

Flexible Manufacturing System. *An integrated system of several CNC machine tools and robots, often with automated material handling and warehousing, which automatically performs several machining, transfer, and inspection functions under common control of a host computer.*

Computer-Aided Design (CAD) System

A system in which a computer serves a designer workstation and a plotting station. The system allows a designer to develop, record, display, and interactively alter the design of a part or assembly at a workstation terminal. The designer may then command the plotting station to produce engineering drawings of the design for use in manufacturing. In its more advanced form, a CAD system can generate NC tapes or computer programs for controlling the manufacturing functions of machine tools and robots.

The advent of digital transmission and switching systems has substantially reduced the cost of voice communication and has permitted new services, such as facsimile transmission and teleconferencing. Advances have also supported high-rate data communications services, linking computers and data bases in commerce, government, and industry. Advanced telecommunications links within and between organizations support high-speed information networks used to access or share information, thereby enhancing a company's productivity or competitive position. Local area networks integrate production scheduling, procurement, and material handling. Many larger manufacturers are using various telecommunications technologies to integrate computer-aided design functions with computer-aided manufacturing to create fully automated factories. 25X1

Advances in computing and telecommunications have depended heavily on the software that generates the myriad instructions that operate, link, and apply computers and telecommunications hardware. Software increasingly determines the function and performance of digital systems, enables hardware to be more generally applied, and serves as the nervous system of national and local telecommunications networks. In 1983, for example, one large telecommunications network was linked to 100,000 computer terminals and required 4,000 minicomputers and 300 mainframe computers to operate. 25X1

The application of microelectronics has revolutionized machine tools, leading to a new generation of highly automated, general purpose machinery with dramatically increased capabilities. Minicomputers and microcomputers routinely control manufacturing processes, machine tools, and robots. Flexible manufacturing systems link machine tools and programmable robots under the supervision of a computer to further automate manufacturing processes in an ever growing range of industries. Computer-aided design terminals with complex and often specialized software packages create in hours designs that would have required months to complete manually. Larger manufacturers are developing computer-integrated manufacturing approaches that will eventually integrate many of these functions into a fully automated factory. 25X1

The Challenge

The appearance of these technologies has substantially increased the pace of change in industrial operations, market development, and the development of even more advanced technologies. Their immediate impact on economic growth and productivity, however, is debatable. Many benefits have proved difficult to represent on a balance sheet—for example, increased product quality and uniformity and greatly

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Figure 1
Microprocessor Production Milestones, United States Versus USSR

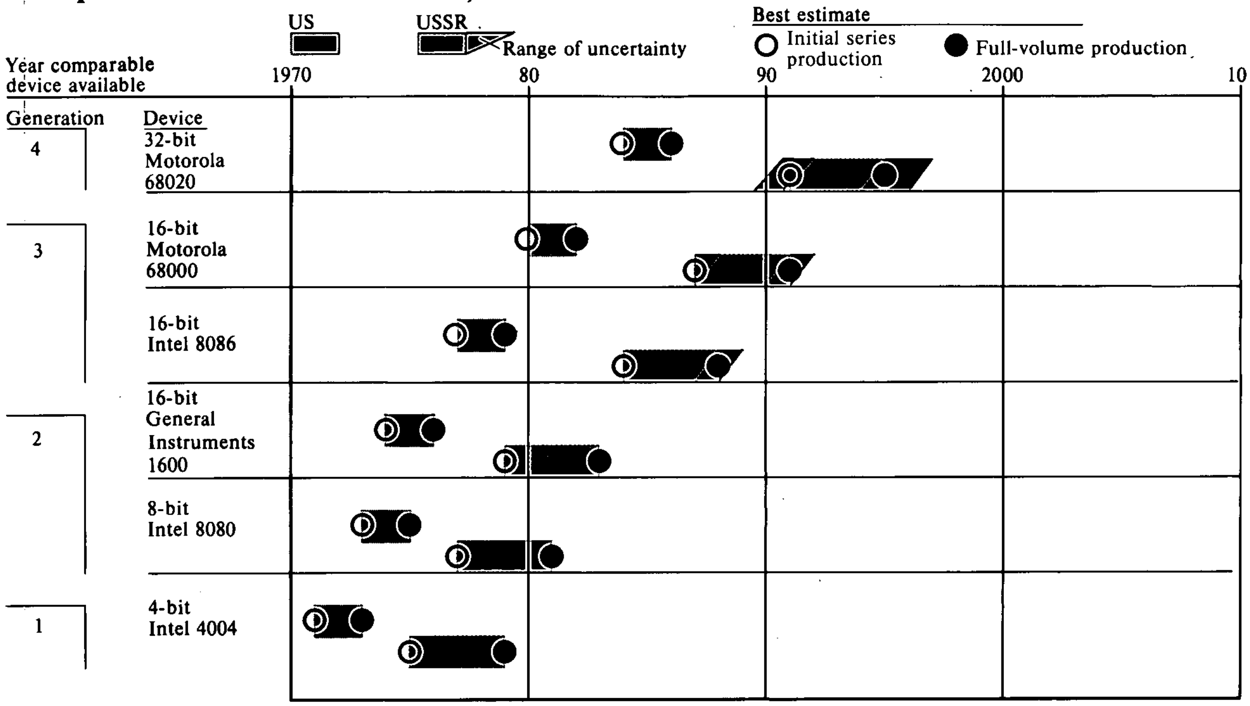

Figure 1 shows the dates the United States and the USSR first achieved initial series production and full-volume production of various types of microprocessors. Microprocessor type is defined by word length, although this measure is necessarily vague because complex microprocessors often have inconsistencies in their internal word length. We have therefore related the various types of microprocessors to a US standard chip for which the Soviets have developed (or probably will develop) a counterpart. It should be noted that Soviet ability to produce a counterpart does not imply that the Soviet part matches the performance of the US original—in fact, Soviet microprocessors seldom approach the performance of US counterparts.

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increased flexibility to change products and product lines with minimum time and retooling, thus enhancing competitive responsiveness. In industry, cost reductions generally arise from reduction of waste and work-in-process inventories, while reduction in direct labor costs is usually of minor significance. Affordable computers, software, and communications have spurred rapid growth of the service sector in the West, but their impact on productivity has been unclear. Some analysts argue that productivity for white-collar workers—three-fourths of the US labor force—is no greater in the 1980s than it was in the 1960s. Even properly applied factory automation is only beginning to live up to earlier expectations as the systems integration skills learned over the past decade begin to bear fruit.

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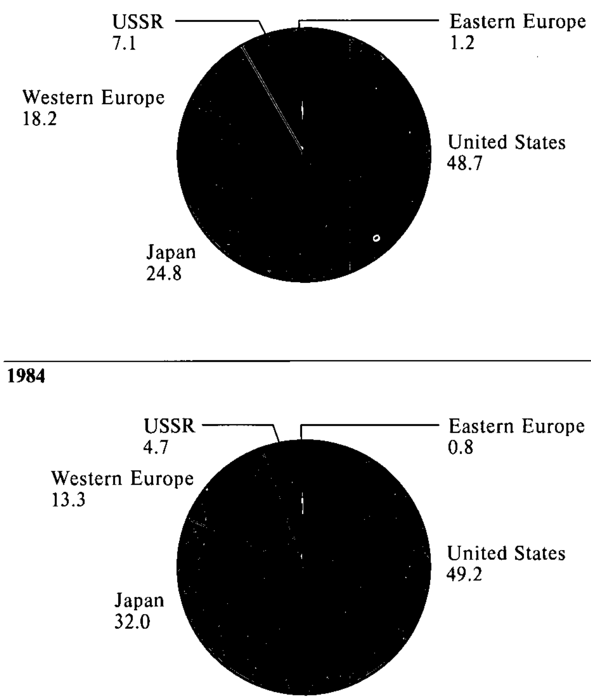
Fostering and accommodating such information technology–based advances has challenged even well-managed Western firms. Most advances occur when existing technologies are applied to old problems in new ways, and successful development and incorporation of these technologies into industry have historically required savvy and determined inventors and

Figure 2
Share of World IC Production by Country or Region, 1980 and 1984

Percent



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implementers. Underpinning all advances are information about what customers require; an infrastructure that provides trained personnel, finances, and support; and a supply of materials and equipment that is sufficiently advanced to allow further progress. The increasingly interdependent nature of modern industrial technologies not only makes these factors more critical, but also produces a broad front of advance, with new developments in one field spurring advances in another. Sustaining this process has blurred the traditional boundaries between engineering disciplines, industries, and countries, and required enormous growth in the information that flows across organizational lines. 25X1

