CHAPTER X

Western Technology in the Soviet Union

CONTENTS

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THE HISTORY OF WESTERN TECHNOLOGY IN THE SOVIET UNION

Debates in the United States over the national security implications of bolstering the Soviet economy through the sale of advanced technology are of relatively recent origin, but the desire to profit from Western technological advances vastly predates both the cold war and the creation of the Soviet State. In this sense, Western technology transfer to the U.S.S.R. has had ample precedent; foreign technology and capital infusion have played a relatively large role in Russian economic growth for the past 300 years. From Petrine times until the present, Russian statesmen have attempted to compensate for domestic inability to generate competitive innovation by importing know-how from abroad. The motivation for this interest in technical and economic progress has varied, and technical advance, economic growth, and military power have all been closely intertwined. Successive heads of both the Russian and Soviet Governments have emphasized the necessity of competing with the advanced states of Europe not only in terms of domestic standard of living, but also in terms of national security.

The first systematic and nationwide attempts at modernizing the Russian State through Government edict occurred during the reign of Peter the Great (1682-1725). During his tenure, the number of manufacturers and mining enterprises quadrupled. Western impact in this period was felt more through the transfer of know-how, ideas, and people than through the transfer of hardware. The main thrust of the Petrine economic reforms directed toward the development of an efficient, modernized Russian armed force that could match those of Poland and Sweden, Russia's major European adversaries. The almost continuous state of war, punctuated by periodic invasions of the Russian homeland, made the development of a modern navy and munitions industry seem crucial to the survival of the Tsarist State.

The State bureaucracy under Peter I, remolded along Western lines, was the prime mover in the development of key military-related sectors of the economy. This established a pattern which was to persist until the October revolution. Growth in the new armaments, metallurgy, shipbuilding, and textiles industries was encouraged by guaranteed demand for their products from the Government sector. The State, in turn, strictly regulated the quality of the product, demanding standards comparable to German and Dutch industry. In 1702, Peter initiated a drive to induce foreigners to settle in Russia. This was intended to be a spur to innovation; Russia was importing both the necessary know-how and what the Tsar regarded as superior Western cultural traits.

Peter attempted a deep and comprehensive Westernization of Russia, but it was based on narrow premises. While a relatively competitive military sector was established by the middle of the 18th century, the structure of the new industries precluded ongoing growth and innovation in the absence of State influence. Manufacturing was based on serf labor, and there was no impetus to discover labor-saving and capital-intensive modes of production. Product quality and quantity in those industries wholly dependent on the State were in many cases determined by administrative decree, but low quality in the private sector was tolerated in the absence of alternatives. Finally, raising the proportion of foreigners in the intelligentsia was an insufficient first step toward the comprehensive educational system necessary for permanent increases in worker productivity and domestic innovation.

The 18th and early 19th century modernization drives depended for the most part on State resources as their motive force, but, by the end of the Crimean War, it was clear that this technique could not support industrial development on a par with that in Western Europe. It was not until Count Sergius Witte became Minister of Finance in 1892 that Government financial policy deliberately focused on industrial development. Witte stabilized State finances, returned the ruble to the gold standard and borrowed extensively abroad. At the same time, he channeled a great deal of foreign capital into the expansion of the railway system, thus lending an added impetus to growth.

Witte was a disciple of Frederick List, whose ideas on tariff protection for developing industries had helped to industrialize Prussia. The result of these policies was a surge of industrial growth unprecedented in Russian history, and based essentially on private initiative. Between 1892 and 1903, when Witte left office, the annual rate of industrial growth consistently exceeded 8 percent.

During this period, the major vehicle of technology transfer was the import of foreign machinery. Its role in the modernization process was considerable: in 1912, only 55 percent of the ruble value of all machinery sold in Russia was of domestic origin, and imports of agricultural machinery increased from 6 million to 50 million rubles from 1895 to 1914. Foreign investment in the last Tsarist period was particularly important in the mining, metallurgy, textile, and chemical industries.

The success of the October revolution ended the period during which economic growth was nurtured by private initiative. According to Lenin, the industrial growth of the prerevolutionary era was based on the exploitation of the masses by the capitalist class and had fostered backwardness in the Russian worker. The Soviet task was to rebuild through State control a society as productive as the most advanced Western nation. Western assistance remained vital to this enterprise.

Lenin's New Economic Policy, which came into effect after 1921, had as its central mechanism of technology transfer the granting of concessions to Western entrepreneurs. Technical assistance contracts, the employment of foreign engineers and experts in the U. S. S. R., and the dispatch of Soviet experts to training positions in the West were also utilized.

