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In this issue:
Soviet Industrial Modernization

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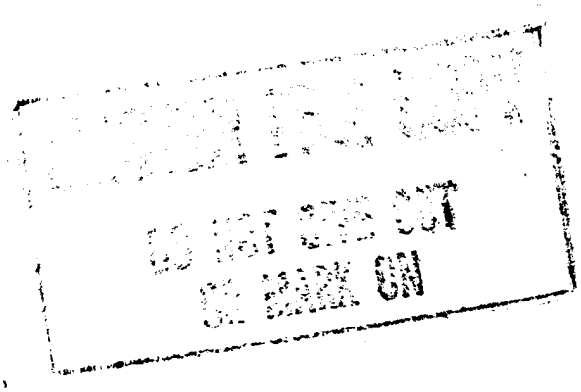
September-October 1985



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The "Samotlor disease"—a vicious circle of flagging output from giant oilfields and ever-increasing use of manpower and equipment in an attempt to sustain total oil output—is spreading throughout the West Siberian oil region. Unless large oil finds are made, the costs of oil exploitation in the USSR will rise exponentially.

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Soviet Industrial Modernization

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Perspective

Since General Secretary Mikhail Gorbachev came to power last March, the watchword of his economic policy has been "modernization," described in Soviet economic jargon as the transition from "extensive" to "intensive" development based on an acceleration in technological progress and a more effective organization of work. This issue of the *USSR Review* focuses on modernization in industry, which Gorbachev believes to be crucial to his objective of matching the productivity of the industrial powers—the United States, Japan, and Western Europe. It reviews the program, points out some of the uncertainties regarding its implementation, and considers the risks that Gorbachev may be taking in stressing modernization so heavily.

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In the eyes of the leadership, the elimination of the large differences between Soviet and Western levels of per capita production has always been a primary policy objective. Under Stalin and Khrushchev, the USSR made substantial progress in this direction. Since 1965, however, the gap has narrowed hardly at all under Brezhnev, Andropov, and Chernenko. In one sense, Soviet leaders believe that the difference between what the Western world has done technologically and what the Soviet Union is doing represents an opportunity as far as economic growth and popular welfare are concerned.

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Perhaps an equally powerful stimulus to industrial modernization is the thought expressed by a prominent party spokesman on economic matters: "In today's divided world, the strong of the capitalistic world do not take the weak into account. And to ensure that they do not cease to take us into account, it is necessary to prevent any military-strategic lag. The way to do this is also the acceleration of the country's socioeconomic development."

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Efforts in the past to lift the Soviet Union on to a faster growth path through policies promoting modernization have foundered mainly because the prevailing incentive structure got in the way. Whereas, in a market economy, firms discard old assets to obtain operating economies or to stay competitive in their product lines, meeting current production targets has dominated the decisions of Soviet managers. The pace of innovation has also been slowed by military preemption of scarce R&D resources, skilled manpower, and high-technology products such as electronics and computers. In addition, the characteristic barriers in the USSR between science and applied research and between applied research and production have delayed the development and assimilation of new technology.

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Gorbachev's program is familiar in its general outline. He proposes to replace outmoded plant and equipment, shift investment toward high-technology industries, and reform management and organization so as to encourage innovation and reduce barriers between science and industry. Gorbachev, however, has proclaimed his goals more vigorously than his predecessors, and the pace of renewal that they imply is breathtaking:

- Rates of retirement of building and equipment are to be doubled.
- By 1990 a third of the country's fixed capital and one-half of the machinery portion is to be new.
- Capital investment in the civilian machinery sector is to rise by 18 percent per year.

Meanwhile, computer-based planning and design and automated production are counted on to support a resurgence in both machine building and basic industries, such as steel and chemicals.

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Realizing that his initiatives will not capture new qualitative levels of production quickly—in a "cavalry charge" as a spokesman put it—he must nevertheless find the resources now to shift the renewal of the country's capital stock into high gear. The impact of accumulated investment in modern equipment will be felt gradually. The fruits of systemic change, if they materialize, are also some years away. To this end, Gorbachev has been telling his planners to submit more ambitious goals for the 1986-90 Five-Year Plan. The objective appears to be an acceleration in the rate of Soviet economic growth by one-third or more.

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The basis for this spurt in production is to be a mobilization of reserves—unleashing the "human factor." Soviet officials attribute a large share of the upturn in the economy in 1983-85 to the measures introduced by Andropov to tighten labor discipline and shake up the economic bureaucracy. Gorbachev is reviving this campaign after a lull during Chernenko's brief tenure. As one of Gorbachev's leading advisers says:

> *It is possible to receive relatively quick returns here, with minimal expenditure. But these reserves and possibilities, lying closer to the*

surface, are limited . . . the wide-scale introduction of the newest achievements of science and technology in production [will require] time and considerable expenditure, but then the results, too, are significant and lasting. [redacted] 25X1

We know, then, one element of the Gorbachev strategy—a reliance on uncovering "hidden reserves" in the short run. As more information on the five-year plan—especially the structure of planned investment—becomes available, we may learn whether he intends to back up his modernization program with sufficient investment. If the 1986-90 plan gives generous increases in investment to all civil claimants—the Energy Program, the Food Program, the Consumer Goods Program, as well as to the machine-building sector—without a substantial reduction in military spending, the plan would be infeasible. Some reordering of priorities within the civilian economy is necessary, or some restraint on the military's priority is essential if industrial modernization is to do more than limp along. Defense preempts about one-third of the production of the machine-building sector and accounts for a much larger share of the output of computers and electronics. [redacted] 25X1

In sum, Gorbachev could be taking some considerable risks in implementing his modernization program:

- If he tries to carry out the program without altering priorities on investment, the impetus to growth based on human factors is likely to trail off after a few years, leaving the shortages and disproportions characteristic of an unbalanced plan. General disillusion might then set in, with the population seeing Gorbachev as no more effective than Brezhnev or Chernenko.

- A determined campaign to introduce new machinery models and throw out outdated capital stock is likely to cause interruptions in production not envisaged in the plan.

- If he shortchanges sectors such as energy, for example, the resulting decline in oil exports could force the USSR to reduce imports of state-of-the-art technology for the modernization program.

- If he tries to curb military demands for machine-building output and R&D resources, the military could become restless while waiting for the deferred improvements in the technological base of military industry. [redacted] 25X1

Gorbachev could relieve some of these pressures by drawing more on foreign sources of machinery—in Eastern Europe and in the West—and by pursuing arms control agreements that hold down Soviet military procurement while avoiding the costs of competing with the United States in the strategic defense arena. How much additional machinery the USSR can extract from Eastern Europe is probably still being debated in CEMA circles, while large increases in purchases of Western equipment will depend on the USSR's obtaining the necessary credits. Equally important, Soviet planners could not have known in preparing the five-year plan how their arms control proposals would be received. 25X1

If Brezhnev could not push his modernization program through, why should Gorbachev do better? In some ways, Gorbachev's position is less favorable:

- Rates of growth of GNP are lower than they were through much of the 1970s, and resource constraints are tighter.
- Gorbachev must contend with a brisk upswing in US investment in military hardware, whereas the Soviet advantage in this area was reaching a peak in the mid-1970s. 25X1

Gorbachev, on the other hand, brings some noteworthy strengths to the task of modernization:

- He is proceeding more rapidly than Brezhnev to consolidate his power. He has already changed the face of the Politburo, and, unlike Brezhnev, he has proved willing to sack ministers and managers who balk at carrying out his instructions.
- He has brought in Nikolay Ryzhkov as Chairman of the Council of Ministers to restructure the economic bureaucracy and Nikolay Talyzin to reorient a reluctant Gosplan.
- Although economic growth has picked up in the past few years, the USSR's recent experience with very low growth (1979-82) has perhaps convinced most party and government officials that Gorbachev is right when he says "there is no other way."
- The rapid transformation of military weaponry in the West and Soviet difficulties in matching this progress lend weight to the argument that the industrial base deserves priority attention. 25X1

The outlook for the modernization program is thus uncertain. Even though the more ambitious quantitative goals for capital stock renewal are unlikely to be achieved, Gorbachev can achieve quite a bit if he can rearrange priorities in favor of his program. The administrative approach—relentless bureaucratic attention—to raising the quality of investment is also likely to have a favorable impact if it is indeed pursued consistently, but a major change in the rate of innovation probably requires some of the reforms in

incentives and organization that are still under discussion. On the other hand, Gorbachev's short-run mobilization strategy has its risks. Unless he also makes hard decisions on resource allocation, he could generate the kind of unbalanced plans that caused so much trouble in the late 1970s and early 1980s. This would badly tarnish Gorbachev's reputation as a man who knows what is wrong with the Soviet economy and what to do about it.

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Leadership Perceptions

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Declining rates of Soviet economic growth since the late 1960s have forced the leadership to admit that the old growth strategy must be abandoned. For more than a decade, Soviet leaders have called for a switch from a policy of "extensive" growth—achieved by the use of larger factor inputs—to one of "intensive" growth—achieved by a boost in productivity. They identify the key to increased productivity as a rejuvenated stock of plant and equipment that embodies the latest technologies—in a word, modernization.

They freely acknowledge that this goal remains elusive; productivity growth has been meager. They admit that this reflects the advanced age of the capital stock—fixed assets have been retained in service twice as long as those in the major market economies. They also blame an uncoordinated and unfocused investment strategy and the weak link between the creation of a new technique or machine and its use in the production process. As a result, the technology gap with the West remains wide, making the import of Western machinery and technology continually attractive. The leadership frequently expresses its displeasure with this situation, not only because of the obvious impact on growth and hard currency requirements, but also because it believes such a lag to be inconsonant with its position as a superpower.

Rationale for the Old Strategy

The Stalinist growth model for industry stressed the rapid infusion of labor, fixed capital, and raw materials, and minimized the importance of productivity growth. This differed markedly from the development path followed by the major market economies. Even since 1960, the USSR has recorded the most rapid growth in employment among the major industrial economies and also the fastest growth of fixed capital stock, along with Japan. In sharp contrast, the rates of growth in both labor and capital productivity have been the lowest among the industrially developed countries.

In the past, this preference for extensive development was a rational strategy for the Soviet leadership because of the country's resource endowment and economic system. Until the 1960s, the Soviet economy could draw upon an unusually large pool of underemployed agricultural labor and was able to induce an ever-growing percentage of its female population to seek employment in urban areas. Large supplies of cheap raw materials and fuels were available. The high rate of growth of productive plant and equipment was achieved by high rates of increase in fixed capital investment, which in turn were made possible by holding down consumption. With its control over resource allocation, the regime could channel this investment largely into heavy industry and energy, with minimal shares directed to some consumer-oriented sectors such as light industry and housing. Investment policy was to prolong the life of productive assets, enabling the bulk of investment to be directed into new plant or expansion of existing plant capacity. The economy's strong system of central planning and direction was particularly adept at this type of resource mobilization.

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The Need for a New Strategy

By the 1970s the Soviet leadership realized that this extensive growth strategy could no longer be maintained. As Leonid Brezhnev said at the beginning of the decade, "We have entered a stage of development that no longer allows us to work in the old way but calls for new methods and new solutions." Sharply reduced birth rates, the exhaustion of the rural labor reservoir, and the approaching ceiling in female labor participation rates—already at 90 percent—brought much lower growth in employment. Sources of cheap raw materials and fuels were being depleted. Fixed capital stock growth rates fell sharply. Falling GNP growth squeezed allocations for all claimants, including investment. Even with large reductions in investment growth rates, the amount of investment required

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to yield a given increase in output (the incremental capital-output ratio) still rose substantially, alarming Soviet economists and planners.

Soviet measures of economic performance, although showing generally higher rates of progress than Western measures of Soviet economic growth, fully documented the trend downward, particularly in the vital area of productivity growth (see graph). The slowdown in growth is particularly painful to a Soviet leadership dedicated to closing the productivity gap with the developed West. After major gains in selected areas, little or no progress has been registered in recent five-year-plan periods:

- Official Soviet statistics show industrial labor productivity to have been 30 percent of the US level in 1950, 53 percent in 1970, but leveling off to roughly 55 percent currently. Labor productivity in agriculture has varied between 20 and 25 percent of the US level since 1966.

- A Soviet foreign trade official responsible for exports has criticized the quality of Soviet machinery and equipment, noting that less than 1 percent of machinery exports are sold to the "capitalist countries," a position comparable to that existing in the 1960s.

- Average leadtimes for the use of both domestic and imported technology continue to be much longer in the USSR than in the West. Data show that about 50 percent of US and West German inventions are implemented in about one year compared with three years for Soviet inventions. At the end of two years, the United States implements about 66 percent; West Germany, 64 percent; and the USSR, 23 percent.

- According to a Soviet planning official, the USSR's waste of metals in the production process is 75 percent greater per unit of metal input than in the United States.