Soviet Development of Key Technologies for Modernization

Soviet progress in these technologies has been sporadic, with spurts of growth and development toward a predetermined target followed by periods of technological and economic stagnation. This contrasts sharply with the more continuous and accelerating development of technology in the West. In every area the Soviets have leaned heavily on the West, pursuing a follower strategy by importing previously proven technical innovations. Nevertheless, Western export controls and Soviet difficulties in assimilating foreign technology have frustrated Soviet efforts to cut into Western leads. 25X1

Microelectronics

The Soviets have developed a major microelectronics industry, specializing in the production of ICs for military applications. Soviet production yields and product quality, nevertheless, remain far below those of Western counterparts. If the Soviet microelectronics industry—with its considerable production floorspace—used US technical processes and equipment, it has been estimated that production would exceed current Soviet levels by a factor of 10. 25X1

The Soviets have developed more than 25 microprocessor types, spread across a number of technologies and system architectures. These include 2-, 4-, 8-, and 16-bit (word-length) microprocessors, which by Western standards would be first, second, and low-level third generation. By 1990, Soviet circuits will probably compare to high-level third-generation and current fourth-generation (for example, 32-bit) microprocessors now widely used in the West [3] (see figures 1 and 2). The Soviets have indicated their intent to use

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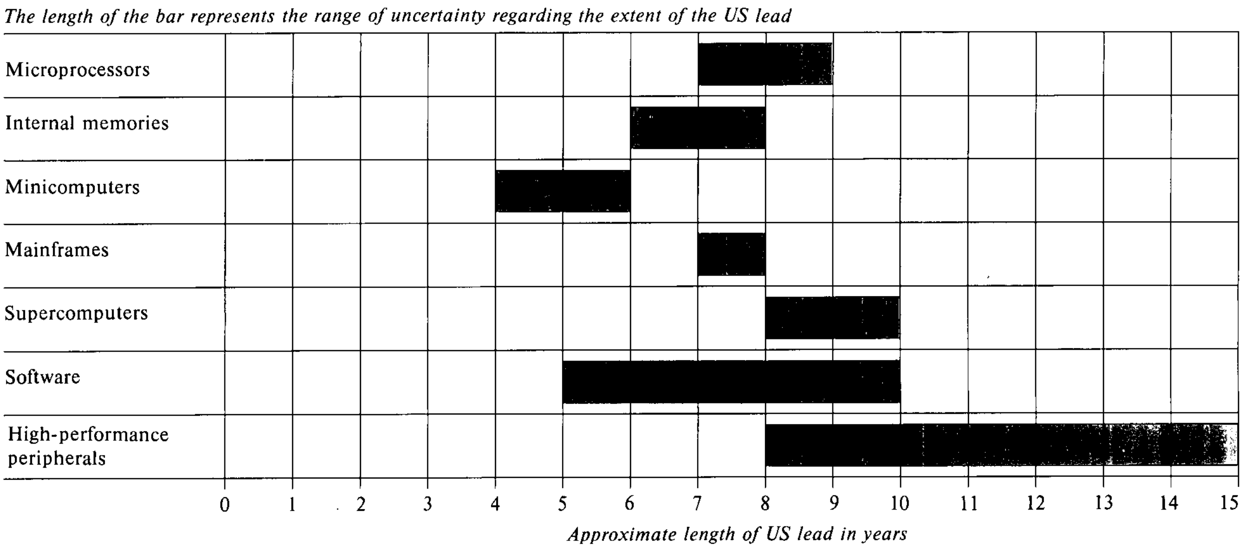
Figure 3
Computer Technology: United States Versus USSR



Note: The United States leads the USSR in all fields of general purpose digital computer technology. This lead ranges from at least three years for internal memory devices to 10 or more years for software and high-performance peripherals. In general, the outlook for the remainder of the 1980s is for the US lead to increase, although for some high-priority applications, the Soviets may be able to reduce, or design around, a particular technology gap.

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these devices in minicomputers planned for series production about 1990. In IC memory technology, the Soviets have produced dynamic random-access memories (DRAMs) up to the 64K level and—as with microprocessors—have spread their memory ICs across several technologies. [redacted] the Soviets are applying considerable effort to improving low production yields on 64K DRAMs and have begun initial series production of a 256K DRAM. [redacted]

The Soviets often partially offset lags in microelectronics production capabilities in military systems by aggressively applying new ICs while they are still in the prototype production stage; the United States usually does not place such circuits in weapon systems until full-scale production is achieved. The Soviet approach, however, limits flexibility to make improvements to production processes and circuit design efficiently, and restricts the range of industrial uses. Further, the USSR's dependence on copying Western technology assures a US applied technology lead of over three years—the minimum time required for the Soviets to adapt a US IC and achieve pilot production. In addition, Soviet weakness in achieving volume production has ensured that the United States remains at least three to four years ahead in series production capability. [redacted]

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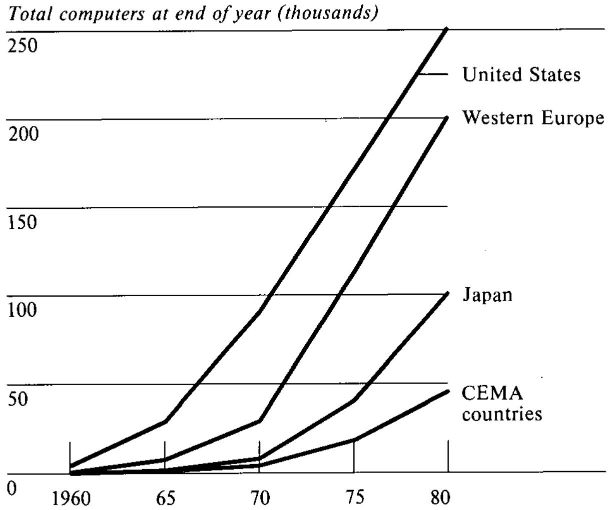
Computers

In 1967 the Soviets made a major policy decision to adapt the architecture of the IBM System/360 to an existing indigenous technology base. This program,

Figure 4
World Stock of Large Computers, 1960-80



Note: The Soviet Bloc countries trail far behind other industrialized nations in computer production capability, and the gap appears to be widening.

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called the Ryad series, was placed under the Ministry of Radio Industry. One Ryad model was seen in 1971, but most models were not displayed until 1973. (It took the Soviets longer to copy the System/360 than it took IBM to develop it.) Early Ryad systems were soon followed by intermediate upgrades in the mid-1970s. A second generation, called the Ryad-2 and modeled after the IBM System/370, was introduced in the late 1970s.

The successful Ryad effort was soon followed by programs in the development of minicomputers, begun in 1974, and microcomputers, begun in 1976. Areas of specialization were allotted to different Bloc countries, but the USSR retained the major role in developing top-of-the-line processors and memories, as well as maintaining some capability in all peripheral equipment areas. The Ministry of Instrument Making, Automation Equipment, and Control Systems is responsible for producing minicomputers used in control processes, while the Ministry of Electronics Industry spearheads the development and production of microprocessors and microcomputers. Figures 3 and 4 illustrate current US intelligence estimates of Soviet computer technology lags behind the United States, as well as the accumulation of the world stocks of large computers. 25X1

Telecommunications

Soviet telecommunications have gained momentum over the past decade but have been outpaced by Western developments in network and digital transmission technologies (see figures 5 and 6). Although the Soviets have recognized that telecommunications are essential for industrial modernization, current Soviet systems are substantially inferior to those in the West—roughly equivalent to US capabilities in the mid-1960s. The 1981-85 Five-Year Plan called for the creation of the Unified Automated Communications Network, a standardized system that was to fully integrate voice, data, facsimile, and video signals on an interactive carrier, but progress has been slow. Meanwhile, increased levels of competition in the Western communications industry—along with rapid proliferation of computers of all sizes—have spurred significant development and diffusion of telecommunications technologies. 25X1 25X1

Western experts consider that the Soviet telecommunications network is relatively spartan, serving primarily government, the military, and industry. The system has a backbone of 20 million telephones, compared with over 150 million in the United States, and individual satellite transmission capacity of six video and about 400 voice channels, compared with 28 video and 98,000 voice channels on a single Western communications satellite. The Soviets are proud of 25X1 their television broadcast system, in which signals are beamed across 11 time zones, covering the entire