Over 200 concessions were made to foreign firms between Lenin's death and the first 5-year plan. While Soviet literature downgrades the contributions of foreign technology transfers accomplished through this medium, it is clear in retrospect that much of the rapid growth of the 1920's was dependent on foreign operative and technical skills. The Soviets at this time made little or no attempt to develop completely new mechanisms of domestic productions; even experimentation was limited and soon abandoned. They concentrated on acquiring new productive processes from the West, training politically reliable engineers, and establishing basic and applied research institutes.

By the end of the 1920's the Soviets were convinced that they had found a more effective mode than the pure concession or the joint venture for the transfer of Western skills and technology. After 1928, technical-assistance agreements and individual work contracts with foreign companies, engineers, skilled workers, and consultants replaced

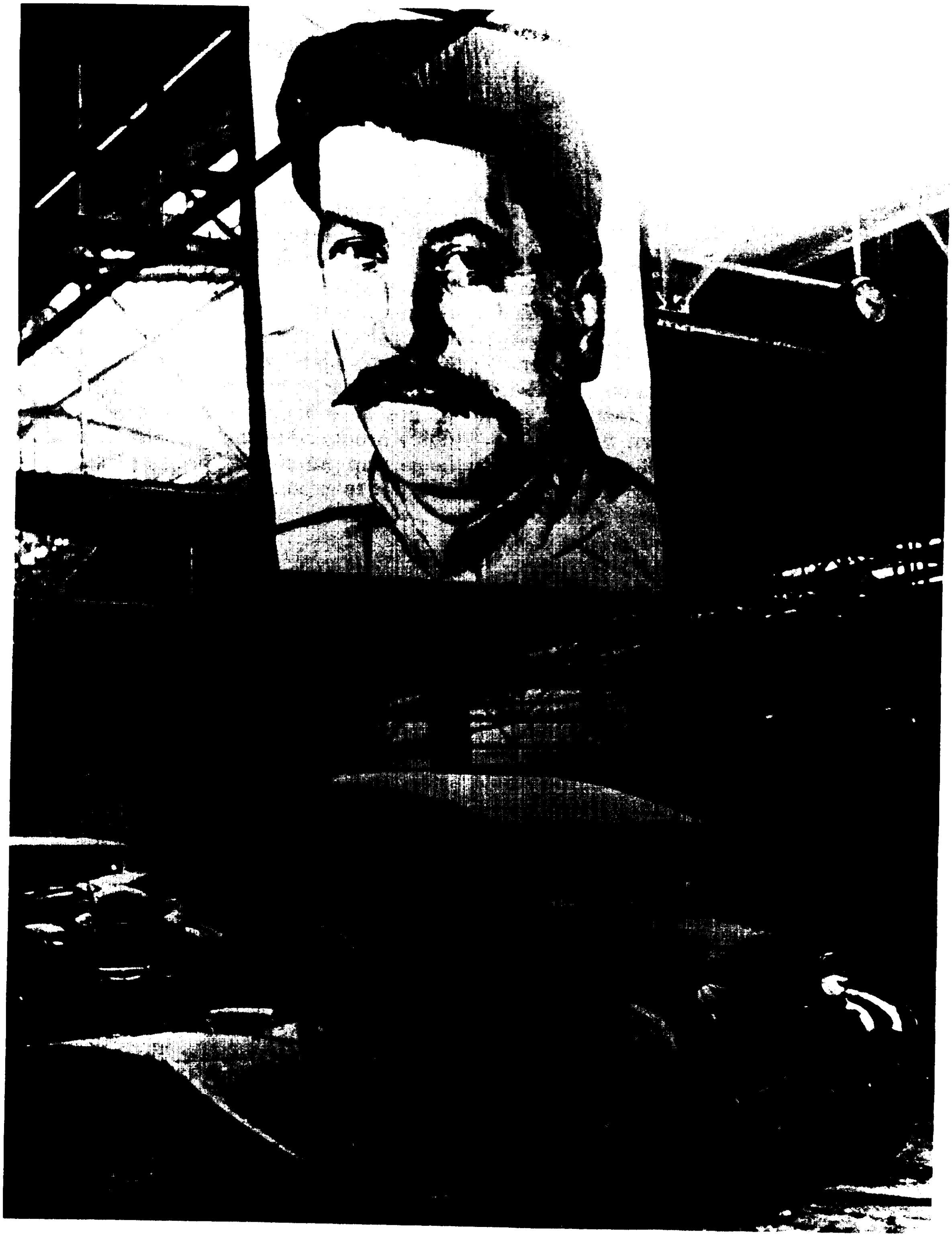


Photo credit: TASS from SOVFOTO

"Model A" Fords roll off the Gorki assembly lines in 1929

the pure and mixed concessions. Under these arrangements the capitalist firms could no longer claim a share of ownership. In addition, the control of technology transfer operations lay totally in the hands of the Soviets. Existing concessions were closed out through taxation, breach of contract, harassment and, in some cases, physical force. [1]

In their place, in the summer of 1929, many wide-ranging technical-assistance agreements were concluded with foreign firms. These were to be of specific, limited duration. The units designed and begun between 1929 and 1932 were some of the largest in the world, so large in fact that in many cases contracting Western firms had not previously dealt on a similar scale. Design and layout of these complexes came mostly from America, with Ford, General Motors, Packard, General Electric, and U.S. Steel contributing heavily. And although nearly a half of the installed equipment was German, it was very often manufactured in Germany to American specifications.