Choosing a New Strategy

Brezhnev, in the early years of his regime, identified a mixture of goals and means to achieve these goals that he believed to be central to achieving intensive growth and boosting the pace of economic growth. He never shaped them into a coherent strategy but continued to pound at these themes throughout his years in power, always lamenting that "we have not achieved the needed breakthroughs." He emphasized the need to:

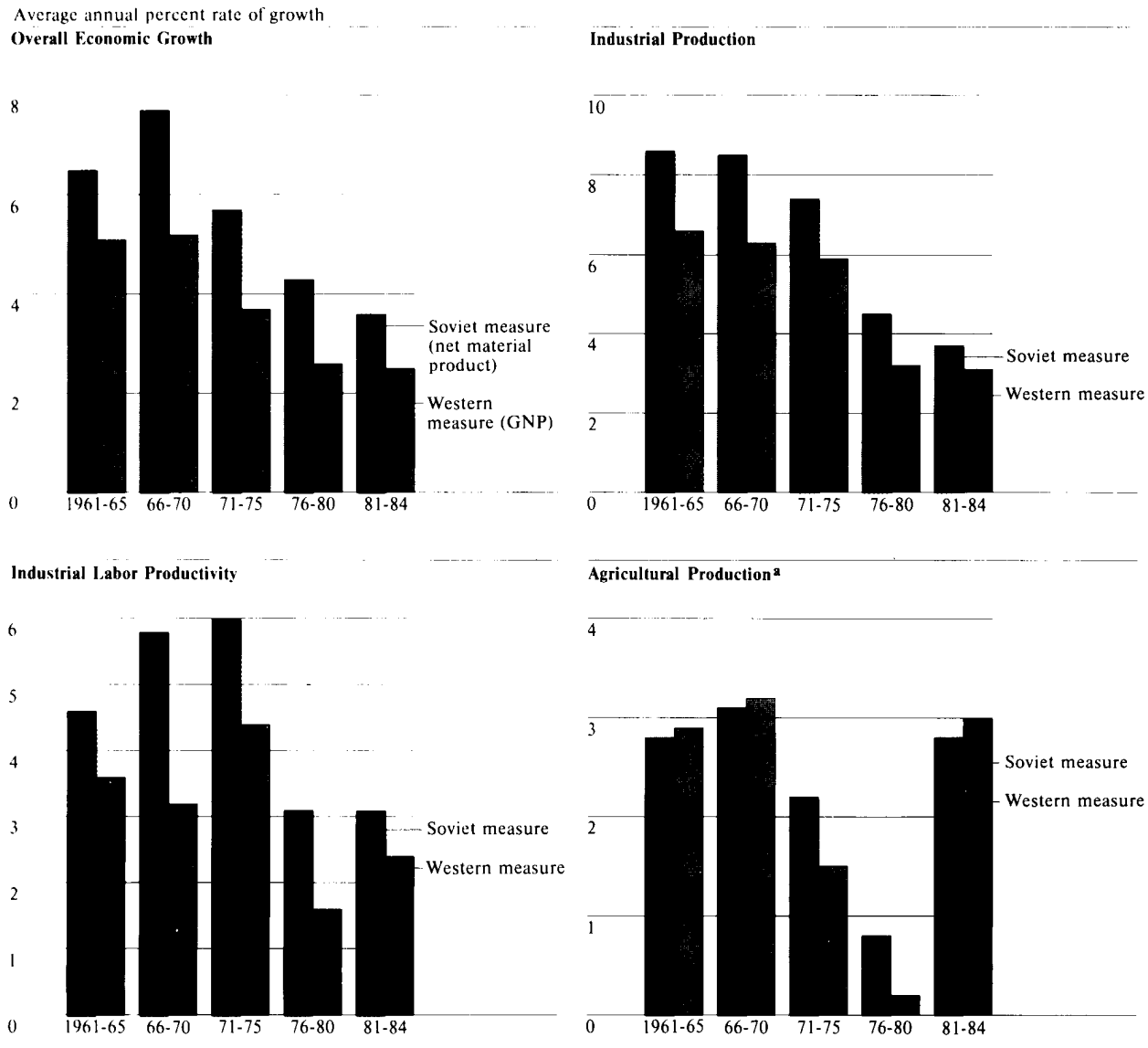
- Introduce new technology into production more quickly.
- Replace old equipment with new equipment.
- Improve product quality.
- Improve management and the system of economic indicators and incentives.

By meeting these intermediate objectives, the USSR would be able to ensure a rise in labor productivity, reduce the unit cost of output, and accelerate scientific and technical progress.

The General Secretaries since Brezhnev have all indicated their commitment to these general goals and their realization that a high price is being paid for the failure to attain them (see inset). They have differed somewhat in the emphasis placed on specific aspects of the program laid out by Brezhnev. Yuriy Andropov largely blamed the poor incentive system for inhibiting the "speedy introduction of scientific and technological achievements and advanced experience into production." He called for "the creation of a situation in which those who boldly introduce new technology do not find themselves at a disadvantage." Mikhail Gorbachev also believes that reform is necessary in the system of economic indicators and worker incentives, but he seems to place a higher priority on upgrading industrial machinery and equipment, calling for an ambitious boost in the output of the machine-building sector (see article "Gorbachev and Industrial Modernization").

Some differences are also discernible in the willingness of successive regimes to rely on Western help in the modernization effort. Brezhnev's enthusiastic support for detente led him to declare that "economic and scientific-technical ties with the capitalist states strengthen and broaden the material basis of the policy of peaceful coexistence." As subsequent events unfolded—growing Soviet indebtedness and Western trade sanctions and technology bans imposed after the

USSR: Selected Economic Indicators, 1961-84



[a] Three-year average.

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Leadership Statements on Modernization

Leonid Brezhnev at 26th Party Congress in February 1981:

> The circumstances in which the national economy is to develop in the eighties make the acceleration of scientific-technical progress even more pressing . . . close integration between science and production is an urgent requirement of the present day. . . . And it is primarily the machine-building industry which can open wide its doors for the new. Truly revolutionary possibilities are opened up by the production and introduction of miniature electronic control machinery and industrial robots.

Yuriy Andropov at the June 1983 party plenum:

> The key task in the economic sphere is the cardinal raising of labor productivity. Here we must strive to attain the highest world levels. . . . We will have to automate production and ensure the widest use of computers and robots and the introduction of flexible technology allowing for a quick and effective readjustment of production for the manufacture of new output.

Konstantin Chernenko in a 1984 Kommunist *article:*

> Before the end of the 1980s it is vital that we achieve a fundamental watershed in raising the efficiency of the national economy. . . . The first and most obvious theory is to mobilize so as to achieve the swiftest possible technical reequipping of all branches of the national economy.

Mikhail Gorbachev to the April 1985 party plenum: 25X1

> Scientific and technological progress in the majority of industries is flagging; it is developing basically in an evolutionary manner, primarily by improving existing technology and the partial modernization of machinery and equipment. Of course, these measures provide a certain return, but it is too small. What we need is revolutionary change, a transfer to fundamentally new technological systems, to the most up-to-date machinery to provide the very greatest efficiency. Essentially it is a matter of reequipping all sectors of the national economy on the basis of contemporary achievements in science and technology. 25X1

invasion of Afghanistan—the Soviet leadership developed a more jaundiced view of the benefits of such trade and became acutely aware of the USSR's vulnerability to Western economic pressures. According to Soviet open sources Soviet political and scientific leaders began to fear that excessive reliance on Western technology could retard domestic technological progress and reinforce the USSR's technological inferiority to and dependence on the West.

It is not yet clear where Gorbachev stands on this issue. No doubt the leadership is presently wrestling with the problem of determining a judicious mix between domestic and foreign equipment and technologies as a necessary input into the new 1986-90 economic plan. Gorbachev took an equivocal line on this issue at the June 1985 CPSU Conference on S&T Progress, noting that "We are not propounding self-sufficiency . . . but we cannot permit our country to depend upon deliveries from the West. The experience of recent years has taught us a great deal." 25X1 25X1 25X1 25X1

Soviet Intensive Economic Development: The Past Record

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The preceding article on leadership perceptions shows that the intention to switch from extensive to intensive growth is not new. This strategy has been pushed hard since at least the mid-1970s, but the results have been meager. The common theme that emerges in an assessment of Soviet efforts to accelerate productivity growth has been the unsuitability of centralized planning and control as an institutional framework for implementing intensive development. While admirably devised for directing the resource mobilization that promoted extensive development, it has so far proved ill suited to stimulate the productivity improvements that are the core of the intensive approach.

Intensive Development Policies

The intensive approach to sustain development approved in the mid-1970s sought as much as possible to preserve existing resource priorities. There was some slippage in the share of personal consumption in GNP in the early 1980s, though part of the explanation may lie in subnormal agricultural performance. The share of investment has continued to creep upward. Meanwhile, the share allocated to defense has remained in the 11.5- to 13-percent range, with little variation since 1970. Accordingly, Moscow had to look for relief more in the supply side of the economy, in policies affecting labor, land, fixed capital, and productivity. The leadership's options regarding manpower and education policies have been limited, so the focus of intensive development has been upon fixed capital and technology—primarily measures to raise their productivity. But the productivity of investment depends on technological advances assimilated with the investment, so investment and technology policies are complementary.

Accelerating Retirements of Fixed Capital

Attitudes and policies toward the retirement of fixed assets have contributed greatly to declining capital productivity in the USSR. On average, fixed assets have been retained in service twice as long as in the major market economies. The annual rate of replacement of capital stock in the USSR is only 3 percent, compared with only 8 and 9 percent for the United States and West Germany, respectively, and 11 percent for Japan. Since productivity gains depend upon adding new capital incorporating recent technology and discarding technologically obsolescent assets, Soviet practices clearly retard productivity improvement.

Asset lives are prolonged at high cost through capital repairs. In the mid-1970s, outlays for repairs were a quarter as large as gross investment in industry and nearly 40 percent as large as outlays for industrial equipment. The resource drain of repairs was considerable, absorbing a tenth of the industrial labor force and a third of the stock of machine tools. Over the lives of these assets, capital repairs generally exceeded original investment costs.

Despite official recognition that shorter asset lives are desirable, the steps taken in this direction have been inadequate. The most recent change in official amortization norms, in 1975, lowered average service lives for industrial equipment from 17 to 14 years, compared with average lives of 10 years in France, Germany, and Italy and 12 years in the United States. In actual practice, the official guidelines have not been followed. A Soviet economist, taking into account retirements for both wear and tear and obsolescence, estimated an average equipment service life of 20 years.

Replacement Rather Than Expansion. The main new focus of Soviet investment policy—raising the share of industrial investment devoted to replacement of old assets—complements the campaign to shorten asset service lives. Traditionally, with the extensive growth approach, investment plans stressed building new plant or expanding capacity of existing enterprise. By

emphasizing reequipment of existing plant, Soviet planners hoped to accelerate the introduction of new technology to the production line by shortening the investment cycle. Construction of new facilities is the most time-consuming element of capital investment, so the idea was to avoid construction by replacing equipment in existing buildings. Reequipment might require some reconstruction, too, but the cost was perceived to be small compared with that of a new plant.

The advantages of an intensified replacement effort are severalfold, according to special surveys carried out in the USSR. Labor productivity is said to be about 50 percent higher and capital productivity 86 percent higher in reequipped plants than in new plants. These results reportedly were attained with cost savings of one-half to two-thirds and with capacity being brought on stream 3 to 3.5 times as rapidly.

Nevertheless, the Soviet replacement effort has been much smaller than that in the United States. In the mid-1970s, 56 percent of US industrial investment was directed toward replacement and modernization. In the Soviet Union the proportion was only 29 percent in the late 1970s and 35 percent in 1983. The US proportion may be too high a standard for the Soviet Union given slower US industrial growth, but some Soviet economists have recommended that the Soviet share should be doubled or tripled.

The rising share of replacement in investment has been matched by a rising technological intensity of investment. The key feature of this trend is the accelerated automation of production. In Soviet official jargon this policy panacea is termed the "scientific-technological revolution." Automation serves the dual objectives of facilitating substitution of capital for labor in an era of worsening labor shortages and raising the productivity of capital. The growing share of high technology in production of producer durables can be seen by comparing the composition of total deliveries of producer durables since the mid-1960s and those projected for the current five-year plan (see table).

The deliveries consisting of high-technology products may be found in the third and fourth rows of the table. Newer machine tools included in the third row are increasingly computer controlled. The share of

USSR: Deliveries of Investment Machinery and Equipment, by Plan Periods [a] *Percent*

Group	Share of Total			
	1966-70	1971-75	1976-80	1981-85 Plan
Railway equipment, automotive equipment, agricultural machinery, construction machinery	60	58	55	49
Mining, metallurgical, hoisting equipment	12	12	19	20
Stamping-pressing, metal-cutting equipment	9	10	10	13
Instruments, automation, and atomic energy equipment	5	7	10	13

[a] Investment time series underlying these shares are measured in 1969 estimate prices, adjusted for selected wholesale price changes on 1 January 1973.

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high-technology products has nearly doubled since the mid-1960s and now constitutes a quarter of total investment. These trends in Soviet investment policy have led to a rising dependence upon foreign technology. Imports of high-technology products surged during the early and middle 1970s, leveled off in the latter part of the decade, and then showed signs of renewed resurgence in the 1980s.

Why the Intensive Investment Campaign Stalled

Low Retirement Rates, Reproduction Instead of Replacement. The accelerated retirement guidelines adopted in 1975, as noted earlier, have not been implemented. Official retirements for wear and tear, as reported in the annual statistical handbook, have shown no significant change. Indeed, a Soviet investment specialist has asserted that rates of retirement of obsolescent assets have actually declined. During the 1970s, the average age (number of years in production) of current machinery output rose significantly. The share of new products fell from 4.3 to 2.5 percent of total output, while the share of machinery in production for more than 10 years climbed from 20 to 28 percent.

The principal reason old equipment was kept in service was that enterprise managers and ministerial officials were led to do so by the existing incentive structure. In a market economy, firms discard old assets primarily because the new capital is usually more economical in the use of manpower and material or because it is necessary to manufacture competitive products. As long as current production targets remained the overriding criterion for judging success, Soviet managers had little incentive to discard obsolescent assets.

As we have indicated above, the USSR has raised somewhat the proportion of replacement in total investment but has fallen woefully short in its bottom-line objective of accelerating capital productivity. The explanation for this lies first in Soviet construction practices and second in the failure of the system to generate and assimilate the advanced technology necessary to support the replacement investment program.

Construction Practices Hinder Replacement. The advantage of the new approach, in theory, was the time and cost savings attained by retooling without reconstruction. Existing buildings and structures supposedly could be used with little or no alteration, while obsolescent machinery and equipment were replaced with technologically advanced models.

The installation of automated production lines and assembly-type operations in the process of retooling, however, often requires some alterations of existing factory buildings. Improvements in light and ventilation are often required. Moreover, traditional Soviet construction practices have favored heavy prefabricated concrete structures. While more durable than those built of lighter materials, these buildings are less amenable to the alterations that accompany equipment replacement. In the same vein, Soviet construction design favors the use of overhead bridge cranes, rather than more mobile lifting and transport equipment. Bridge cranes require heavy columns and overhead building supports that limit the possibility of rearranging the use of floorspace.