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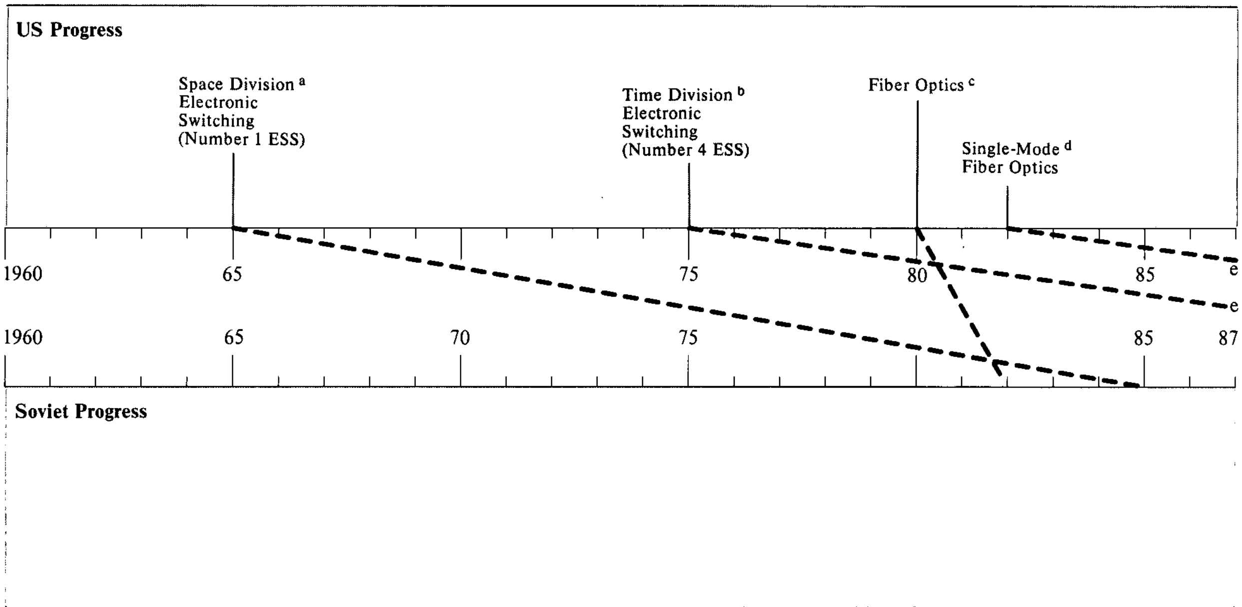
Figure 5
US Lead Over Soviets in Telecommunications

Dashed lines indicate extent of Soviet lag in developing counterpart to key US telecommunications technologies



a Space division switching transmits an electronic signal sequentially through a series of communications links assigned for the duration of the call.

b Time division switching transmits two or more signals or calls through a common communications link using successive time intervals for different calls.

c Fiber optics transmit signals using light waves traveling along thin glass or plastic fibers, thereby enabling a more complex signal to be passed more rapidly.

d Single-mode fiber optics use glass or plastic fibers so thin that only a single wavelength of light is transmitted, thereby reducing signal loss and allowing communications over greater distances without amplification.

e No Soviet capability.

[redacted] 313139 9-87 25X1

country, where over three-quarters of the homes have receivers. At the same time, the automation level of the existing telephone network—that is, switching of long-distance calls without the use of an operator—is only 55 percent, possibly the lowest level in the industrialized world. [redacted]

Qualitatively, the Soviet telecommunications network is poorly suited to support data transmission and networking because it is based largely on analog technologies used in the West in the 1960s and suffers from severe shortages of digital switching, computer, and software technologies. Although the Soviets produce most types of hardware required for digital communications, networks that permit different computers to operate interactively are rare, and a shortage of computers has forced them to make routine use of data transmission from remote locations over low-grade lines. Leading-edge technologies such as production of optical fibers, network control programs, and digital switching are discussed in the Soviet press in the context of problems that must be solved before wide-scale use begins. [redacted]

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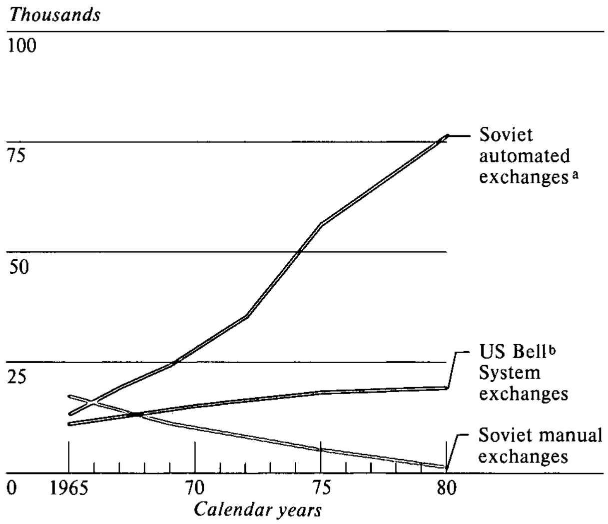
Figure 6
United States and USSR:
Number of Telephone Exchanges



[a] Calls placed on approximately 20 million telephones that these exchanges serve are switched using electrical relays similar to those used in the United States before 1970.

[b] Since the mid-1970s nearly all calls placed on the more than 150 million telephones that the Bell System serves have been switched digitally under the control of supervising computers.

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Machine Tools and Robotics

In 1968 the USSR established a national program for numerically controlled (NC) machine tools, designating lead ministries for the civilian and defense industries and a third ministry for the machine control systems. NC machine-tool production increased by about 3 percent annually until the mid-1970s, but its share of total production remained small—about 3 percent. (Relative US and Soviet progress in the manufacture of advanced machine tools is shown in figures 7 and 8.) In 1978 the USSR began cutting back production of general purpose equipment and expanding output of specialized and automated equipment. This led to a 15-percent decline in machine-tool production by 1984 and an increase in the NC machine-tool share from 3 to 7 percent over this period. In contrast, computer-operated NC machine tools constitute more than 60 percent of Western machine-tool production. [redacted] 25X1

The Soviets embarked in the mid-1970s on a program to develop and produce industrial robots. Production figures are impressive, with annual production reaching 14,000 in 1984, and plans are to have 120,000 robots in use in the machine-building industries by 1990. Most Soviet industrial robots, however, are akin to simple manipulators as opposed to Western programmable robots, which are capable of multiple, precise, and even machine-vision-guided operations. [redacted] 25X1

In 1980 the USSR launched the third stage of a drive toward manufacturing automation. They are pressing for large-scale production of computer numerical control machine tools and robots and the production of flexible manufacturing modules and cells, which combine one or several NC machine tools with pallets and robots for material handling, assembly, and checkout. The first Soviet flexible manufacturing systems (FMSs) were installed in 1983, roughly a decade behind their first use in the United States. Currently, at least 35 full-fledged FMSs are now used in US metalworking operations, [redacted] 25X1 25X1 25X1 The Soviets claimed publicly in 1984 that they had 60 FMSs in operation, but this number included less capable, flexible production (FP) modules, cells, and semiautomated lines that lack the computer support essential to Western FMSs. The plan calls for installation of 1,800 FP systems and 30,000 FP modules and cells during the 1986-90 period.[5] [redacted] 25X1

[redacted]