For 2 years there was an unparalleled infusion of foreign technology in the form of skilled labor, technical data, and equipment. Although most of the engineers were gone by 1932, they left behind designs based on Western models which contributed to a large increase in manufacturing capacity. Until 1941, production increases in most Soviet industrial sectors were the result of the installation and expansion of the Western plants acquired in the massive transfers which took place during this brief period.

Stalin had used the threat of war to initiate the new era of industrialization and collectivization in 1919. First priority was therefore given to the military departments of the new works, and many plants built in this period simultaneously produced civilian and military equipment. After World War II, the most significant vehicle of technology transfer was the stripping of German industry. It has been estimated that at least two-thirds of the German aircraft and electrical industries, most of the rocket production industry, several automobile plants, several hundred ships, and a host of military equipment were transferred *en masse* to the U.S.S.R.

In the late-1950's, the Soviets turned their attention to technology transfer in industries where the German acquisitions had been slight–the chemical, computer, shipbuilding, and consumer industries. During this period, the U.S.S.R. began a massive complete plant-purchasing drive. Between 1959 and 1963, at least 50 complete chemical plants were bought for chemicals not previously produced in the U.S.S.R. In addition, a large ship-purchasing program was initiated in order to expand the Soviet merchant fleet.

In sum, whatever the role of technology transfer in the contemporary Soviet economy, it is clear that Western technology has long been looked on as a way to overcome domestic economic shortcomings. These imports have played a major—and continuous—role in both the Russian and Soviet States. In this sense, Soviet efforts to obtain imported technology are neither surprising nor new. In addition, throughout both Russian and Soviet history such transfers of know-how and capital from the West have been conscious tools of State economic and military policy. The centralization of economic decisionmaking, particularly as it relates to the selection and use of foreign technology, has been practiced in Russia for at least 300 years.

Equally normal, however, has been great vacillation in the ways in which foreign exporters and technicians have been treated. While Western-Soviet trade has had a long history, this history has been characterized by periodic State-imposed deteriorations of trading conditions and by a conspicuous lack of predictability in commercial contacts. On the basis of the historical evidence, at least, there is no reason to expect that increased sales of technology to the U.S.S.R. will much enhance the opportunities for Western exports of manufactured goods.

I Anthony Sutton, *Western Technology and Soviet Economic Development*, 1930 to 1945 (Stanford, Calif., 1977), pp. 20-26.

THE NATURE OF THE SOVIET ECONOMY

THE COMMUNIST PARTY

No market mechanism officially operates in the U.S.S.R. Instead, economic decisions concerning allocation of resources and rates of expansion of different sectors are made administratively, and basic economic policy formulation is one of the principal functions of the Communist Party.

The Party exercises control and supervision over the economy in a number of ways. Many branches of the Government report directly to Party organs. The State Planning Committee (Gosplan), for example, reports directly to the Politburo (Executive Committee) of the Party.[2] At lower levels, building projects are first submitted to the Party before being submitted to the appropriate Government office. At the enterprise level, the Party organization both mobilizes workers to fulfill the plans and monitors the activities of enterprise managers.

The most potent tool used by the Party to direct the economy is the *nomenklatura system*. The *nomenklatura* is a comprehensive list of appointments under Party control. It nominates individuals to all important posts in the State, industry, and army. As a result, although only about 6 percent of the Soviet population belongs to the Party, nearly all agricultural or industrial managers are 'Party members.

THE GOVERNMENT APPARATUS

The State apparatus administers the detailed planning and organization of the economy. The Soviet economy operates under a ministerial system in which individual enterprises belonging to a particular branch of the economy (petrochemicals, metallurgy, etc.) are subordinated to a single ministry. There are three types of ministries: the all-union ministries run the enterprises under their control directly from Moscow, and these enterprises are not answerable to regional authorities; the union-republic ministries have offices both in Moscow and the republics; and the republic ministries direct enterprises in their own republics. The heads of these ministries are either members of the Council of Ministers of the U.S.S.R. or of the other republic Councils of Ministers.