These features of Soviet industrial construction have required costly and time-consuming reconstruction as part of equipment replacement programs. In effect, the durability of Soviet construction has been self-defeating and has required that retooling be matched by reconstruction. The theoretical cost and time savings envisaged in the Soviet investment literature have not been realized.

The replacement effort has also been confounded by organizational deficiencies in construction. Soviet construction organizations work best in building new plants, where standardized techniques can be used on a large scale. Reconstruction is typically carried out on a smaller scale, requiring specialized techniques for which construction organizations are ill prepared. The incentive system is skewed toward those indicators of construction activity that characterize new construction. As a result, reconstruction activity has often been performed by inefficient repair organizations belonging to the enterprises being reequipped rather than by specialized construction organizations.

Investment in Obsolescent Technology. Since the ultimate success of the replacement investment campaign rests upon the accelerated introduction of advanced technology into the production process, technological performance has been crucial. A perceptive Soviet economist who analyzed the reasons for the continuing decline in the rate of return on investment cited such external influences as the worsening quality of natural resources, the growing share of investment in high-cost eastern and northern regions, rising pollution-control outlays, and reduced manpower availabilities. However, he asserted that the principal reason has been an insufficient rate of scientific and technological progress.

Sluggish Technological Performance. The explanations for lagging Soviet technological progress can be found mainly in managerial incentives, the institutional relationships between research and development and production, and the technological drain caused by the priority given to defense production.

Weak or Perverse Incentives. Technological progress in market economies depends upon both consumer and supplier initiatives. In the Soviet system, the influence of the consumer is weak, except in defense production where the initiative comes from the Ministry of Defense with reinforcement from the top leadership. Innovation has been inhibited by the chronic seller's market that prevails for Soviet producer durables—a trait that a Soviet scholar called "planned scarcity." Under such circumstances, consumer demand has provided little effective pressure for technologically improved or lower cost products. The potent influence of consumer sanctions has been absent. From the point of view of suppliers, willingness to pursue cost savings through asset replacement has been deterred by what a leading Soviet investment expert terms "self reproduction," the propensity toward the perpetuation of existing technology, which has assured sources of material supply and provides near-certain production bonuses.

Reliance on longstanding sources of materials to avoid supply disruptions has also slowed technical advance. Centralized planning promises a producer an adequate allocation of necessary inputs but provides no guarantee of timely and sufficient delivery. As a result, a good deal of Soviet machinery has been produced in small machine shops attached to the consuming organization rather than in large-scale machine-building ministries. Only the specialized ministries, however, have been able to afford to support the research and testing facilities required to develop advanced technology. To the degree that the propensity toward vertical integration (self-sufficiency) has prevailed, Soviet industry has forgone the benefits of division of labor that characterize modern industry in market economies.

Even within the 20-odd machine-building ministries, product specialization has not matched administrative specialization. The prevailing exceptions have been those machinery ministries largely engaged in military production. Even in the production of general purpose semifabricates—such as gears, castings, forgings, and stampings—the degree of specialization has been far lower than in US industry. Production of single-unit customized equipment has not been organized in specialized machinery ministeries. By default, such items have been produced in the technologically backward internal machine shops.

Technological backwardness is also explained by insufficient supplier initiative. In market economies, most technical progress at the plant level originates in sales pressure by equipment suppliers. In the Soviet system, research and development have been separated from production. The incentives for R&D organizations reward expenditures of budget allocations more than completion of projects or the satisfaction of consumer demand. This supplier-consumer gap has not been closed by the central planning coordination process, nor by attempts to improve the returns from science.

The Drag of Military Production. Still another major deterrent to technological progress in the production of producer durables has been the superior priority accorded to defense production. The share of GNP allocated to defense changed little over the past decade, but the burden of defense on capital productivity continued to rise in terms of the preemption of advanced technological resources and the economy's innovational energies.

The cutting edge of improved capital productivity is the application of high technology in the production of producer durables. Within the Soviet industrial classification system, high technology includes the following sectors: precision instruments, communications and other electronic equipment, transportation machinery and equipment, and electrotechnical machinery and equipment. The changing composition of investment durables purchases, which reflects the rising high-technology ingredients, has been shown in the table.

The heavy defense production drain on high-technology output may be deduced by combining information in the reconstructed versions of Soviet interindustry tables for 1966 and 1977 with estimates of the breakdown of deliveries of machinery to investment by a Soviet economist. In 1966, the military probably accounted for more than half of final demand for the four high-technology machinery sectors. Conclusions for 1977 are more tentative, but they indicate that the military procurement claim was of similar magnitude.

The technological burden of military production appears even larger when product quality is taken into account. Information obtained from emigres reinforces the presumption that the presence of military inspectors in all plants producing defense products has enabled the Ministry of Defense to refuse defective or inferior output, a privilege not accorded to civilian customers. The observers also assert that factories that produced products with both military and nonmilitary applications have set higher quality standards for their military customers.

Some notion of future trends in the high-technology content of Soviet investment may be conveyed by citing US experience. By the early 1980s, purchases of office and computing machinery and communications equipment comprised over a third of the producer durables component of new fixed investment. If this definition of high-technology investment is expanded to include scientific and engineering instruments and photographic equipment, the share rises to nearly half.

This rising investment imperative collides with the continuing push to upgrade the technological content of military production. Even though there has been little increase in total military procurement in the Soviet Union since the mid-1970s, the technological sophistication of most systems has risen markedly.

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Gorbachev's Strategy

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In a series of recent speeches and well-publicized appearances, Gorbachev has emerged as a forceful advocate of industrial modernization. The goals he has proposed thus far reflect and build upon ideas advanced by Brezhnev, Andropov, and Chernenko (see the preceding article on leadership perceptions), but they are unique for the vigor with which they are put forth and the pace of renewal that they imply.

Unless Gorbachev is willing to shift resources drastically toward the investment sector (at the expense of consumption and/or defense), his immediate goals appear much too ambitious. Nonetheless, sustained pressure by the leadership on managers and the governmental bureaucracy—with some less wrenching adjustments in priorities—could well have a positive impact on productivity in the economy. To ensure a major, long-lasting impact on productivity growth, the leadership would have to agree on some systemic changes that would overturn the existing preference given to quantity rather than quality.

Elements of the Gorbachev Program

What we know of the Gorbachev program consists of a mixture of distant goals, intermediate objectives, and implementing measures having to do with investment, organization, incentives, and high-level attention. Gorbachev places the acceleration of scientific and technical progress at the center of his strategy for industrial modernization. He proposes to accomplish this modernization by following through on the familiar theme of replacing outmoded capital stock, by investment shifts benefiting high-technology industries, by management reforms to speed innovation, and by organizational changes reducing barriers to the application of scientific advances in industry.

Investment Goals

The General Secretary's investment strategy is not much different in principle from that proposed by his predecessors. He has, however, been more ambitious in setting specific targets for the 1986-90 Five-Year Plan.

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Renewal of the Country's Capital Stock. The transition to intensive modernization of the economy—in Gorbachev's words, "the technological reconstruction of the economy"—will require a large increase in investment in strategically important areas. To shift the economy to an intensive footing, Gorbachev has proposed:

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- Doubling retirement rates of capital stock to accelerate the replacement of obsolete capital by more efficient, state-of-the-art machinery and equipment.
- Modernization of the nation's capital stock so that by 1990 a third of it, including up to half of the machinery portion, is new.
- Increasing capital investment in civilian machine building in 1986-90 by 80 percent over that of 1981-85.
- Raising the rate of growth of machine-building output by 50 to 100 percent.

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Stress on Key Industries. The qualitative side of Gorbachev's strategy emphasizes development of the industries that provide the advanced equipment needed for industrial modernization, especially those producing machine tools and tooling systems, robots and flexible manufacturing systems, microelectronics, computers and industrial controls, and telecommunications (see the article "Advanced Technologies in the USSR"). Computer-based planning and design and automated production are to provide the foundation for a resurgence in machine building and a reconstruction of the national economy as a whole. Advanced technologies will be the decisive factors for improving the productivity and quality of production of all industries.

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Organizational Measures

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Most, but not all, of Gorbachev's initiatives with respect to management also have a familiar ring.

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USSR: Investment Trends
(Average Annual Percentage Growth)

	1976-80	1981-84	1986-90
Allocation of investment			
New fixed investment	3.3	3.7	6 [a]
Investment in industry	3.5	3.8	NA
Investment in machine building	3.9	3.3	NA
Of which:			
Civilian	NA	NA	18
Components of investment			
Construction-installation work	0.9	2.3	1 [a]
Machinery	6.5	4.5	9 to 10 [a]
Sources of investment			
Output of machinery [b]			
Soviet measure	8.2	6.0	9 to 12
CIA estimate	5.0	4.4	NA
Domestic production of producer durables	5.9	4.9	NA

[a] Implied by goals for renewing capital stock and raising retirement rates.
[b] The official index of machinery output has an upward bias because of the treatment of price and quality changes.

Reorganizing Management. Gorbachev has declared that changes have to be made in the way resources are managed if his modernization strategy is to be implemented. His aim is to rid the system of some of the bureaucratic tutelage that interferes with the implementation of Central Committee decisions. Several actions already taken suggest a shift in the management approach to science and technology (S&T) issues:

- An experimental management program—described as a model for the rest of industry—has begun at the Ministry of Instrument Making, Automation Equipment, and Control Systems. It emphasizes the creation of more scientific-production associations to bring research, development, and prototype production responsibilities together under one roof.
- Plans reportedly are under way to reduce the power of ministerial bureaucracies by forming superministerial bodies for groups of related industries, beginning with the agro-industrial, machine-building, and energy sectors.
- A tenacious bureaucrat, Nikolay Baybakov, has been replaced as chairman of the State Planning Committee by Nikolay Talyzin, a man with some technical expertise.
- Dzhermen Gvishiani, a leading authority on S&T management, has been named deputy chief of the State Planning Committee.

From time to time Gorbachev has spoken of the need for a thoroughgoing shakeup of economic management. In addition to the creation of superministries, he has advocated a reduction in the powers of existing ministries. Occasionally he has also said that much greater decentralization of decisionmaking is required. The February 1986 Party Congress might reveal some changes of this nature. 25X1

Emulating Defense Industries. Gorbachev has exhorted civilian industry to adopt some management and development approaches used in the defense industries. (Defense management techniques and S&T progress in the defense sector were also singled out by Brezhnev in the 1970s as an example for the civilian economy.) Gorbachev held up the defense industries as a model for the revitalization of machine building and in particular praised the defense industries for producing specialized equipment to meet their own needs. He then encouraged the rest of the machine-building industry to follow their example—a reversal of Soviet policies of the past 20 years that have called for reliance on centralized suppliers to meet the needs of a variety of user industries. 25X1 25X1

Integrating Science and Production. To boost productivity in science, Gorbachev repeats the 20-year-old call to link science to production more tightly by eliminating the bureaucratic separation of research

establishments, higher educational institutions, and production. In this vein, he proposed the formation of a department for engineering problems in the Academy of Sciences and asked for greater collaboration between the Academy and industry, particularly through the formation of additional interindustry scientific-technological centers modeled on the Paton Electric Welding Institute.[1] He also suggested that the volume of research performed in institutions of higher education be increased by a factor of 2 to 2.5.

Adjusting Incentives

The new incentives approved by the leadership to encourage innovation represent a mixture of sticks and carrots. The threat to enterprises is the edict that those who produce goods judged to be of lower quality will have to reduce their prices by 30 percent. They will then have to reimburse the state for lost revenue with money taken from worker bonus funds.

The positive incentives center mainly on a provision of the industrial experiment that gives enterprises more control over investment funds to spend on renovation projects of their own choice. By January 1987 the experiment is to be extended to all of industry. Another new measure raises the salaries and bonuses of scientific workers and engineers, who have not been paid much more than the average industrial worker.

High-Level Attention

The strongest part of the modernization program so far has been the massive campaign to indoctrinate party and government officials on the leadership's determination to accelerate technical progress. The administrative approach to modernization features, at every level, surveys of plans for the introduction of new technology and extensive reviews of the comprehensiveness and truthfulness of these plans.

[1] The Paton Institute was cited for successfully integrating pure and applied research with the needs of industry to obtain new welding technologies for nuclear reactors, ship construction, and the automotive industry.

Outlook for the Modernization Program

Gorbachev's modernization goals seem out of reach given the present capacity of the investment sector and the limited nature of the organizational and incentive changes announced to date. Nonetheless, a sustained campaign focusing on ministerial and enterprise plans for technical progress, coupled with some reallocation of investment, could result in some acceleration of productivity growth in the economy. 25X1

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The Investment Bind

Gorbachev's investment goals are unlikely to be met in an economy in which resources are already stretched tautly to satisfy the competing demands of consumption, growth, and defense. To meet Gorbachev's goal for renewal of the Soviet capital stock, for instance, total capital investment would have to rise by 6 percent a year compared with the 3.7-percent average annual growth achieved in 1981-84. If retirement rates are not raised, even more new investment would be needed to push up the share of new fixed capital in total capital stock to one-third by 1990. A rough calculation suggests that investment in this case would have to rise by 9 percent per year. 25X1 25X1

The most wrenching shift is the plan to increase investment in civilian machine building and metalworking (MBMW) by roughly 18 percent per year compared with the 3- to 4-percent growth characteristic of investment in all MBMW during the past decade. Just as it supplies most of the machinery for all investment in the economy, MBMW will have to support investment in itself. The plan will require a pronounced shift in the assortment of machine-building products over a short period of time. 25X1 25X1

Moreover, the goal for machinery modernization—if met from domestic sources—would, according to our calculations, require growth in the production of producer durables of 9 to 10 percent a year. Investment in machinery could be pushed to the levels 25X1

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planned without depending so much on faster growth in the machine-building sector if the leadership is willing to make certain decisions. Clearly, a substantial rise in machinery imports would help fill the gap, although Soviet statements and the status of trade negotiations suggest that Gorbachev has not decided whether to take this course (see the article "Acquiring Western Technology").