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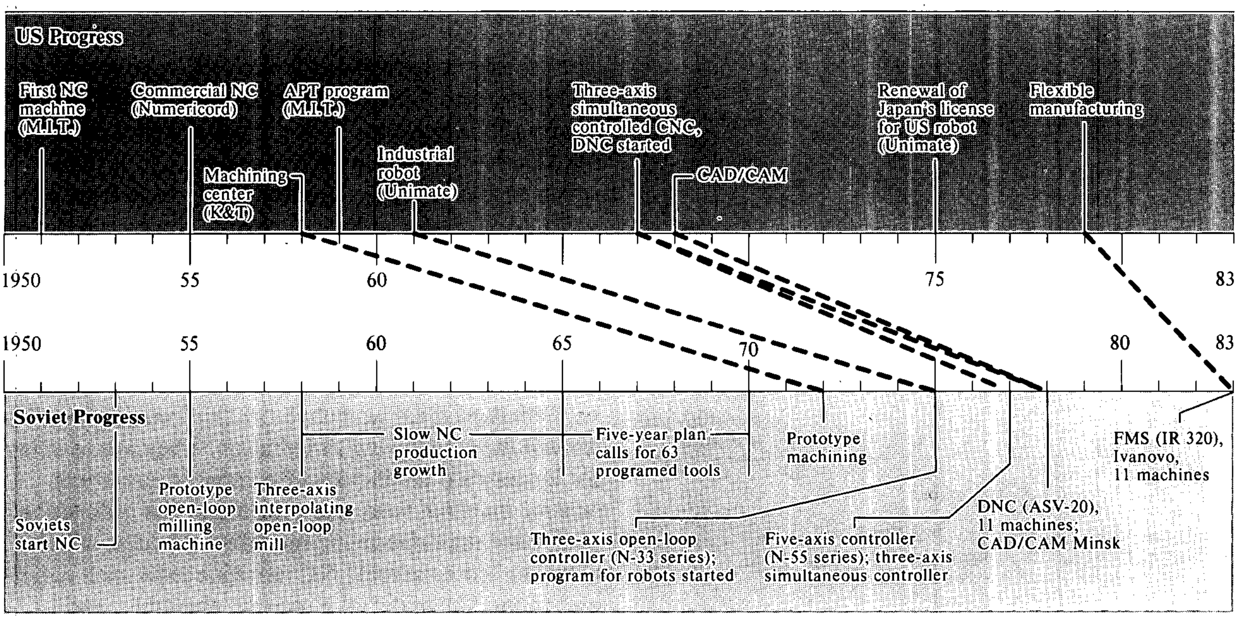
Figure 7
US Lead Over Soviets in Numerical Control (NC) Systems[a]



[a] Dashed lines indicate extent of Soviet lag in developing counterpart to NC technology in the West—a lag that is gradually declining. Manufacturer or developer shown in parentheses.

APT—automatically programed tool
CAD/CAM—computer-aided design/manufacturing
CNC—computer numerical control
DNC—direct numerical control

[redacted] 313141 9-87 25X1

Managing Technological Progress in the United States and the USSR

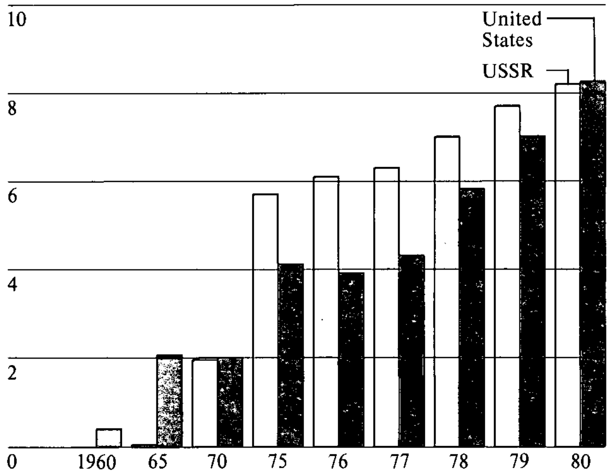
Moscow has historically chosen to centrally orchestrate development and application of technologies, using an approach that has been essentially supply-oriented and hierarchical. The Soviets have sought to achieve efficiency gains through economies of scale in massive, self-contained plants. Because enterprise manager rewards depend mainly on meeting quantitative output targets on schedule, managers prefer to reduce their risks through long production runs and infrequent or minimal product changes (see inset). Shortfalls in meeting ambitious plan targets frequently cause a cascade of additional shortages throughout industry, thus encouraging enterprise managers to minimize dependence on the remainder of the economy. Western scholars have documented the deadening impact of these conditions on the development and diffusion of new technologies.[6] [redacted] 25X1

These systemic factors have particularly frustrated Soviet development of advanced technologies. These technologies—and especially information technologies—have not been well served by the imposition of campaign-style, top-down management approaches.[7]

[6] See, for example, Joseph Berliner, *The Innovation Decision in Soviet Industry* (Cambridge: 1976). [redacted] 25X1

[redacted] 25X1

Figure 8
United States and USSR: Production of Numerically Controlled Machine Tools
Thousands of units



Sources: *Narodnoye khozyaystvo SSSR;* US Department of Commerce Current Industrial Reports: Metalworking Machinery

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Efforts to compensate for shortfalls by buying or stealing Western technologies have been frustrated by Western export controls and the difficulty of reverse engineering.

Although these general Soviet systemic shortcomings are well understood, little research has been done to document why managers—particularly in the enterprise—have been unable or unwilling to foster greater technological progress. To analyze the systemic differences that underpin technological development, we compared the priorities and behavior of managers in operating US corporations with those of Soviet enterprise directors. We followed two tracks:

- We reviewed Soviet experience in managing high-technology industry. 25X1

The Important Considerations in US Experience
Analysis of Western literature and business experience suggests that the many influences on enterprise development and application of product and manufacturing technology can be grouped into eight primary factors:

- The management process—the organizational structure, planning philosophies and practices, performance reporting and control systems, and the decisionmaking process used within the enterprise.
- Market information (or its equivalent)—availability and quality of information regarding customer preferences and needs for the enterprise's products or services.
- Financial resources—the timeliness and extent of the enterprise's access to capital.
- Technical services—the quality, mix, and level of sophistication of available plant services, such as maintenance, engineering, material control, and support staffs for programing, information handling, and productivity improvement. 25X1
- Technical knowledge—scientific expertise, efforts to develop products and processes that utilize what is known, and R&D programs to solve problems that restrain technological advances. 25X1
- Plant, equipment, and machinery—the quality, mix, and sophistication of process equipment for fabrication, process control, assembly, and testing of products.
- Material inputs—the availability of the suitable-quality material inputs needed to make the company's product.
- Personnel resources—the number and mix of employees and the training and incentive programs that make them productive. 25X1

The Traditional Soviet Managerial Environment

Organization. *The enterprise—the basic unit of Soviet industry, roughly equivalent to a medium-sized US corporation—reports through a two- or three-layered vertical structure to a ministry, such as the Ministry of Medium Machine Building or the Ministry of Electronics Industry. The sources of much new technology—scientific research institutes and design bureaus—may or may not report to the same ministry as the subject enterprise. In any event, the enterprise usually has little or no leverage on R&D organizations.*

Management Structure. *The enterprise is given production orders by its ministry, which is given its orders via the annual plan developed by the state. The physical quantities to be produced are usually based on some increment to the actual quantities produced the previous year, and performance is primarily judged on and rewarded for timely meeting of monthly quotas. The enterprise is expected to make a "profit" in an accounting sense, but wages, staffing levels, prices of capital and materials, and the price the enterprise must charge for its products are usually set by the state. From the profits come bonuses paid to workers for meeting or exceeding quotas, funds for employee housing and benefits, and some of the funds to be used for investment. Additional investment funds are received from the state via the annual plan.*

Production and Support. *The annual plan specifies the inputs and sources of capital and materials an enterprise is to receive to execute the plan. In practice, inputs are usually of poor quality, frequently late, and may not be exactly what the enterprise needs. The only avenue for assistance in making suppliers responsive to the needs of the enterprise is through the bureaucratic chain or by unauthorized, back-channel approaches, usually involving the exchange of personal favors. Once the final product is out the door, the enterprise has performed its duty to the state and feels no responsibility for product performance; thus the service sector of the Soviet economy is very poorly developed.*

Market. *The enterprise has to be responsive only to the plan (but not too responsive, lest next year's quota be impossible to meet). Through creative accounting, surreptitious price increases, stockpiling, outright falsifications, and other well-established practices, enterprises usually just exceed their quotas. The goods to be produced are specified by the ministry, which must also approve any new products, and bear little relation to market demand. Marketability of products generally is of little concern, since buyers generally are forced to take what they can get. Even if unsold products accumulate, enterprises are not forced into bankruptcy.*

[redacted] 25X1

The relative importance of each of these factors depends on how managers view trade-offs among such factor characteristics as quality, quantity, cost, and timeliness of application.[redacted]

Weighing the Factors

[redacted] developing and applying innovative technologies.[redacted] relative importance of each factor, as well as how quality, quantity, cost, and timeliness weighed on each factor.[redacted] 25X1 25X1 25X1

[redacted] a consistent profile that tends to group the eight primary factors affecting enterprise development and assimilation of new technology by their principal characteristics: information, infrastructure, and inputs. The values assigned to 25X1 25X1 25X1 25X1 these elements [redacted] (see figure 9) suggest that a sustained development and application of new technologies must be underpinned by a foundation of supply and support that leaves managers free to concentrate on the most important element—information:

- *Information.* "Technical knowledge" and "market information" together constitute the most important of Western managers' concerns. Market information is considered more important for technology assimilation, while technical knowledge dominates for innovation, with this pairing clearly being more important than the others.

- *Infrastructure.* "Financial resources" and "personnel resources" alternate as the most important factors for diffusion and innovation, respectively. Together with "technical services" and the "management process", they form a stable, middle-level grouping.

- *Inputs.* "Plant, material, and equipment" and "material inputs" consistently ranked in the same low range. [redacted]

Information. The predominance of market information and technical knowledge as factors in innovation indicates that feedback and interaction among customers, research, and manufacturing is necessary to support continuing technological development. [redacted] knowledge of the state of the technological art must be married to awareness of demand or need for new products or processes that technology advances make possible. [redacted] a close relationship between supplier and customer that sheds light on the utility of one product relative to another, since better product utility means better competitive position. Consequently, US managers aggressively pursue the market information and technical knowledge that must feed their decisionmaking structure, viewing this activity as the largest and most important commitment of their time. [redacted]

We sought to identify the *source of corporate technical advance*—in-house development or acquisition from other companies. Although Western executives largely prefer to foster and control development of technologies within their own companies, [redacted] the pressures to respond rapidly to frequent market changes are forcing them to rely increasingly on external suppliers for assistance. This in turn bolsters the strength of the suppliers, who are also available to provide their goods and services to other competitors in the same market. The net result is increased competition, which drives further technology development. Market pressures of this kind contributed to the explosive growth of the personal computer (PC), for example. Apple's initiative forced IBM to break with its policy of total vertical control and to use outside suppliers for many of its PC components. This made the same components available to other potential competitors, who placed less expensive "clones" on the market, forcing standardization around architecture of major suppliers and adding to the pressure for more capable and highly differentiated products. [redacted]

[redacted] the importance of the market information–technical knowledge link by comparing the integrated circuit with the laser. Both were invented at approximately the same time, but the IC was the result of a very specific program to solve a technological problem that faced the electronics industry. On the other hand, the laser was the result of theoretical research without a particular application in mind. The result was rapid proliferation of the IC into a myriad of applications within five years, while finding a commercial or military application for the laser took much longer. [redacted]

Infrastructure. Financial and personnel resources clustered together with technical services and the management process as the second-most important group of factors, suggesting that these aspects of business demand considerable amounts of detailed management attention to make a company responsive to changing technological conditions. The infrastructure—the support structure in the economy—supplies the needed resources to apply information to inputs, thereby adding utility and value to a product. Western managers must compete for investors and employees, which develops a mobile resource base. [redacted] they spend an appreciable portion of their time ensuring the acquisition of these types of resources. For example, both the

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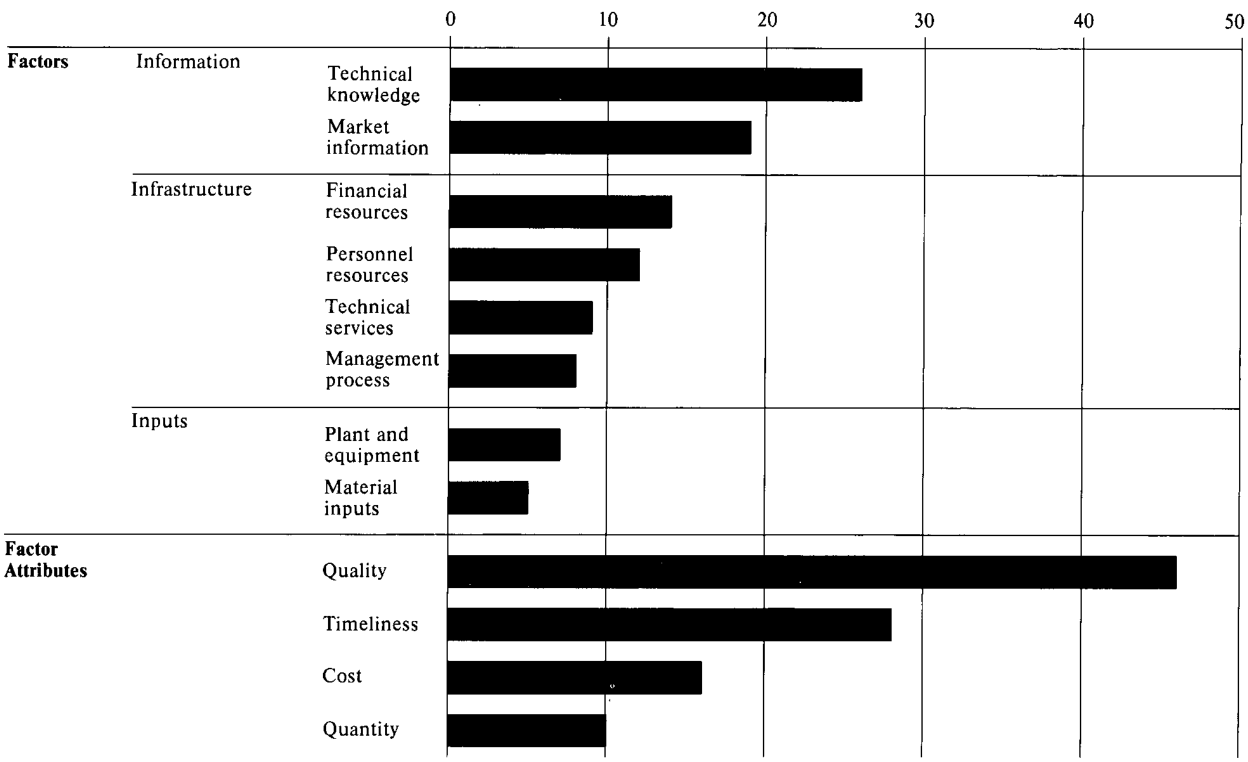
Figure 9
The Relative Importance of Different Factors to the US Business Executive

Percent[a]



[a] The values shown for each factor and attribute are relative to the other elements. For example, technical knowledge (26%), is considered to be about twice as important as personnel resources (14%) and five times more important than material inputs (5%).

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supercomputer and the microcomputer originated when innovators left a large company and started a new company of their own—but only after the inventors succeeded in obtaining venture capital financing. [redacted]

Inputs. The low perceived importance of plant, machinery, and equipment and material inputs reflects the dependability of supply afforded by a host of competitors, allowing managers to focus attention on factors more critical to technology development. [redacted] the availability of substitute suppliers offers Western managers a variety of options when selecting the most efficient mix of plant and material inputs. As a result, [redacted] their attention only occasionally turns to decisions about whether to develop such inputs internally or to acquire them from external sources. [redacted]

Factor Attributes. Quality is the overriding characteristic that all of the factors other than financial resources must share, implying that technology development is synonymous with quality improvement. Timeliness, cost, and quantity follow in descending order. [redacted] both quality and timeliness are the attributes that must be associated with responsiveness to customers, [redacted]

How Do the Soviets Measure Up?