Meanwhile, the Soviets do not plan to increase the output of steel and nonferrous metals at rates commensurate with the planned growth in machinery output (see the article "Modernizing Basic Industries"). If Gorbachev's goals for saving metal in production are not met, the machinery targets will be put in jeopardy.

Reliance on High-Technology Industries

The last two decades have seen repeated appeals to modernize Soviet industrial processes. Soviet progress in the development of automated production technology has been impeded, however, by inflexible planning and an incentive system that rewards quantity rather than quality. In particular, Soviet managers have not had the incentives to take the risks associated with innovations or new technology.

In addition, production equipment is underused or left idle as enterprises and industries targeted for reconstruction receive new equipment without the detailed planning regarding product and process changes and supply and maintenance arrangements that are necessary to run the equipment effectively. Trained production engineers, programers, and operators needed to rectify these problems remain in short supply.

Achievement of civil modernization objectives depends heavily on the availability of computers and electronics. The extremely ambitious goals for production of computers, robotics, and the like are intended to cover both modernization and military requirements. Shortfalls, which are to be expected, will force the leadership to scale back plans for either industrial or military modernization—or both.

Looking to Defense Industry

The emulation of management practices within defense industry does not—in our view—have much of a payoff for the modernization program. We believe four considerations, which have to do with how defense industry is treated rather than how it is managed, account for its generally superior technological performance:

- The priority afforded defense needs, leading to assignment of the best personnel and access to critical supplies and equipment.
- The focused attention of senior leaders—including members of the Military-Industrial Commission—on details of the planning and production process.
- Much better endowed experimental production bases than exist in civilian industry for testing the compatibility of design and production techniques.
- The presence of military watchdogs at plants, ensuring that standards are maintained and deadlines met.

Moreover, the suggestion that each ministry produce more of its own equipment seems to go in the wrong direction if the regime wants to encourage the highest possible quality and modernity.

Enlisting Science in Support of the Economy

The proposals outlined thus far by Gorbachev for improvement of the operation and output of science for the most part rehash previously unsuccessful measures. In 1980, for example, the Central Committee passed a decree enhancing the role of state standards in improving product quality. The intent was to reduce development time and improve quality through the use of up-to-date manufacturing methods and equipment. Incentives and sanctions have been introduced to encourage innovation. The use of contracts to enforce mutual obligations between scientific and industrial facilities has been increasingly stressed in recent years. The creation of scientific production associations—which combine research institutes, design bureaus, and prototype production facilities—has been urged by the Soviet leadership since 1973. Only 250 have been created to date, however, and attempts by the State Committee on Science and Technology to form more have met with resistance from turf-conscious managers.

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To promote the integration of science and production, the new General Secretary appears to be relying largely on jawboning and on the creation of additional organizations—the interindustry scientific-technological centers, new departments for computers and engineering problems within the Academy of Sciences, and more scientific production associations.

Incentives Still a Major Problem

The measures adopted so far to reinforce managerial incentives to adopt new technology appear to be too weak to do the job. To accomplish all he says he intends to achieve, Gorbachev will have to address effectively the many problems impeding technological progress in the Soviet economy. The unevenness in the diffusion of new developments, combined with the traditional Soviet emphasis on end products rather than production technology, has continued to impede industrial and economic development. In the Soviet economy, where performance is judged primarily against targets defined in terms of production volume, faster assimilation of advanced technologies has been largely incompatible with the current system of management and rewards (see the preceding article on the past record of intensive development). So far, the experiment in industry has not provided evidence that technology is being introduced more rapidly because of changes in the incentive structure.

The Leadership Factor

Taken at face value, Gorbachev's stated modernization goals are unrealistic. But, as the relative success of the military-industrial complex demonstrates, a good deal can be accomplished in selected sectors by intense, consistent leadership attention and the granting of priority with respect to skilled manpower, R&D, and material supplies.

Gorbachev seems determined to maintain the pressure on lower level authorities to adopt more demanding plans for technical progress. How far he is willing to go in adjusting priorities in favor of his program is still unknown. The annual plan for 1986 and the 1986-90 Five-Year Plan should provide some evidence in this regard. The 1981-85 plan, for example, showed that Brezhnev was unwilling to make hard choices on resource allocation. The plan was balanced by approving targets that were plainly unrealistic in relation to the resources available. The imbalances inherent in the plan were soon reflected in economic performance. 25X1

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Gorbachev has concentrated on uncovering "internal reserves" by replacing mediocre managers and officials and enforcing stricter discipline in the workplace. But, beyond a certain point, a bullheaded search for potential efficiency gains can be counterproductive, as it leads to plans and policies based on wishful thinking. 25X1

In this connection, the repeated rejections of the draft 1986-90 plan suggest that the Soviet leadership through the summer and early fall had not decided how much to rely on administrative measures to extract ambitious plans for productivity gains rather than on additional resources to support the modernization program. In *Ekonomicheskaya gazeta* (the authoritative economic weekly) the managers of a series of machine-building enterprises have told of taking their individual plans back and "finding ways" of raising production targets markedly without requiring more labor or plant and equipment. 25X1

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Advanced Industrial Technologies in the USSR: Progress and Problems

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In his June 1985 speech, General Secretary Gorbachev singled out advanced technologies—microelectronics, computers, and instrument making—and the information industry as having a "revolutionary" role in transforming the Soviet economy. He has since announced plans to substantially increase investment in the industries supporting these technologies. His initiative accelerates major technology development programs begun in the mid-1960s and responds to the manufacturing revolution well under way in the West.

By Western assessment the Soviets have made great strides in these areas, particularly in microelectronics, where they have moved from almost total dependence on Western sources for both circuit design and production equipment to a position from which they can go forward using indigenous resources. However, their lag in such key technologies as microelectronics and computers remains. Moreover, Soviet success in applying these basic technologies to manufacturing processes depends in large measure on the USSR's ability to overcome systemic problems in industry. In the meantime, accelerating Western progress in both support industries and applications will make it difficult for the Soviets to prevent the gap from widening in terms of both productivity and product quality.

Key Technologies in Industrial Modernization

Advanced machine tools, robots, microelectronic devices, computers, and telecommunications systems are finding widespread applications in industrial operations:

- Computer numerically controlled (CNC) machine tools and machining centers allow fabrication of complex parts to consistently high tolerances and more rapid changeover from one machined part to another.
- Robots are highly effective in repetitive operations, speeding production and assuring uniformly high product quality while freeing laborers from hazardous tasks.
- Computer-aided design systems enable rapid change in product designs and documentation, saving time and permitting more options to be considered.
- Computer-based management information systems and networks provide precise and responsive control of supply and production scheduling and performance.
- Computer-to-computer data links allow rapid exchange and update of management, design, and production information.

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Microelectronic systems provide the control and data storage and transfer functions for this equipment and numerous business and manufacturing operations.

These technologies have their most substantial impact when they are combined in computer-integrated manufacturing (CIM) systems. These systems centralize control of plant production. The most advanced integrate computer-based management and design systems with computerized machining, robotics, automated inspection, automated material handling and warehousing, and automated stock control and planning. In the West they are being widely applied in the production of automobiles, machine tools, electronics, computers, and weapons.[1] They have led to substantial economies in labor and inventory costs, while enabling manufacturers to respond quickly and economically to changing demands.

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The interdependence of these technologies requires a coordinated, broad-based advance. Progress in microelectronics, for example, feeds advances in the entire range of advanced machine tools, robotics, industrial

[1] For example, Vought is employing automated lines to assemble the Multiple-Launch Rocket System and manufacture major B-1B subassemblies. The IBM plant at Lexington, Kentucky, has automated lines to manufacture computer equipment, and General Motors has automated engine parts machining and automated parts handling and retrieval in its stamping and assembly plants.

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Glossary

Advanced Machine Tools and Robots

Numerically controlled (NC) machine tool. *An automated machine tool whose movements and functions are controlled by numerical information 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 machine 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.*

Machining center. *A complex NC machine tool, usually under computer control, which performs all the production functions of a machining operation, including machine axis control, tool changing, workpiece changing, machine scheduling, and cost control.*

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 performs several machining, transfer, and inspection functions automatically under common control of a host computer.*

Design and Management Systems

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. He may then command the plotting station to produce engineering drawings of the design for use in*

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process control systems, telecommunications systems, and computers. Telecommunications and computer hardware or software advances expand applications for automated manufacturing either by pushing the state of the art (for example, robotic vision systems and pattern recognition) or by reducing cost. Advances in machining, robotic assembly and inspection, and computers in turn fuel new rounds of improvement in electronic components and systems. This kind of interaction underpins the dynamic growth of these industries in the West and Japan but generally has not characterized Soviet development.

Advanced Technologies in Soviet Industry

Gorbachev's program builds on longstanding Soviet efforts to develop indigenous high-technology industries. These efforts have relied on:

- Centralized management, wherein specific ministries have been charged with prime responsibility for developing industrial technologies, and national-level programs have been created to coordinate the efforts of contributors.

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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.

Management information system (MIS). *A computer-based system incorporating automated order processing, production scheduling and supervision, and inventory control. The MIS accumulates summary data from these processes and combines them with financial data and information on market trends, business conditions, and monetary factors to provide a comprehensive background and input for management decisions.*

Microelectronics

Integrated circuits, or chips. *Circuits consisting 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.*

Photolithography. *Process by which elements of a circuit design, represented in a mask template, are transferred to the wafer by shining light through the mask and exposing light-sensitive material on the wafer surface in the spatial pattern of the circuit.*

Small-, medium-, large-, and very-large-scale integration (SSI, MSI, LSI, VLSI). *Terms referring to integrated circuits having 100-999, 1,000-9,999, 10,000-99,999, and 100,000 or more transistors per chip, respectively.*

Telecommunications

Analog transmission. *A process in which the information content of each communications channel is represented by a continuously varying 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. This 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.*

- Substantial infusion of R&D and production resources. Analysis of institutes, plants, and associated manpower indicates that high-technology industries generally have grown the most rapidly over the last two decades.[2]

- Large-scale use of foreign technology and assistance agreements for testing and evaluation, reverse engineering, startup of new plants and processes, and improvements of manufacturing processes. The Soviet acquisition program has concentrated on manufacturing technology and equipment for developing the capability to produce advanced military equipment.

Output in these industries has risen dramatically and, in the case of machine tools and robots, has exceeded Western levels. But production numbers do not reflect differences in quality. The Soviets' greatest shortfall in all areas, moreover, lies in application. Their efforts in the 1970s were still largely directed at improving specific production processes rather than at developing genuinely integrated production systems embodying the new technologies.

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Advanced Machine Tools. In 1968 the Soviets 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 control equipment. The machine tool ministry (Minstankoprom) and the Ministry of the

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Aviation Industry were given responsibility for civilian and defense NC machine tool production, respectively, and the automation and control ministry (Minpribor), for control equipment. 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). 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. By contrast, computer-operated NC machine tools constitute more than 60 percent of Western machine tool production.

Throughout the period the USSR relied heavily on foreign technology. It became the largest importer of machine tools in 1970 (a position relinquished to the United States in 1979) and entered into at least 36 scientific and technical assistance agreements with West European companies for numerical control technology and, more recently, for flexible manufacturing systems. The most spectacular example involves the machine tool plant at Ivanovo. Starting in 1975, the plant was stocked almost completely with advanced precision machine tools—NC and CNC tools and machining centers—purchased largely from West European manufacturers. This enabled it to become in a very short time the premier producer of machining centers and prototype flexible machining systems in the USSR.

Nonetheless, the best Soviet computer-operated machine tools lag about three to four years behind Western models, and flexible manufacturing systems are five to six years behind. The USSR is even further behind in production and application of advanced machine tools.

In May 1984 the Soviets launched the third stage of a drive toward manufacturing automation. They are pressing for large-scale production of CNC 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 materials handling, assembly, and checkout. We estimate the United States currently has 550 cells in operation compared with 50 in the USSR. The Soviets have only a few of the most advanced multimachine flexible manufacturing systems, while US firms have about 35

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Robots. The Soviets embarked in the mid-1970s on an ambitious program to develop and produce industrial robots. Production figures are impressive—annual production reached 14,000 in 1984—and the Soviets plan to have approximately 120,000 robots in use in the machine-building industries by 1990. Most Soviet industrial robots, however, are akin to simple manipulators, and thus too elementary to fit into flexible manufacturing systems.

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The growth of the robotics industry in the USSR is inhibited by shortages of key electronic components (controllers, computers, probes, and feedback devices) and hardware (servomotors) and by quality problems. Many industrial facilities are too antiquated and improperly staffed to assimilate robots. Failure to adapt manufacturing lines to take advantage of the characteristics of newly installed robots, compounded by poor installation and maintenance support, has led to waste of robotic work capacity and, in the worst cases, reduction in line production and productivity. Thus, the USSR lags the West considerably both in the production of advanced robots and in their integration into computer-integrated manufacturing.

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These shortcomings led the USSR to reverse engineer simpler robots (for example, US Unimate robots for spot welding), import sophisticated freestanding robots or robotic systems from both Eastern Europe and the West, and implement R&D and cooperative production arrangements with Bulgaria, Czechoslovakia, and East Germany.

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Microelectronics. In the early 1960s the Soviets constructed a large microelectronics R&D center near Moscow and opened their first microelectronic production plant. With extensive use of Western integrated circuit (IC) precision machinery and production technology, the Soviets series-produced ICs, or chips, at the small-scale-integration (SSI) level of complexity by the early 1970s, medium-scale-integration (MSI) chips in 1975, and large-scale-integration (LSI) chips in 1977. They recently have produced a limited number of devices at the very-large-scale-integration (VLSI) level. Today they operate 75 microelectronics production plants, compared with roughly 200 in the United States and 100 in Japan.