The quality and availability of inputs, information, and infrastructure available to the Soviet manager, and his control over them, are profoundly different from the situation prevailing in the West, as are the performance measures that define success. Consequently, Soviet managers must take a very different approach to innovation. [redacted]

[redacted] 25X1

[redacted] the Soviet manager's hierarchy of concerns and attention is the reverse of the Western manager's in several areas (see figure 10). [redacted] (see figure 11) show starkly the importance of information to the Western manager and of inputs to the Soviet manager, while infrastructure appears to receive roughly equal emphasis in both economies. [redacted]

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Inputs. The Soviet manager, driven primarily by the demand to meet production targets, is forced to concentrate his effort on the factors that most directly affect current production. He must devote considerable attention to obtaining and protecting the requisite materials, plant, equipment, and spare parts—a challenge made more difficult by the chronic supply deficiencies in the Soviet economy. In contrast to his Western counterpart, the Soviet manager is not very concerned about whether the application of production technology or equipment warrants the investment required. Indeed, the relatively fixed and artificial character of Soviet prices effectively precludes the empirical cost-benefit analysis that plays heavily in the West. [redacted]

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The emphasis on quantity and timeliness frustrates innovation programs, which operate on quality and usually take a long time to reach fruition. Quality in the Soviet Union means state-defined acceptance criteria, which are frequently artificial and sometimes arbitrary and do not necessarily reflect product utility. This absolute and relatively static concept, reflected by the low ranking of market information [redacted] creates difficulty in defining consumer needs and, consequently, in sustaining continuous technology development. [redacted]

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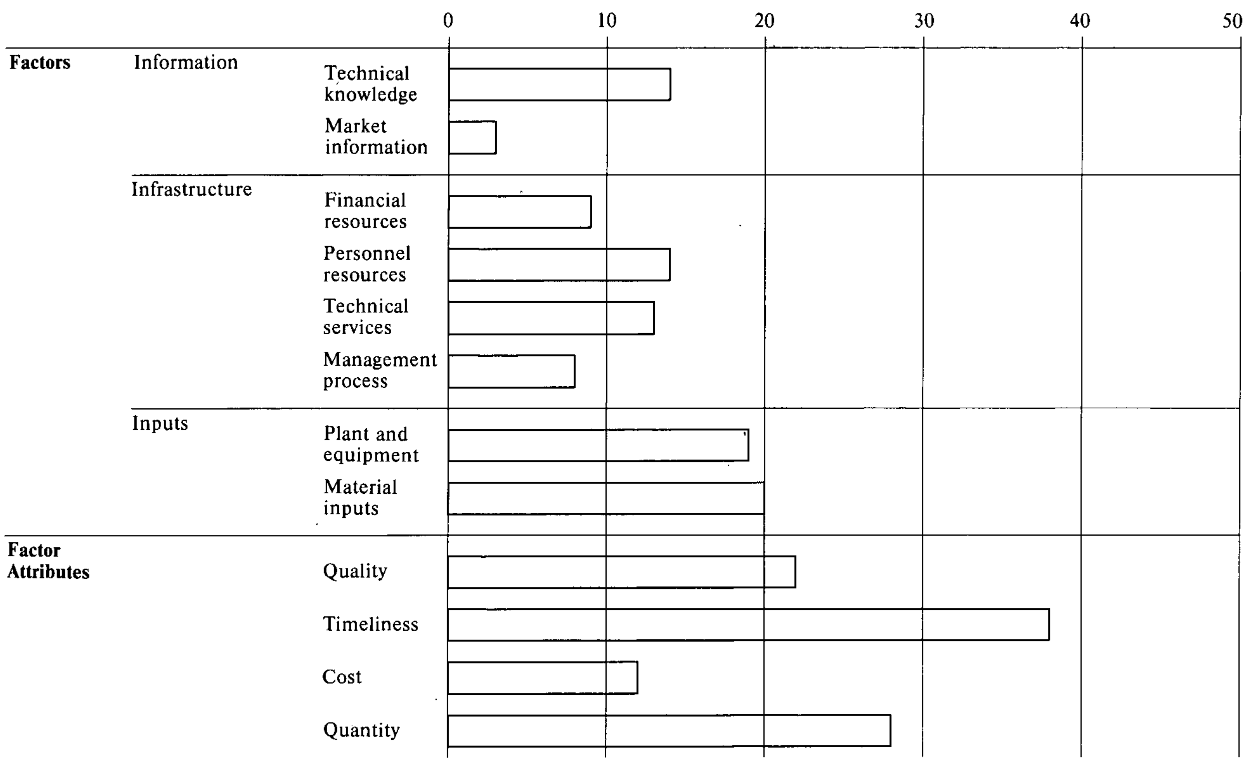
Figure 10
The Relative Importance of Different Factors to the Soviet Enterprise Manager

Percent [a]



Note: In contrast to his US counterpart's thirst for information, the Soviet manager's highest priority is obtaining the equipment and material needed to meet quantitative production targets on schedule.

[a] The values shown for each factor and attribute are relative to the other elements.

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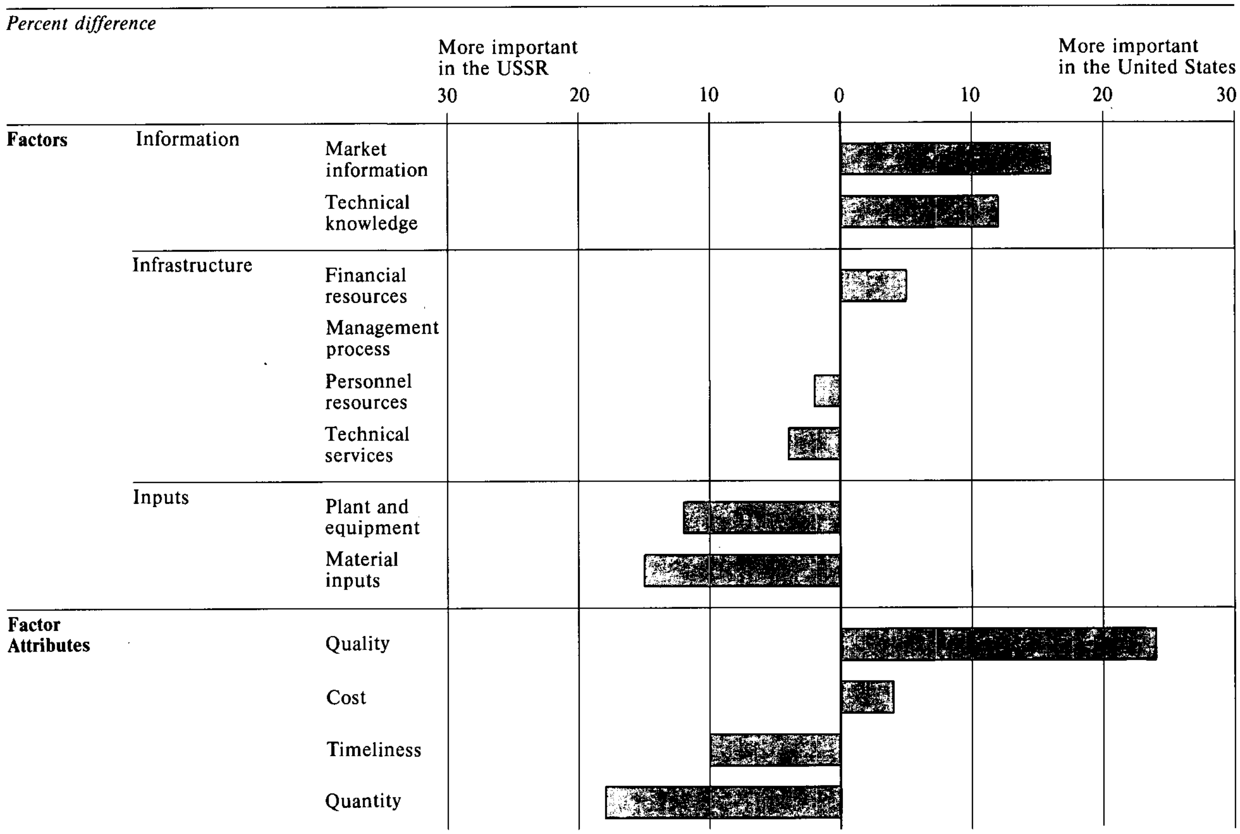
Figure 11
Differences in the US and Soviet Managers' Perspectives of the Relative Importance of Key Factors in Technological Innovation



Note: 25X1 25X1

The factors shown are clustered into three categories that we characterize as information, infrastructure, and inputs. In the United States, where advanced technologies are widely used and well assimilated, managers consider factors that convey information concerning product utility decisive in technological advance but take a supportive infrastructure and dependable supplies of material and equipment for granted. In the USSR, where many advanced technologies are scarce at any price, managers must focus on ensuring adequate supplies of material and equipment, leaving little time to focus on information related to product utility. In terms of factor attributes, quality and cost matter most in the United States while quantity and timeliness matter most in the USSR.

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The Soviet reliance on bureaucracies and centralized planning of resource allocation generally creates an inhospitable environment for innovation and diffusion of new technologies:

- The Soviet personal computer program illustrates the Byzantine complexity of Soviet industry. Soviet literature indicates that development and production of PCs are split among four ministries, three of them primarily defense-industrial (the ministries of the electronics, radio, and communications equipment industries) and one primarily civilian (the Ministry of Instrument Making, Automation Equipment, and Control Systems). Components of PCs are produced in 30 ministries. The lead organization coordinating PC development is itself split among 17 organizations in Moscow. Because of the large number of participants in the program there are many complaints about the lack of hardware and software standardization.

- The Soviet system provides little flexibility to managers and stifles producer-consumer interaction. For example, [redacted] enterprises have experienced severe problems introducing automated production control systems, which require that vendors tailor a network of computers, sensors, and communications links to the enterprise plant and equipment. Vendors typically show little interest in being responsive, requiring customers to resort to bureaucratic arbitration to force compliance with contractual obligations.

- A rigid decisionmaking process has evolved that effectively discourages initiative from below—the source of most innovative ideas. For example, one Soviet industrial concern recently took the initiative in drawing up its plans to incorporate an automated process control system. But, because its proposal was not part of an authorized plan, it had difficulty finding financial backing—a local construction bank refused the organization its support—and had to abandon the project in its planning stage.

- The case of the Ivanovo Machine Tool plant illustrates the costs of successful innovation based on local initiative. In the early 1970s, the plant manager established a long-range plan to manufacture NC machine tools and machining centers but chose to avoid the arduous tasks of obtaining complete approval by its parent ministry and ensuring compliance with all budgetary regulations. Thus, although the plant accomplished most of its plan and is widely regarded as the most advanced Soviet machine tool plant, it lost 2 million rubles in incentive funds in the last half of the 1970s, and members of its engineering and technical staff lost 1,800 rubles each in bonus money. The enormous costs of electronic components and service, which are not built into the usual budget for machine tool plants, forced the plant to underfund housing, vacations, and other employee benefits and led to an exodus of 50 percent of its staff. Nevertheless, since the late 1970s, Ivanovo has been consistently praised as a model innovator at the policy level.

- The machinery that is produced is often misdirected or misapplied. For example, one Soviet industrial concern received from its ministry a higher allocation of robots than it could cope with. It had asked for a third as many robots, consistent with its needs, engineering resources, and acquisition in previous years. However, pressure to accelerate modernization had led to a higher allocation being imposed by the ministry. [redacted]

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Infrastructure. The Soviet command economy is able to marshal financial and personnel resources and to focus them on a particular project when necessary. But, in a broad-based modernization campaign, even targeted industries and technologies become snarled in red tape. A manager must worry about the uneven quality and availability of services and the ponderous centralized system for allocating them. Western managers can independently arrange financing in a few weeks or months; the Soviet manager must appeal to central planners and sometimes wait years for funds to be allocated. Skilled personnel needed for installation and operation of advanced manufacturing technologies—software engineers, programers, and electronics and telecommunications repair technicians—are in extremely short supply, and Soviet managers find it difficult to secure employee training. Some more sophisticated forms of support—such as the

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systems engineering savvy needed for design and operation of automated factories—are almost unavailable. [redacted]

In a command economy, suppliers feel little sense of responsibility to customers. For example, the Noril'sk Mining and Metallurgy Combine won approval to install a flexible manufacturing system. Backed by a state resolution, Noril'sk requested the supplying ministry to furnish design and installation services, but the ministry stated that the supplying factories alone were responsible for individual orders. When challenged, the ministry decided that it would eventually provide the services. [redacted]

Suppliers also are protected—and customers discouraged—by a formidable bureaucratic maze. The pyrometallurgical facility at the Noril'sk Mining and Metallurgy Combine won State Planning Committee approval to install an automated management accounting system. The combine then had to seek approval from its own ministry and the ministry's Nickel Industry Association. Following this, the requirements were submitted to the supplier, which at first refused to accept the job. Only after the combine secured a joint agreement between its ministry and the supplier's ministry would the supplier comply, over a year after the initial justification was submitted. [redacted]

Information. The largest difference between the market system and the Soviet system is that the Soviets have poor access to product information and feedback from users, and this is perhaps the most severe barrier to effective automation that a Soviet manager faces. This is exacerbated by the physical separation of research, design, and production organizations that has long been a hallmark of Soviet industry. In the West, sellers innundate managers with technical information in the form of advertisements, catalogs, technical sales representatives, and numerous technical expositions. In the USSR, managers must depend on professional house journals controlled by their parent ministries and intended to further ministerial objectives. To gain access to Western technical literature, Soviet managers frequently have to go to centralized repositories, and even then the advertisements that Western managers regard as highly informative have been removed by censors. [redacted]

The Soviet enterprise manager, moreover, depends much more heavily on acquisition of technology from external sources than does his Western counterpart. 25X1
[redacted] this stems from the fact that 25X1
enterprises generally do not have the freedom to obtain financing, materials and equipment, or permission to undertake risky new projects. [redacted] in the "catch-up" mode in which the 25X1
managers frequently find themselves, acquisition of the technologies is the most efficient way to proceed. This does not mean that technologies diffuse rapidly. To the contrary, the sluggishness of the planning and supply systems creates a paradox: because they usually cannot obtain the necessary ingredients for new 25X1
technologies, Soviet managers often are forced to be inventive in their problem solving—yet the system finds it hard to harness this creativity. [redacted]

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Obstacles to information flow are a particular handicap to potential users of new technology:

- In the Soviet Union, the burden of determining the benefits of using a product rests with the enterprise, which, [redacted] must resort to a 25X1
rigidly centralized set of manuals on available products issued by the State Committee of Standards. The manuals specify technical characteristics and parameters for industrial items but contain no information on the suppliers. It usually takes three to 25X1
four years to register a new product, although some technological innovations may appear within one to two years. The 25,000 manuals are updated regularly, and their number grows by more than a 1,000 a year.

- In the USSR, customer demand for products and production equipment is supposed to be expressed and fulfilled through the planning process, but the complexity of the massive economy drives planners to compromises and standardization for the sake of planning efficiency rather than production efficiency. According to *Pravda*, the Soviet Ministry of Machine Tool and Tool Building Industry (Minstankoprom) is "proceeding at full speed" to produce flexible manufacturing modules, but they reportedly are not well suited for incorporation into complex

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manufacturing systems because of difficulty in linking the machining modules to the automated conveyor and storage systems (produced by the Ministry of Heavy and Transport Machine Building). To circumvent the need to integrate the two systems, Minstankoprom is trying to create a unit that can be operated autonomously—that is, using manual loading.

- Soviet researchers, designers, and manufacturers are encouraged to communicate and cooperate with each other to foster useful innovations, but in practice they make little effort to determine the needs of the customer. The deputy director of the USSR State Committee for Inventions and Discoveries said in a published interview that, of the 180,000 applications received annually for certificates of invention, about 80,000 receive certificates, and only about 24,000 of these find applications in the economy. Of those adopted by industry, 90 percent are employed in only one or two enterprises. Only 20 percent yield savings of 100,000 rubles or more, and three-quarters of the rest yield savings of fewer than 1,000 rubles.

Will Gorbachev's Initiatives Help?

The Soviet Union trails the West in most advanced industrial technologies partly because the centrally planned economy diverts attention from product utility by focusing on production in a seller's market. The success criteria used to reward performance ignores the opinions and needs of the customer—the only qualified judge of product utility—giving producers neither the incentive nor the information needed to change and improve their products. In contrast, the market system weds information about state-of-the-art technology to customer perceptions of product utility—indeed, it makes that information extremely valuable. In a supply-rich environment where firms have alternative sources of differentiated products, producers are constantly motivated to differentiate their products to provide more utility to their customers.

To bring Soviet technology up to world standards, Gorbachev must create an environment that can sustain continuous technology development on a broad front. Past Soviet successes have been achieved in areas where heavy investment could be applied to technologies that are independent of other immature technologies, are relatively simple to reverse engineer, and are easily controlled by vertical, restricted, and autocratic organization structures. In cases where multiple immature technologies have needed to advance in concert—such as the automotive or chemical industries—there have been few notable Soviet accomplishments. The growth of the microelectronics-based advanced technologies that Gorbachev has targeted represents a major challenge to Soviet industry, because they present a core of several immature technologies whose potential for application spreads across a wide range of new and existing technologies. In addition, these technologies are difficult to reverse engineer because their keys to growth are embodied in their own production processes.