Deficiencies in Soviet production technology are holding back advances in circuit complexity. At the LSI and VLSI levels, sophisticated equipment is required to reproduce accurately the extremely small circuit line widths. The Soviets also are experiencing shortages of advanced, automated manufacturing and test equipment, especially in design, photolithography, and mask making, and of clean-room equipment, necessary to maintain material purity.

According to US estimates, the USSR has imported—legally and illegally—up to 100 million ICs a year in the past few years. This is about 10 percent of potential Soviet production capacity from installed equipment and about 1 percent of US IC production. Because Soviet production yields are low, imports account for substantially more than 10 percent of actual Soviet production of sophisticated devices. Imports are generally of higher quality than Soviet-produced ICs and have considerably higher reliability. In the past 10 years the Soviets also have imported 2,500 pieces of major manufacturing equipment, most of it illegally. These efforts to upgrade production technology cost more than $250 million.

Progress in domestic production coupled with foreign support cut the West's lead in microelectronics technology from eight to 10 years in the mid-1970s to approximately four to six years in 1985. The latest generation of Soviet SAM systems and fighter, interceptor, and bomber aircraft all employ microelectronic circuitry. 25X1

Computers. The promise that computers would increase the efficiency of central planning and economic control encouraged Soviet development of the computer industry in the 1960s. In 1967 the Soviets adopted the architecture of the IBM System/360 computer for their standard mainframe computer—the Ryad. Ryad models became available in 1973, and a second generation—known as Ryad-2 and copied from the IBM System/370—became available in the late 1970s. A parallel program produced the first minicomputers in 1974 and microcomputers in 1976. 25X1 25X1

The USSR has been slow to apply computers to process control, stock control, machine tool control systems, and especially product design systems (CAD). According to analysis of Soviet open literature, only 8 percent of all Soviet industrial facilities had mainframe computers in 1984, including one-third of facilities with over 500 employees. By comparison, nearly all US industrial facilities with more than 100 employees have computers. Aside from equipment shortfalls, slow software development (especially for machining operations and computer-aided design) and severe shortages of programers and repair technicians have constrained applications. 25X1

Although the USSR now has modern, unified computer systems, its progress in computer technology and production has been dwarfed by advances in the West and Japan. The Soviets lag the West by an estimated seven to eight years in mainframe technology and four to six years in the development of minicomputers and microcomputers. 25X1

Automated Management Systems and Telecommunications. The development of the computer and microelectronic industries allowed the Soviets in the late 1970s to begin introducing automated management 25X1

systems (ASUs) on the plant, regional, and national levels. The Soviets have plant ASUs for economic, administrative, inventory, and product planning and for process control. By 1975, the USSR had installed 4,400 systems of all types. We cannot fully assess the overall impact of these plant ASUs, but reported shortages of reliable computer hardware and software, managerial resistance, and the failure to fully integrate these systems into industrial operations suggest that the introduction of this new technology is still at an early stage.

Part of the difficulty the Soviets have had with ASUs originates in the telecommunications links between plants and other organizations in larger ASU networks. The Soviet civil telephone system, based on analog transmission and electromechanical or manual analog switches, provides notoriously poor service characterized by high transmission error rates and unreliable connections. Linking Soviet computers over distances greater than a few kilometers requires installing separate, dedicated communications links. Even equipment used to pass data without a direct computer-to-computer link is limited to slower transmission rates than are typical in the West.

The Soviet leadership has only recently initiated a program to upgrade the national civil communications system to standards sufficient to support integrated industrial automation. Digital transmission will be instituted throughout the national system, with computer-controlled digital switching at local and regional centers, and major coaxial cables will be replaced with fiber-optic lines. The USSR apparently intends to support the program with substantial technology imports, including digital and optical transmission equipment from France and Japan and large and small computer-program-controlled digital switches from France and Finland.

The expansion of digital service beyond a few local areas, however, will require series production or large purchases of complex electronic and computer equipment of the general type the Soviets have had difficulty producing up to now. Completion of the entire network, including long-distance links among digital "islands" in major cities, within the period of the plan will require a massive investment in new equipment and a considerable expansion of communications equipment production. Even if implemented according to schedule, telecommunications would still lag the West by about 10 years and be out of step with development in the other advanced industries. We believe telecommunications is the least developed of the technologies required for broad-based Soviet industrial modernization. 25X1

Implications

The Soviets have made substantial progress in developing the technology base necessary to support broad application of automated manufacturing. However, 25X1
they now face an even more formidable challenge in trying to close the gap in these technologies or even to avoid falling further behind. Their advances have relied on a brute-force approach focusing national priority, scarce resources, and high-level management attention on technology development and emphasizing imports and illegal diversion. Continued reliance on foreign technology will provide substantial benefits but will yield diminishing returns in closing the gap with the West because of the inherent lag in assimilating acquisitions into Soviet support industries. Western export controls force the Soviets to rely more on illegal acquisitions, which deny or impair the technical contacts and training so necessary in high- 25X1
technology industry to transfer manufacturing "art." Integrated applications of the technologies in manufacturing requires that they be tailored to Soviet industrial conditions, so Western experience, short of large-scale construction of turnkey plants, will be of less direct benefit to the Soviets. 25X1

Diffusion of these technologies will largely determine the impact on industrial modernization, and success in assimilating them will depend in large measure on overcoming systemic problems in Soviet industry. Implementing advanced manufacturing technologies is hindered by the problems that frustrate Soviet innovation generally, including cumbersome planning 25X1
and prices that do not adequately reward improved quality. Gorbachev and the central leadership that he is assembling recognize the challenges confronting Soviet industry, particularly its systemic problems, but they have not yet worked out a consistent set of policies to deal with them. 25X1

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Modernizing Basic Industries

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The Soviet emphasis on intensive growth directly affects the basic industries. Because of the sharp increase over the last 10 years in the costs of extracting and processing raw materials, the Soviets are waging a campaign to reduce the consumption of these materials throughout industry. In his speech to the June 1985 CPSU conference on S&T progress, Gorbachev emphasized the importance of such resource savings, which would stabilize the share of investment devoted to extraction of fuel and raw materials and free more investment funds to support the drive for modernization. In the past decade, investment in basic industries has changed very little (see table). The rising cost of raw material development has limited the ability of the basic industries themselves to devote investment to improvements in the quality of products or the efficiency of processing. These efforts are needed to reduce their own consumption of raw materials and energy and to produce the higher quality materials required by the modernization effort.

An examination of recent developments and trends in three of the basic industries—chemicals, steel, and construction materials—reflects these imperatives. Although their development programs are individually tailored to meet their own peculiar needs, they all emphasize improving the quality and variety of output, reducing the consumption of raw materials and energy, and importing Western technology when alternative sources are deemed inadequate.

Chemicals

The Soviets are trying to raise the efficiency of the chemical industry by increasing mechanization and automation and introducing advanced technology. This industry is critical to fulfilling plans for boosting agricultural productivity, improving the quality and increasing the quantity of low-cost consumer goods, and creating new industrial and defense-related materials. The Politburo recently examined a comprehensive program for the "chemicalization" of the Soviet economy during 1986-2000. Although details have not yet been released, the program calls for a substantial increase in production of fertilizers, pesticides, plastics, and chemical fibers.

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To boost the efficiency of the chemical industry, the composition of output is being redirected toward the production of close substitutes for those products that require large amounts of energy and toward production processes for certain basic chemicals that are less energy intensive. For example, the Soviets can save energy by producing more synthetic than artificial fibers or by producing more caustic soda by the diaphragm method rather than the mercury method.

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Since the 1960s the chemical industry has been dependent on Western technology to meet expansion and modernization goals. During the 1970s, Soviet orders of Western chemical equipment and technology amounted to about $9 billion—some 30 percent of total equipment orders from the West. After a lull in such purchases during 1981-84, the Soviets are returning to the plant-contracting market. Over the last year or so, Western contractors have received inquiries for new turnkey chemical projects in the USSR totaling $5 billion. In addition, some existing plants will be modernized with Western assistance.

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The introduction of Western equipment and technology in the chemical industry has paid off, despite initial problems caused by poor planning and inexperience with the installation, operation, and maintenance of complex equipment. Western equipment is now contributing substantially to Soviet output of several major products, including ammonia, fertilizers, plastics, and synthetic fibers. In some cases, Western equipment and technology have provided sizable savings in construction and production costs, including economies in labor. For example, ammonia plants incorporating imported Western technology use only 5 percent of the electricity and one-third or less of the workers per ton of output required by older Soviet-designed plants.

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USSR: Investment by Branches of Industry

Billion 1973 rubles

	1971-75 [a]	1976-80 [a]	1981	1982	1983	1984
Total industry	34.5	44.8	49.5	50.9	53.7	55.3
Basic industry	9.2	11.1	10.8	10.9	11.4	11.2
Ferrous metals	2.6	3.0	3.1	3.2	3.3	3.0
Chemicals/ petrochemicals	3.1	4.4	3.8	4.0	4.1	4.3
Wood products	1.1	1.2	1.3	1.3	1.4	1.4
Pulp and paper	0.5	0.6	0.6	0.6	0.6	0.5
Construction materials	1.9	1.9	2.0	1.8	2.0	2.0
Fuels and power	9.7	13.2	16.6	17.7	18.7	19.6
Machinery	7.7	11.0	12.4	12.5	13.3	13.6
Other [b]	7.9	9.5	9.7	9.8	10.3	10.9

[a] Annual average.
[b] Includes the light and food industries, nonferrous metals, and some miscellaneous industries such as glass and porcelain.

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Steel

Modernization of the Soviet steel industry since the late 1970s has aimed at improving the quality of steel, expanding the assortment of products, and increasing efficiency. The Soviets have attempted to achieve these goals largely by increasing productive capacities using modern equipment and technology. The 10th and 11th Five-Year Plans called for new facilities to be built at existing plants and for construction of new integrated steel complexes. To help with their modernization effort, the Soviets have sought Western steelmaking equipment and technology.

The Soviets have achieved some success in renovating their steel industry. Dependence on inefficient open-hearth furnaces has decreased about 13 percent since 1975, largely because of greater use of basic oxygen furnaces. More quality steel sheet is available, largely because of the new rolling mill at Novolipetsk built by West Germany and Japan. The minimill at Zhlobin, built by Italian and Austrian firms, is now providing high-quality construction steel to Belorussia. These newer steel facilities have a high proportion of automated operations.

The modernization path, however, has not been entirely smooth. Gorbachev replaced the Minister of Ferrous Metallurgy in July after complaining that the ferrous metals industry would not fulfill its 11th Five-Year Plan targets because investment was concentrated on new construction instead of "technical reequipment." Also, the share of steel produced in electric furnaces has fallen far short of plans.[1] Part of this failure is due to continuing delays plaguing the Oskol Electrometallurgical Complex, which is being built with West German equipment and technology. The steelmaking facilities at Oskol were to be finished by 1979, but delays caused by an inefficient management system, deterioration of equipment already delivered but not yet installed, and purchasing and distribution problems have pushed back the estimated completion date to 1988.

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[1] Electric and basic oxygen furnaces permit the greatest control of temperature and chemistry and are best suited for producing high-quality steel. Also, steel is produced in smaller, more rapidly produced batches, which can be tailored to a wide range of consumers' specifications.

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The industrial investment strategy already laid out for 1986-90, which will emphasize reconstruction rather than new construction, apparently will apply to the steel industry. According to the Soviet press, 50 percent of investment will be used to renew existing plants, 30 percent will go toward improving product quality, and only 20 percent will finance expansion of capacity. This is in sharp contrast with past five-year plans, which allocated 75 percent of investment to physical growth. This investment pattern, together with Gorbachev's statement in his *Time* interview that he will not continue the traditional pressure to raise the output of such basic industries as steel and cement, indicates that overall steel output may remain roughly at current levels over the next five years.

The recently adopted long-term development program for the ferrous metals industry includes:

- Replacing open-hearth furnaces with basic oxygen or electric furnaces.
- Reconstructing older steel plants.
- Increasing the share of steel continuously cast by a factor of 2 to 2.5 (this process saves energy and labor, increases steelmaking efficiency, and improves the quality of the output).
- Expanding the range of steel products.
- Replacing old coke plants.
- Adding new iron ore capacity.

Western firms have landed $1 billion in contracts for the construction of a new steel pipe plant at the Volzhskiy pipe works and have reached the bid stage on the construction of a new rolling mill at the Orel steel works. In addition, Western firms probably will be involved in the reconstruction phase of the program—negotiations have already begun for some deals.

Construction Materials

The Soviets hope that productivity gains in other industries and sectors of the economy and the emphasis on reequipment rather than new construction will reduce the need for construction materials. Accordingly, they are devoting more attention to increasing the efficiency of the construction materials industry than to expanding its output. Improved refractory materials, for example, are required by the metals industry. The Soviets are also attempting to shift a larger share of cement production from the "wet" method to the "dry" method, which uses much less energy. 25X1

To make significant improvements in efficiency, however, Moscow needs to make a substantial investment in new machinery and equipment. So far, there are no indications that the necessary investment funds will be allocated. Moreover, the Soviets probably will not devote large amounts of hard currency to this effort, although small amounts will probably be used to bridge temporary gaps in supply for important products. 25X1

Outlook

The programs Moscow has tailored for the basic industries are both sensible and necessary strategies if the Soviets are to achieve their modernization objectives. Expanding output of chemicals has a high payoff for both the consumer and heavy industry. Sacrificing output volume for better quality goods and wider variety of products in metallurgy will reduce waste and more closely meet the needs of the builders of modern machinery. Holding down the growth in output of construction materials and general purpose steels chokes off excess capital construction and releases more investment for new machinery. All of these programs embody important resource-saving strategies. 25X1 25X1

In the past, the Soviets have failed to implement similar programs and investment policies, but the outlook for change may be brighter today. Gorbachev is the most aggressive economic manager since Khrushchev. He may capture the attention of management through punitive measures alone. Also, the entire economy—from defense industries to the consumer—is now more aware of resource constraints. However, there are still hurdles to clear. The incentive system for managers and workers alike, which in the past was largely responsible for failing to spur resource savings and the introduction of new technology, is still basically unchanged (see article "Gorbachev's Strategy"). Moreover, these basic industries during 1986-90 will be in tough competition for investment resources and foreign exchange with priority sectors such as machine building and energy. 25X1

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Acquiring Western Technology

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Western Technological Support—A Long History

Western technology has contributed heavily to Soviet industrial modernization since the 1920s. Civilian industry benefited from massive imports in the 1930s and again in the 1970s. Imports included major turnkey projects that effectively built major portions of such key Soviet industries as chemicals, metallurgy, and motor vehicles. Acquisition for the defense industry—much of it clandestine—has been continuous. Use of proven Western weapon design solutions and test data has evidently expedited weapon development, and acquisition of Western manufacturing equipment, processes, and know-how has enabled Soviet defense plants to implement relatively advanced manufacturing approaches many years before similar indigenous capabilities could be developed. Acquisition for both civilian and defense industry consistently has been motivated by the objective of developing Soviet capabilities and avoiding long-term dependence on foreign suppliers.

The priority and pace of foreign technology acquisition increased substantially during the mid-1970s because of several factors. Liberalized export controls in an era of detente, overdue modernization of key basic industries, strong hard currency earnings, and pressing military technology needs all were significant. Flush with earnings from exports of energy sources and raw materials, the Soviets sought Western plant and equipment to alleviate developing bottlenecks in long-neglected basic industries and to improve industrial productivity. military writings during the early and middle 1970s also indicate that Soviet leaders were becoming increasingly concerned about the ability of the military-industrial complex to compete in a high-technology arms race with the United States. The technologies required—digital electronics, phased-array radars, sensors, sophisticated guidance and navigation systems, composite materials, computers, and signal-processing equipment—were relatively new to Soviet industry and required unusual sophistication in development and manufacturing. Defense industry efficiency was also a consideration, inasmuch as the cost of advanced systems was escalating while Soviet economic growth was beginning to slow markedly.

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The Acquisition Process

In the 1970s the Soviets increased the priority and support of their technology acquisition efforts for both defense and civilian industries. They created an interlocking network for overt and covert acquisitions.

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State Planning Committee (Gosplan) approves funding for all of the major acquisitions. Both programs use some of the same international trade and scientific organizations as collectors;

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Acquisition for defense programs, however, generally benefits from advantages in collection tasking, funding, and exploitation.

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Generating Requirements. The Soviets generate and process requirements for overt and covert acquisitions in much the same way. Prospective users usually originate requests and pass them up through ministry channels, where they are subject to review, justification, and approval. Sufficiently large or important acquisitions are considered by national-level organizations.

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Research institutes, design bureaus, and industrial plants with defense connections usually have several advantages over their civilian counterparts. They have access to detailed information on Western technological trends and developments that their counterparts only rarely enjoy.

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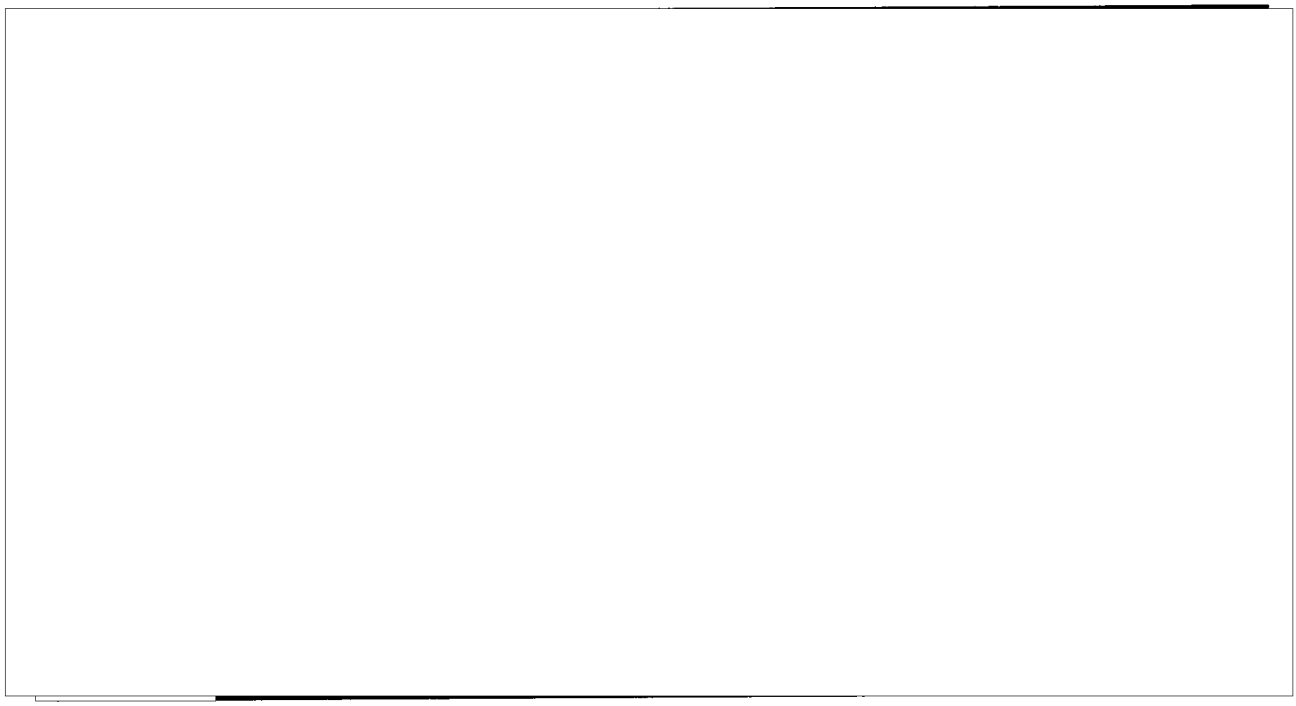

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The defense-industrial sector maintains generic standing requirements for Western design and production equipment and documentation that generally receive priority treatment. Defense-related acquisitions also benefit from centralized management of the requirements process provided by the Technical Center of the All-Union Institute for Inter-Branch Information (VIMI). VIMI documents and assigns priority to acquisition requests submitted to the VPK and disseminates documentary and hardware acquisitions.

Securing Funding. Proposed acquisitions are assessed in terms of prospective benefits and the availability of funding. Benefits are determined on a case-by-case basis, but, as indicated previously, national defense has priority. As a commission of the Council of Ministers, the VPK can unilaterally mandate an acquisition of overriding national priority.

The allocation of funds—generally hard currency—depends on the type of acquisition and the user. Plants and ministries usually maintain small reserves of hard currency, and Gosplan can approve and support larger authorizations. If the VPK assigns a high priority to an item, it can draw upon the nationally allocated funds it controls. The GKNT provides central control by authorizing outlays of hard currency for technology acquisitions.

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Approved acquisitions then proceed along one of two paths. Soviet organizations negotiate contracts for overt imports with the intervention of the appropriate foreign trade organization.

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Monitoring Assimilation and Exploitation. The Soviets monitor and report on progress made in assimilating new technologies acquired overtly and covertly through much the same channels. In most ministries one or more lead R&D organizations coordinate the

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USSR: Hard Currency Imports and Energy-Related Orders

Billion current US $

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Total imports	14.6	15.2	14.0	16.9	21.6	20.1	27.8	27.5	27.7	27.4
Machinery and equipment imports	4.6	5.1	5.1	6.0	6.0	6.0	4.5	6.1	7.0	5.8
Total machinery and equipment orders [a]	4.8	5.9	3.8	2.8	2.7	2.7	6.8	3.8	2.2	1.1
Energy-related equipment orders	0.5	1.5	0.3	0.8	0.2	0.4	4.3	1.3	0.8	0.07

[a] Orders represent signed contracts in a given year, deliveries for which run from a few months to several years.

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ministry's exploitation of any acquired technology that has broad applications across product lines. These lead organizations work closely with plants and design bureaus in assimilating the technology, sometimes over several years.

The system for tracking the impact of foreign acquisitions responding to VPK military requirements is pervasive, uniform, and aggressively implemented. Ministries must evaluate acquired technology hardware or intelligence information within a certain time and report to a centralized information network on their plans for applying it to their own projects. Later they must report on how those projects have been affected. Although this is done systematically in the defense sector, followup in the civil sector appears to be more haphazard. Reporting is likely to vary according to the industrial ministry involved and is often not subject to central control and followup.

Effectiveness of the Program

Foreign technology has contributed substantially to increasing production capacity and improving product quality in both civilian and defense industry. The hard currency costs have been high, however. As the table shows, hard currency outlays for imports of machinery and equipment exceeded $4 billion annually by the mid-1970s and rose to more than $6 billion in the early 1980s. This surge resulted almost entirely from sharp increases in orders for energy-related machinery and equipment. During the 1970s, imports of computers and associated equipment totaled $400 million, and imports of microelectronics technology totaled several hundred million dollars. We also estimate that, since the mid-1970s, ruble outlays for the VPK military-related covert acquisitions have averaged the equivalent of several hundred million dollars annually if converted at the official exhange rate. From 1975 to 1980 these outlays supported acquisition of at least 400,000 technical documents and 30,000 hardware samples.

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The impact of foreign technology, however, depends on how well the Soviets capitalize on their acquisitions. Here the record is less impressive. As some of the preceding articles have indicated, the Soviets have proved to be relatively slow at assimilating foreign or domestic technology. In acquiring technology overtly, they can strike a relatively quick bargain and ensure rapid Western deliveries, but must then confront the problem of overcoming generally unresponsive construction and installation bureaucracies and resistant plant managers. Conversely, for covert technology, the high priority, substantial funding, and systematic

followup by VPK managers can overcome domestic resistance, but more time usually is required to find and obtain the Western item.

The impact of acquired technology—at least on industrial modernization—depends especially on how quickly and widely it is diffused. In this regard, overt acquisitions probably have an edge. Secrecy limits diffusion of military-related technology outside the defense-industrial community. Moreover, technology overtly acquired—particularly manufacturing technology—is usually more generally applicable. Diffusion of openly acquired technologies provides for fundamental technological progress in industries serving both defense and civil needs. Progress in the Soviet computer and steelmaking industries, for example, is primarily due to the legal purchases of Western technology.

For industrial modernization, overt acquisitions have clear advantages in terms of the size and effectiveness of the transfer. The Soviets are able to purchase entire turnkey facilities, with all necessary tooling and supporting facilities, while covert acquisitions of production equipment are selective and usually limited in scope. As part of overt acquisitions, the seller can be asked to provide predelivery training, often in the vendor's plant where the equipment is being produced. The seller's engineering personnel can supervise installation, calibration, training, and startup, and troubleshooters can be dispatched to deal with subsequent problems. Conversely, even the origin of covertly acquired equipment is often concealed from the user, and the manufacturer usually is not permitted access to the facilities where it is used. As a result, a large share of covertly acquired equipment achieves only a part of its potential and is sometimes not even installed or operated.

On the other hand, covert acquisition is often the only way to overcome Western export controls, and such acquisitions provide substantial benefits to critical industries such as computers, microelectronics, and telecommunications. Covert acquisitions, in documented cases, have enabled the Soviets to advance specific manufacturing technologies by as much as 10 years. The Soviets try to mitigate the disadvantages of doing without Western training and assistance by maintaining large R&D centers—such as that at Zelenograd for microelectronics—equipped and staffed for indigenous development, exploitation, and reverse engineering. For example, Soviet successes in the microelectronics industry are attributable in part to such efforts, but they are costly, time consuming, and generally less effective than dealing directly with Western firms. 25X1

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Outlook

The extent to which the Soviets will turn to the West to support Gorbachev's modernization program is still unclear, but the record of imports and covert acquisitions suggests that Western technology will continue to be vital. Past dependencies assure future dependencies in key technologies critical to modernization. For example, most Soviet computers are based on Western models, and technology in the microelectronics industry is nearly completely of Western origin. 25X1
Moreover, Gorbachev has signaled his intention to continue turning to the West to aid programs—such as computer literacy—that support modernization. On the military side, ongoing Western programs such as Stealth and the Strategic Defense Initiative, along with advances in such key technologies as electro-optics, fire control, and missile guidance, indicate the Soviet covert acquisition program probably will be at least as aggressive as it has been since the 1970s.

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There are, however, few indications of a major upsurge in the overall level of imports. Although the Soviet hard currency position currently is strong, soft prices for major export items such as energy, commitments to client states, and other considerations suggest the Soviets will not have the reserves to sustain large increases in imports. Soviet scientific literature indicates, moreover, that there is some resistance to importing Western technology. Soviet scientists and 25X1
engineers argue that they can do the job and probably believe that Western acquisitions undermine indigenous technology development programs. For his part, Gorbachev has called only for more "rational" concentration of imports on key projects. As in other aspects of his modernization program, Gorbachev apparently feels that much more can be obtained through improved use of existing resources. Moreover,

we believe that the Soviets' campaign-style efforts to solve critical technology bottlenecks by pouring massive resources into large, high-priority projects—while effective in basic industries—would not be highly effective in high-technology industries. [redacted] 25X1

Western export controls and enforcement policies—and trade policy generally—also will weigh heavily. Export controls hit especially hard in the "dual-use," high-technology areas of computers and microelectronics and their use in the advanced manufacturing technologies crucial to the modernization program. Aggressive enforcement of export controls by the West could curtail open trade and thereby increasingly shift the focus of acquisition to covert channels.