To attain Gorbachev's goals, the efficiency and effectiveness of the Soviet planned economy will have to improve dramatically. The strategy implemented to date—the traditional approach—contains heavy doses of administrative fiat and lavish application of resources. Gorbachev's program relies on huge production gains in the machine-building complex, the source of these technologies (see inset). He has announced a large infusion of resources to support his demands; 1986-90 investment in the civilian machine-building complex is to be 80 percent greater than investment in the 1981-85 period. And on 1 January 1987 he shocked the machine builders by introducing a quality control system with real teeth, leading to wholesale rejection of substandard factory production.

This strategy is likely to result in some improvement in product quality and performance. In 1986 civilian machine-building production grew by 4.4 percent—the best showing in a decade. Although still criticized for shortfalls, machine-building ministries seem to be weathering the storm, and even meeting some of the administered quality control challenges.

Nevertheless, official statements and actions reveal a growing appreciation of the implications of our interviews—that sustaining rapid technology development to keep pace with the West depends critically on

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Forcing the Pace of Technical Renewal

Gorbachev plans to force the pace of technical renewal by:

- *Doubling retirement rates of capital stock to accelerate the replacement of obsolete capital by more efficient, state-of-the-art machinery and equipment.*

- *Modernizing the nation's capital stock so that by 1990 a third of it, including up to half of the machinery portion, is new.*

- *Increasing output of the machine-building complex in the 12th Five-Year Plan by 43 percent over that of the 11th Five-Year Plan.*

- *Stressing high-technology industry. For example:*

  — *Increasing production of computer equipment by 18 percent annually through 1990.*

  — *Producing in the 1986-90 period 120 percent more robots, 90 percent more numerically controlled machine tools, and 220 percent more machine centers than were produced in the 1981-85 period.*

- *Doubling the proportion of industrial products in the top-quality category during the 12th Five-Year Plan.*

- *Tripling the share of Soviet products that meet "world standards" in terms of quality, reliability, and competitiveness during the 1986-90 period.*

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stimulating local initiative and responsibility, developing a strong linkage between customers and suppliers, and enabling managers to rapidly shift resources to the most productive applications. To date, the Soviets have adopted several initiatives to realize these objectives.

On 30 June 1987 the Supreme Soviet approved guidelines for a set of measures aimed at reforming how the Soviet economy is managed. These changes at least suggest movement toward greater enterprise control over day-to-day decisions with less interference from the ministries. As details on how these are to be implemented take shape, their likely impact will become clearer. In sum:

- Although the Soviet economy is to continue to be centrally planned and managed the level of detail will be reduced. Prime Minister Ryzhkov has stated that the annual economic plan will no longer require approval after 1991.

- A new law governing state enterprises slated to be placed in effect after 1 January 1988 provides for greater enterprise independence in planning and contracting with other firms, but also ties wages to performance and requires more self-financing of investment and operating outlays.

- In addition to the six new "superministries" created during 1985 and 1986 to oversee key categories of economic activity, the ministerial structure in industry is to be streamlined by the elimination of some intermediate echelons.

- Beginning with industries producing consumer goods, wholesale trade—whereby firms would be more able to contract with suppliers and customers of their choice—is slated to replace the centrally managed supply system over the next four to five years except for national-priority items.

- Price and wage reforms of unprecedented scope are to be introduced during 1987-90 in an effort to better reflect the higher utility of scarce labor skills and products.

- To improve the finance system, the number of banks providing investment financing is to be doubled to six, and principles of self-finance and economic accountability encouraged through a system of incentives.

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- Although the 1986 initiative permitting free enterprise activities—by pensioners, handicapped, housewives, and moonlighting state employees—was endorsed, the size of such efforts continues to be limited.

- Although the right to engage in direct trade or joint ventures with foreign firms—granted to selected ministries and enterprises on 1 January 1987—was endorsed, it was not expanded.

These initiatives are aimed at giving more independence and incentives to enterprise managers, but none has proceeded far enough to permit a firm judgment on how effective they will be. Even some Soviets expect delays in actually changing the attitude of workers and managers, and others have voiced concerns that the reforms have not proceeded far enough. In any case, the environment for innovation is unlikely to change substantially over the next several years:

- The fluid industrial environment characteristic of a Silicon Valley has no counterpart in the Soviet Union. In March 1987, for example, *Izvestiya* extolled a daring new initiative—the independent technical consultant—but bankruptcies are virtually nonexistent, and decisions are still made in bureaucratic compartments.

- The Soviet solution for energizing the sluggish R&D establishment maintains the thrust of "pushing" technology onto the industry, rather than giving industry much incentive for "pulling" technology from science. The Soviets have come up with yet another organizational solution—the Interbranch Scientific-Technical Complex—to bridge the gap between science and production, but have given the leadership of most of them to Academy of Sciences organizations.

- Industrialists may be under pressure to meet quality standards, but the standards are set by committee, not the test of the marketplace. Soviet enterprises remain insulated from real domestic and foreign competition. The Soviet economy remains a seller's market.

Negotiations between a Western firm and a Soviet industrial ministry for one of the joint ventures that the USSR has been seeking illustrate the different approaches of Soviet and Western managers. Soviet officials have no precedent nor any body of regulations to tell them how to handle questions raised by their capitalist counterparts. The officials are neither well organized to deal with the questions nor well informed on basic commercial factors that affect the viability of a business enterprise.

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Under these conditions, the Soviets have yet to change the economic environment to the point that innovation affords more benefits than costs to the local manager.

Implications

The Soviets are likely to duplicate Western successes in large-volume production of standarized equipment but will probably fall short in developing the type of efficient, flexible manufacturing capability that takes full advantage of the benefits of advanced technologies. Consequently, rates of return on costly high-technology investments may be substantially lower than originally expected. The centralized Soviet approach to technology development will serve better in areas where standardization provides some advantages—such as telecommunications and computer equipment—than in machine tools and microelectronics, where the compromises of standardization may directly affect performance. Further, Gorbachev's initiatives do little to affect the ability of the economy to respond to the industrial needs that will change as technology evolves, nor is it likely that the system will become efficient at eliminating unproductive efforts that could otherwise be focused on more productive innovations.

Technological Progress

On balance, the strategy the Soviets are pursuing is likely to complicate their efforts to narrow the technology gap with the West. The Soviets have opted to plan and centrally manage progress in critical target technologies rather than create more supportive conditions for technological progress to build momentum. They are striving to allocate resources to follow paths of development in selected technology areas blazed in the West as much as a decade before. Meanwhile, the pace of technological progress outside the USSR is picking up and its unpredictability is increasing, as more competitors enter into the global high-technology race.

The risks in the follower strategy the Soviets are pursuing are twofold. First, the rate of progress among these interdependent technologies may be very uneven, and such uneven progress could result in serious misallocation of critically scarce resources.

Second, the Soviets are committed to a long-term and relatively fixed path of technology developments with a point of departure as much as a decade behind current Western practice. Therefore, the USSR will be less able to pursue alternative solutions or opportunities that appear unexpectedly in the West. 25X1

Military Modernization

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The Soviets will be hard pressed to address the escalating technology demands of economic and military modernization—particularly if a full-fledged US SDI overturns the basis of military and technological competition. In the 1970s the more leisurely pace of US military modernization dictated by the resource dislocations resulting from Vietnam and its aftermath enabled the Soviets to gain ground. Through a massive and sustained effort to develop guidance, propulsion, radar, and nuclear technologies and by translating them relatively quickly into hardware, the Soviets were able to reduce or eliminate lags in performance of their strategic and conventional weapons. Although some of the technology initiatives—microelectronics, for example—also helped the civil economy, much of the effort was specialized. To the extent that the Soviets choose to emulate such Western initiatives as precision-guided conventional weapons or SDI, they will need to accelerate development and military application of microelectronics, computers, software, 25X1 electro-optics, radars, guidance, and composite materials technologies. Several of these technologies are at the heart of Gorbachev's industrial modernization program. 25X1

The Economic System and Society

Clearly, the centrally directed agenda for technological progress the Soviets are now pursuing limits their ability to adjust to radical shifts in the thrust of technology development. Prospects for more flexible and efficient development and use of advanced technologies would improve with structural reforms targeted at the free flow of information, labor, and investment resources and more decentralized management. Such changes would challenge the leadership's 25X1 preference for central political, social, and economic control, but sticking to the current blueprint for technological progress may cause the Soviets to lose ground to the industrialized West and perhaps even to newly industrialized nations. 25X1

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