[redacted] 25X1

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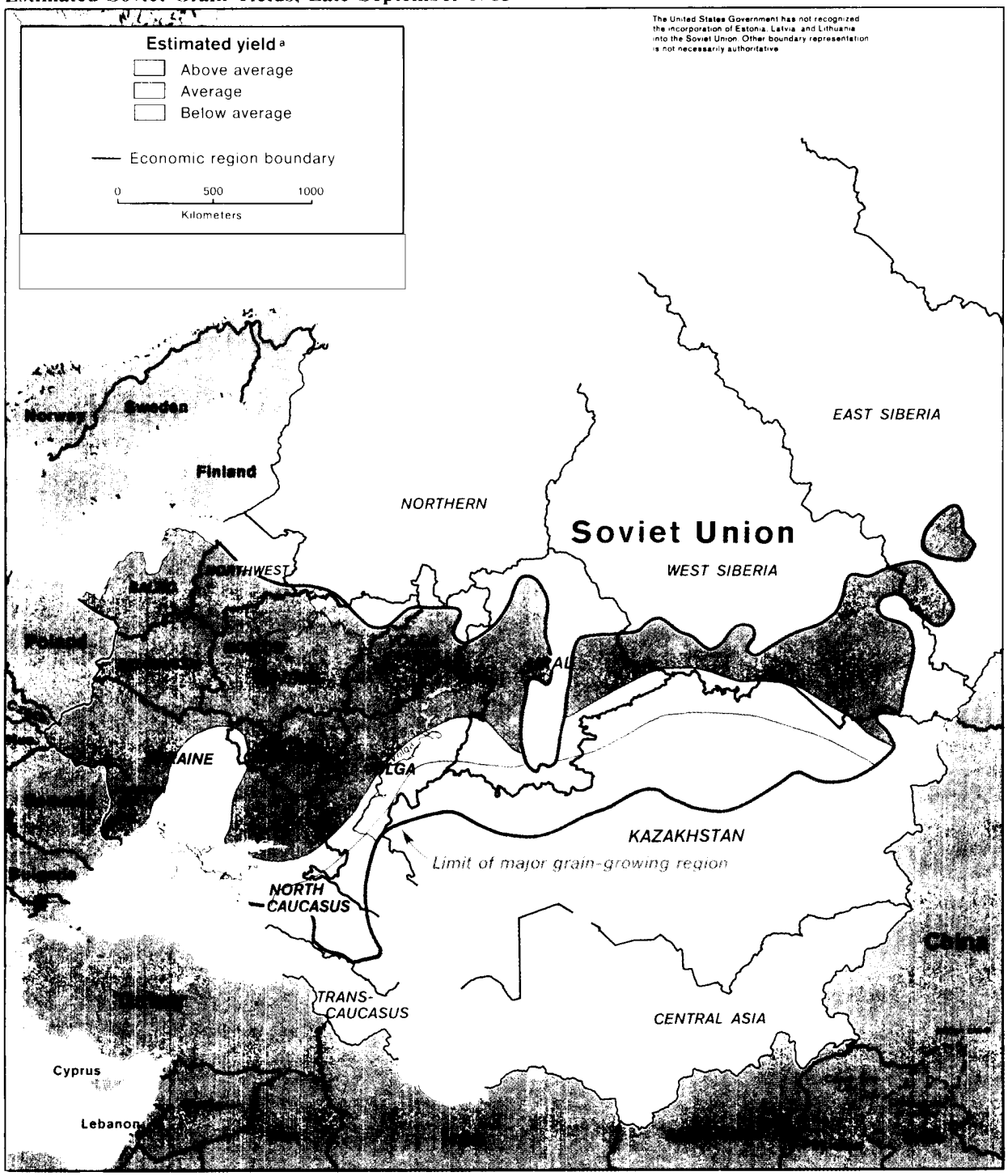
Figure 1
Estimated Soviet Grain Yields, Late September 1985



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Other Topics

Good Grain Crop Cuts Soviet Import Needs

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With the harvest nearing completion, the USSR appears headed for a grain crop of some 200 million tons, its best since the 1978 record of 237 million tons. Prospects are also good that the production of forages—a major livestock feed—will reach an alltime high, providing the basis for further growth in livestock products. As a result, total agricultural output in 1985 probably will exceed the 1983 record. Production at this level will benefit both the population—by improving supplies of quality foods—and General Secretary Gorbachev—by permitting him to claim credit for getting the Food Program back on track. The good crop-year also means that Moscow may need to import only about half of the record 53 million tons of grain purchased last year to meet its estimated domestic requirements. US grain sales to the USSR may plunge by more than 50 percent from last year's peak of some 22 million tons.

Crop Developments

Prospects for well-above-average grain yields have been partly offset by the fact that the area sown to grain this year is the smallest in over a decade. As a result, given normal weather for the rest of the season, the 1985 Soviet grain crop is likely to be about 200 million tons, 20 million tons larger than both last year's estimated output and the estimated average for 1980-84, but well below the 1978 record of 237 million tons.[1] The US Department of Agriculture currently forecasts the crop at 190 million tons. Estimates by other Western grain analysts range from 180 million to 200 million tons.

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The 1985 crop season got off to a good start last fall, and overall crop prospects remained bright through this spring and summer. There were some developments, however, which we believe cut the potential size of this year's grain crop by some 25 million tons. Most damaging were several periods of hot, dry weather in the Volga Valley, North Caucasus, Ukraine, and Kazakhstan. Continuation of the downward trend in total grain hectarage—begun in the late 1970s—also contributed.[2] We estimate that since 1978 the combination of adverse weather and declining grain hectarage has cost Moscow an average of roughly 55 million tons of potential grain output annually.

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The outlook for selected forages—hay, haylage, silage, and grassmeal—is excellent. According to Soviet data, forage procurements as of late September were running 5 percent ahead of the record 1983 pace, overcoming a gap of nearly 30 percent that existed in early July. Given this performance, we believe that,

[1] The 200-million-ton figure is our best estimate of the 1985 crop. On the basis of our analysis of best and worst case scenarios, there is a 90-percent probability that the crop will come in between 190 million and 210 million tons and a 75-percent chance that it will be between 195 million and 205 million tons.

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[2] The cutback in grain area appears to be a consequence of Moscow's policy to greatly expand the amount of arable land put into fallow. Between 1977 and 1984, the harvested grain area of the USSR declined steadily from a record high of 130.4 million hectares to 119.6 million, while fallow increased from 11.7 million hectares to 20.1 million.

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USSR: Grain Production [a]

Million tons

	Actual 1976-80 Average	Estimated [b]				
		1981	1982	1983	1984	1985
Total	**205.0**	**158.0**	**180.0**	**195.0**	**179.0**	**199.0**
By Republic						
RSFSR	113.9	78.0	99.5	112.0	94.5	112.0
Ukraine	43.1	38.2	42.0	39.0	44.5	43.0
Kazakhstan	27.5	23.8	19.5	25.0	17.5	21.0
Other	20.5	18.0	19.0	19.0	22.5	23.0
By crop						
Wheat	99.7	81.0	90.0	80.0	77.0	88.0
Coarse [c]	95.1	68.0	80.0	102.0	92.0	99.0
Other [d]	10.2	9.0	10.0	13.0	10.0	12.0

[a] Measured in bunker weight, that is, gross output from the combine, which includes excess moisture, unripe and damaged kernels, weed seeds, and other trash. For comparison with United States or other countries' grain output, an average discount of 11 percent should be applied.
[b] The USSR has not published overall grain production or yield statistics since 1980. Total grain production in 1981 was unofficially reported at 158 million tons. Data for Kazakhstan for 1981 and 1982 are official. All other figures represent our estimates.
[c] Coarse grains comprise rye, barley, oats, corn, and millet.
[d] Other grains include pulses, buckwheat, and rice.

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unless the weather deteriorates markedly in the coming weeks, forage production will set a new record this year. Since harvested forages constitute slightly more than one-half of the nutrient content of the Soviet livestock ration, the outlook for feed supplies is quite good.

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Remaining Uncertainties

Although all evidence suggests that the 1985 Soviet grain crop will be the largest since 1978, there remains some uncertainty regarding its exact size. Excessive rainfall during the final few weeks of the harvest could seriously hamper combining operations and lead to losses in both grain quantity and quality. Moreover, because the harvest is running about one week late, slightly more grain than normal would be lost if an early snowfall precluded its completion. The latest Soviet harvest progress report indicates that a maximum of only some 10 million tons of grain are at risk.

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Other factors could boost this year's grain production above 200 million tons, perhaps by as much as 10 million tons. We estimate that the amount of grain growing on land that was previously fallow increased again this year, continuing the upward trend begun in the late 1970s. Although fallowing sacrifices production in the year in which the land is idled, it usually results in higher, more stable yields in subsequent years as long as the fallowed hectarage is maintained in the crop rotation schedule.

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In addition, Moscow almost certainly will realize some benefit from a large-scale program in intensive

wheat cultivation that is being undertaken on some 17 million hectares—nearly 15 percent of the area sown to grain. According to Soviet press reports, Moscow has purchased large amounts of Western insecticides, herbicides, and fungicides in an attempt to raise average wheat yields by 1 ton per hectare on the intensively cultivated area in the RSFSR, Kazakhstan, and the Ukraine. Because of the experimental nature of the program, we have been conservative in incorporating potential gains into our 200-million-ton figure. Problems with deliveries of the chemicals to farms and with field applications will hold this year's results well below the planned increase of 16 to 18 million tons. But, even so, sizable gains of 5 million tons or more are possible because many of the test areas experienced favorable growing conditions this year.

Soviet Grain Requirements and Imports

The Need for Grain. A much-improved grain crop this year, coupled with Moscow's apparent success in restraining growth in the use of grain for livestock feed and prospects for a record forage crop, means that Soviet grain import needs during the marketing year (MY) that began on 1 July will be down sharply from a year ago. During MY 1984/85, the USSR imported roughly 53 million tons of grain, a new record. Assuming a 200-million-ton grain harvest this year, Moscow would be only some 25 to 30 million tons short of the quantity of grain we believe is necessary to maintain recent levels of seed, food, and industrial use and sustain growth in meat and dairy products.[3] This figure could be somewhat less if livestock feeding efficiencies continue to improve, as we believe likely.

Slack Grain-Buying Activity. Soviet grain purchases thus far in MY 1985/86 are running well behind last year's record pace. By the end of September, Moscow had lined up only some 12 to 13 million tons of grain

[3] Because the USSR measures grain production from the field before cleaning and drying, our bunker-weight estimate of output must be reduced by an average of 11 percent to be comparable with the international standard weight measure for seed, food, imports, and other items. The discount varies according to moisture conditions prior to and during harvest and according to crop size, and thus can become either larger or smaller than average as the season advances. Our currrent estimates indicate a standard-weight crop of roughly 180 million tons (given a bunker-weight crop of 200 million tons) and consumption needs of about 205 to 210 million tons.

Soviet Agricultural Policy Under Gorbachev

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Soviet agricultural policy under the new leadership of Mikhail Gorbachev appears to be basically in keeping with that of his three predecessors. The General Secretary's public statements indicate that he continues to endorse the Food Program—which he played a key role in formulating—and strongly supports:

- *Reorganization of farm labor into small, semiautonomous units that operate on the basis of contracts with state and collective farms and are paid according to what they produce.*
- *Self-financing—a system whereby farms finance operations out of earnings—as a means of improving managerial accountability and initiative and farm productivity.*
- *Private agriculture, recognizing that this sector provides substantial quantities of quality foods such as meat, vegetables, and fruit—albeit with the help of state resources.*

Gorbachev's one major departure from past policy is his push to shift resources away from direct investment in farms, such as in the construction of large-scale livestock complexes, toward development of the rural infrastructure (storage, transportation, and housing) and supporting industries, particularly agricultural machine building. Recognizing that better storage facilities and transportation could reduce considerably the enormous waste and spoilage of Soviet agricultural products, Gorbachev has made it clear that some shifting of investment funds will be included in the forthcoming five-year plan for the 1986-90 period.

Although by no means assured, implementation of these measures, combined with what we anticipate will be increasing imports of Western farm technology and equipment, could markedly improve the USSR's crop and livestock production and thus bring more food to Soviet tables. The potential gains, however, would be several years in the making and would be dampened by more fundamental problems plaguing Soviet agriculture. For example, farms will continue to face chronic shortages of agrochemicals and equipment, low labor productivity, and high production costs for the foreseeable future.

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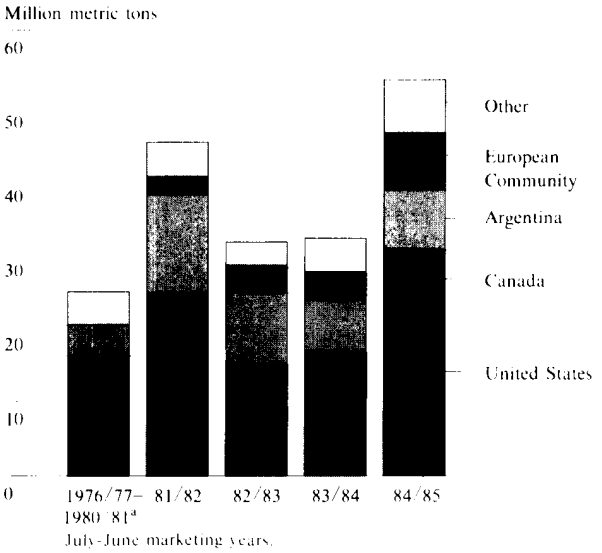
Figure 2
Grain Exports to the USSR, 1976/77-1984/85



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for shipment during the current marketing year compared with about 24 million tons a year ago. Moreover, the USSR reportedly has bought only 2.7 million tons of US corn, in marked contrast to last year at this time when total purchases from the United States already stood at over 12 million tons. Moscow's abstention from the US wheat market comes despite high-level Soviet assurances given to Agriculture Secretary Block in late August that it would buy the remaining 1.1 million tons of wheat called for under the US-USSR grain agreement before 1 October. As a result, Moscow is now no longer in strict compliance with the terms of the second year of the accord.

The USSR's reduced grain-buying activity probably reflects more than just lower import requirements. World grain markets are soft—prices are at their lowest level in several years and exporters are anxious to sell off burdensome stocks—thus putting Moscow in a good bargaining position. Moscow's ability to play the market is somewhat limited, however, by various long-term agreements (LTAs) and protocols that commit the USSR to buy some 20 to 23 million tons of grain in MY 1985/86.[4] 25X1

The slow buying to date does not necessarily mean that imports during MY 1985/86 will fall to the 25- to 30-million-ton minimum implied by estimated domestic needs. Purchases of this magnitude are already virtually assured because of LTAs and recent trading patterns that suggest the Soviets probably will buy another 6 million tons of grain outside LTA obligations from countries such as Argentina, Australia, France, India, and China. Given the favorable market situation for grain buyers, Moscow could choose to import even larger amounts of grain and thereby expand the livestock sector beyond plan or add more grain to stocks. Even so, estimates of up to 41 million tons by grain traders, who generally see a somewhat smaller Soviet grain crop, appear, in our view, to be on the high side at this time. 25X1

Few Import Constraints. The USSR should encounter few constraints—either financial or logistic—on importing the amounts of grain it needs this marketing year. Although hard currency earnings probably will be down about 10 percent as a result of lower oil and gas revenues, Moscow may be able to offset part of these losses through increased exports of gold, diamonds, and platinum. In addition, world grain prices are low, Western credits and loans are readily available, and grain imports from India and China—perhaps 2 to 3 million tons—are largely on a barter basis.[5] As for logistics, the massive grain import program in MY 1984/85 proved that the Soviets have greatly reduced the transportation bottlenecks that previously curtailed grain shipments to the USSR. 25X1

25X1

[4] Recent actions indicate that Moscow may be readjusting its thinking on LTAs in light of the growing competitiveness of world grain markets and its own long-term hard currency outlook. For example, in negotiations with Argentina, which is competing for a larger share of the Soviet market, Moscow has resisted pressure to increase commitments. 25X1

[5] The USSR is trying to expand its soft currency or barter grain trade with these two countries, but neither can presently guarantee long-term availability of exportable grain. 25X1

Implications

The prospect of a sizable drop in Soviet grain imports during the current marketing year means that US sales will fall well below the record 22.3 million tons exported in MY 1984/85. While some additional purchases of US corn are likely in the near term, Moscow could stay out of the US wheat market for several more months and still be able to meet its import needs for the marketing year as well as its obligations under the third year of the US-USSR grain agreement, which began on 1 October. If so, US wheat prices f.o.b. Gulf—already at their lowest level since 1978 in nominal terms (not adjusted for inflation) and since the early 1930s when adjusted for inflation—could decline further. Moreover, total US corn exports during the marketing year could be adversely affected should Moscow begin substituting low-priced wheat—from the United States or other exporters—for corn. [redacted] 25X1

On the Soviet domestic front, the USSR's potentially best agricultural year ever carries with it some favorable implications for Soviet consumers as well as for General Secretary Gorbachev. The drop in per capita food supplies that occurred last year should be remedied this year, giving new momentum to the Food Program. More quality food on Soviet tables almost certainly would boost worker morale and productivity, providing an immediate growth dividend to the overall economy. Sizable benefits over the long term, however, will depend partly on continued success in the farm sector, a situation that is by no means certain. Meanwhile, a potential 50-percent cutback in grain imports from a year ago means that the USSR could save as much as $2.5-3 billion in hard currency outlays, helping ease the negative repercussions from the expected downturn in hard currency earnings this year. [redacted] 25X1

[redacted] 25X1

The "Samotlor Disease" Is Spreading

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The "Samotlor disease"—a vicious circle of flagging output from giant oilfields and ever-increasing use of manpower and equipment in an attempt to sustain total oil output—is spreading throughout the West Siberian oil region. Unless large oil finds are made, the costs of oil exploitation in the USSR will rise exponentially.

Developments associated with the aging of Samotlor, the USSR's largest oilfield, are the principal cause for last year's decline in nationwide oil output and for the incipient decline in West Siberian oil output.[1] As Gorbachev noted recently, Samotlor production accounts for half of the 3 billion tons of oil that have been extracted from West Siberia. Yet now one-third of Samotlor's wells stand idle. In the first quarter of 1985, the number of flowing wells in the field declined by nearly one-third, leading to a doubling of the number of inactive wells there. The number of inactive wells reflects the chronic shortage of pumping equipment—a shortage that becomes more acute as the proportion of water (water cut) in the oil-and-water mixture produced from oil wells rises sharply. At Samotlor, the water cut is now 55 percent, compared with about 40 percent in early 1983. The high water content in turn causes additional complications (more corrosion of piping and equipment, more need for storage facilities and separation equipment to handle the water) that boost both the labor and capital intensity of the oil-production effort.

Major Causes of the Decline in Oil Production

Two groups of factors, partly interrelated, are contributing to the spread of the "Samotlor disease." One group—often referred to as "fixable" problems—includes shortages of skilled manpower, poor quality of equipment, and inadequate infrastructure. The second group of factors embraces the aging of several giant oilfields, with the consequent decline of their crude oil output, rapidly escalating water production, and a corresponding surge in demand for pumping equipment, well workovers, and general oilfield maintenance.

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The "fixable" problems have long plagued the oil industry's production effort in West Siberia and most recently were addressed by a Politburo decision in August 1985 and by General Secretary Gorbachev in his September speech in Tyumen'. The Politburo decision calls for increasing construction and assembly work in the West Siberian oil and gas complex by 60 percent in the 1986-90 plan and for providing new working capacity, a more reliable supply of electricity, and improved transportation facilities. The Politburo decision also calls on the factories to improve the quantity and quality of equipment produced for the oil and gas industries. Housing construction in the region—long a factor adversely affecting labor recruitment, morale, and retention—is to increase. The Gorbachev speech stressed these factors, together with greater application of science and technology, improved management, and heightened oversight by local Communist Party units.

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Implementation of these measures can do little to improve output in the short run. In the long run, they can ameliorate operating conditions in the West Siberian oilfields, but this offers only the prospect of slowing the decline in output. A spate of articles in the Soviet press has described the decline in West Siberian oil production, the increased number of idle wells, and continuing problems with poor management. During the period January-July 1985, for example, oil production by Glavtyumenneftegaz (which accounts for about 90 percent of oil output in West Siberia) was reportedly some 15 million tons below plan for the period, because large numbers of wells ceased flowing oil.[2] Although the productivity of well-repair crews

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[1] After reaching 616.3 million tons in 1983, Soviet oil output slipped to 612.7 million tons in 1984 and could well post a further decline, to 595 million tons or less, in 1985.

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[2] The share of West Siberian oil output attributable to the Glavtyumenneftegaz production association decreased from 97 percent in 1984 to about 90 percent in 1985 as the result of the transfer of several oilfields from the operational control of Glavtyumenneftegaz to two Volga-Urals production associations.

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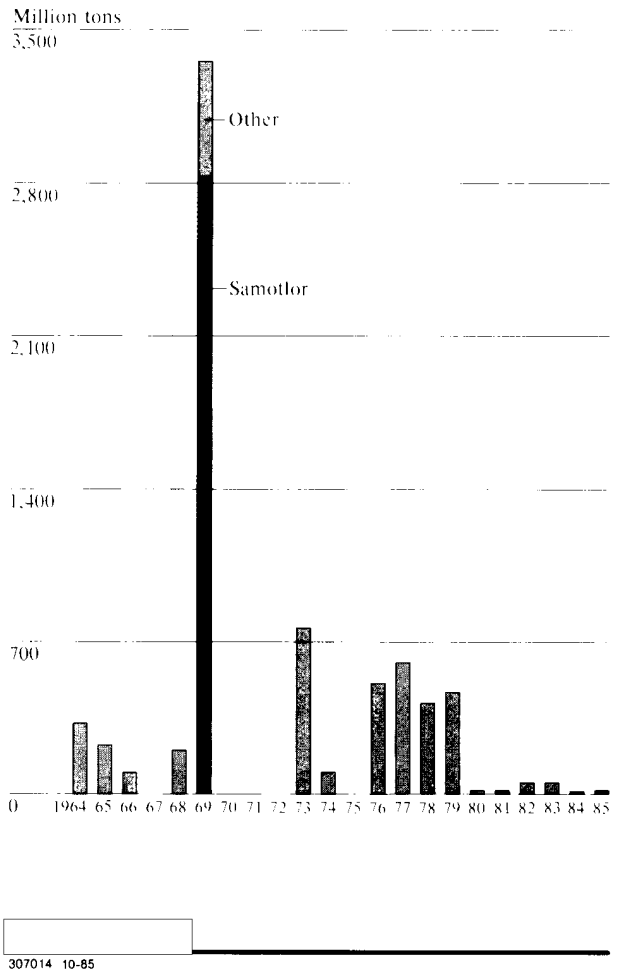
has increased, the number of wells being idled each day outstrips the number being returned to service. Efforts to return the wells to active service are hampered by shortages of equipment. Moreover, the seriousness, extent, and persistence of the oil industry's production problems enumerated by the Soviet media strongly suggest that far more is involved than problems with poor management, labor, and equipment supply. [redacted] 25X1

Indeed, far more is involved. The age distribution of the developed oilfields in the USSR exacerbates the effects stemming from the aging of giant oilfields. A large proportion of West Siberia's developed reserves were tapped in the 1969-79 period (see chart). Consequently, the peak and decline of output from these fields are occurring in a relatively short period. Samotlor, placed on stream in 1969, accounts for 40 percent of the West Siberian oil reserves tapped from 1964 to date. As illustrated by the figure, oilfield commissionings in the 1970s were smaller than Samotlor by an order of magnitude—and those in the 1980s have been much smaller yet. Because the new commissionings are not of comparable size to the aging fields introduced in the 1960s and 1970s, the Soviet oil industry is now on a treadmill and faced with the hopeless prospect of having "to run faster to stay in place." [redacted] 25X1

Only the discovery and development of new oilfields of comparable productive capacity can offset the large declines in output from aging giant fields at competitive costs. In his Tyumen' speech, Gorbachev noted that, when oil deposits pass their peak output, priority attention must be given to finding and tapping new deposits. But the odds against finding additional giant fields in West Siberia have increased rapidly since 1975, according to Soviet geologists. Indeed, the Soviet press states that these geologists no longer predict the imminent discovery of a second Samotlor. Offsetting the production losses from aging fields thus requires the development of an increasing number of small fields—which are proving less productive. For example, the average flow from new wells has decreased by 50 percent since 1980, according to the Soviet press. These circumstances are leading some Soviet oil officials to emphasize development of "difficult-to-extract" oil reserves. The methods required for such development, however, are costly and technically demanding. [redacted] 25X1

West Siberia: Oil Reserves Tapped, 1964-85
(A + B + C_1 Reserves in Fields Started Up)



[redacted] 25X1

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The Soviet oil industry has taken steps to deal with some of the "fixable" problems. Changes in managerial personnel and a large increase in the number of well-repair crews assigned to West Siberia have sped up the servicing of wells and undoubtedly have prevented a steeper decline in oil production. But the

negative impact of the aging process ultimately affects all oilfields and will surely cause more wells to cease flowing in the future. Soviet emphasis on short-term production gains through more drilling and larger water-injection programs accelerates the aging process.

The Status of Tyumen' Oilfields

Because of the advanced age (12 to 20 years) of the dozen largest Tyumen' oilfields, only one of three wells in this key region flows oil naturally. Even more ominous for the Soviet oil production outlook, less than one out of seven newly completed wells flows oil—the rest need pumps. The number of old and new wells inactive for lack of pumping equipment is nearly as large as the number of Tyumen's remaining free-flowing wells and is growing.

The supergiant Samotlor oilfield provides a stark example of the downward course of oil output and the difficulties encountered in attempting to sustain production in an aging field. Currently, after 15 years of exploitation, only one of five wells at this giant field flows oil naturally. Nearly 2,000 high-yield oil wells are being converted to gas-lift operation in order to handle ever-increasing volumes of water. The fluid produced from Samotlor's gas-lift wells already averages 70 percent water and 30 percent oil. With the aging of other major Tyumen' fields like Fedorovo, Mamontovo, and Var'yegan, the number of wells awaiting pumps can be expected to grow at a much brisker rate, and the rate of attrition in the number of flowing wells will accelerate.

Also associated with aging of fields is a sharp increase in problems associated with maintenance of reservoir pressure and with advanced corrosion of oilfield equipment and piping. Recently, for example, the new oil minister, Vasily Dinkov, blamed below-plan performance on the inability of Tyumen' oilworkers to maintain oilfield reservoir pressures by waterflooding. Concurrently a speech by the Al'met'yevsk party chief complained about the serious pipeline and equipment corrosion problems that were encountered by the Tatar and Bashkir workers assigned to Tyumen' last January. These problems apparently prevented them from making their production quotas. The speech noted that crude oil pipelines develop numerous leaks after only one or two years of service because of hydrogen sulfide corrosion. In normal Soviet experience, such pipelines last two or three times as long, according to the party official. The corrosion of water-supply and crude-oil-gathering pipelines poses severe operational problems that affect waterflood-pressure maintenance programs and crude oil production operations, in turn intensifying the demand for scarce labor, replacement equipment, and spare parts. 25X1

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Outlook

In contrast to the 1970s when several giant, highly productive oilfields were being tapped, the oil flow from new wells in the mid-1980s is meager (for many, less than 200 b/d)—that is, less than one-fifth the average flow from new wells in 1975. Indeed, many of the new wells in some fields reportedly do not flow. This condition—in the absence of the discovery of a "second Samotlor"—leads to a spiraling increase in commitment of manpower and equipment for well drilling and other oilfield activities in an attempt to sustain the nation's oil output. 25X1

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Output from the supergiant Samotlor, the driving force behind West Siberian oil production growth for a decade, will probably amount to only about 2.4 million b/d in 1985, down sharply from its 1980 peak level of over 3.0 million b/d. Output from the second-generation West Siberian fields—such as Fedorovo, Mamontovo, Lyantor, Agan, and Severo-Var'yegan—is beginning to decline, and the rate of decline is increasing. By the end of the decade, the aging of all major fields will pose a requirement for an added 2-3 million b/d of oil from other deposits if the Soviets intend to compensate fully for the decline of output from the major fields. Attempting to do so (which in the end may be futile) by exploitation of the smaller, poorer quality fields that have been coming on line will entail steeply escalating costs in terms of manpower, equipment, and logistic support.

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