ECONOMIC PLANNING

Coordination of ministry activities is done primarily by Gosplan, the principal planning agency.[3] While only a limited number of commodities are centrally planned and distributed by Gosplan, the planning process is extremely complex.

The first step in this process is for the Party to establish priorities, in the form of output targets, for the upcoming plan period. These targets are sent to Gosplan, which tentatively formulates a detailed set of output goals and determines the resources required to produce them. These goals or "control figures" are sent down through the planning hierarchy to the individual enterprises. At this point, enterprises and ministries formulate their own input estimates for Gosplan's output targets. Gosplan must reconcile the two. Should demand for a particular commodity input exceed supply over the

'P. Gregory and R. Stuart, *Soviet Economic Structure and Performance (New* York, 1975), p. 118.

'Ibid., p. 119.

economy as a whole, Gosplan may decide to reduce demand, to draw on stocks, or to import. After it has arrived at this "material balance, " Gosplan submits the plan to the Council of Ministers for approval and/or modification. The finalized targets are then communicated down the hierarchy to individual firms.

This system of material balance planning is cumbersome and slow; it stresses quantitative output goals and requires the maintenance of a vast bureaucracy. While it strives for consistency (equating outputs to inputs), it has proven incapable of achieving optimality, i.e., the most productive resource mix for desired production levels. On the positive side, material balance does permit the Government to channel growth in high-priority sectors while maintaining strict control over the economy.

The monetary counterpart of each enterprise's input and output plans are financial plans. These facilitate planner control over enterprise operations to the extent that deviations from the financial plan signal deviations from the physical plan. This control is reinforced by the fact that all legal interfirm transactions, with the exception of certain investment allocations and foreign trade, are handled by the State Bank (Gosbank), which is the sole center for settling of accounts.

Each year, Gosplan formulates and the Council of Ministries approves an investment plan for the entire economy. The plan is carried out by "project-making" organizations in charge of investment planning at the enterprise level, and its implementation is supervised by Gosplan and the ministries. Thus, decisions to expand enterprise capacity are made outside the enterprise itself. Investment choice in the U.S.S.R. is hampered by the inefficiencies that arise from the reluctance of planners to rely exclusively on profitability criteria, and from overly taut investment planning.

Soviet enterprises operate on an independent "economic accounting" system. This is often taken to mean that they operate to maximize profits. The system guarantees, however, only that enterprises have financial relations with external organs such as Gosbank and that their operations are evaluated in terms of value indicators using official prices. Under this system, future production targets bear no relation to profits.[4]

The plan, formal and informal constraints, and the managerial incentive structure have made gross output the most important indicator of enterprise performance. A manager is rewarded primarily for rapid expansion in physical output in a given planning period, irrespective of poor performance in other areas. Managers therefore tend to avoid change, expecting negative impacts from innovation in process or products.

These factors, which inhibit incentives and may result in misallocation of investment funds, are endemic to the Soviet system of economic organization. Even where a measure of local decisionmaking power exists, such decisions must conform to the wishes of the central planners, who perform without necessarily according priority to issues such as prices or profits.

The declining rate of economic growth in recent years has lent impetus to attempts to reform the Soviet economy. In 1965, Premier Kosygin submitted a plan designed to reduce the number of enterprise targets set from above and, most important, to replace gross output by "realized output" (sales) as the primary indicator of the success of an enterprise. Further, profits were to be an important source of funds for decentralized investment by enterprise managers and were to be used as a source of funds for bonus payments to workers. These changes were to be phased over 5 years.

The period since 1971 has witnessed a reversal of official attitudes toward the solution of basic economic problems. Rather than relying on economic "levers" at the enterprise level—the basis of the Kosygin reforms—attention is being increasingly directed toward improving planning methods and increasing control over enterprises

‘Ibid., pp. 179-230.

to improve economic performance. Emphasis is now on new planning methods such as perspective planning, automated plan calculations, automated information retrieval systems, and new organization methods.

One of the major motivations of the 1965 reforms and of the later modifications to them was the continuing reluctance of managers to introduce new technology and raise product quality. The subsequent recourse to more centralized administrative techniques means that those features of the economy that deterred innovation in the past continue to exist.[5] Major innovations in Soviet technology are therefore more likely to come from technological infusions from the West than from domestic R&D.

[5]See Gertrude Schroeder, "Recent Development in Soviet Planning and Incentives," in *Soviet Economic Prospects for the Seventies*, Joint Economic Committee, 1973.

In conclusion, while modest attempts at reform have been undertaken in the Brezhnev era, the basic problems of economic incentive in the innovation process have not, in the final analysis, been seriously addressed. The economic reforms of 1965 have been so modified as to dilute their effect. In lieu of emphasis on economic "levers" as spurs to innovation, reorganizational and administrative solutions have met with little success. Western technology continues to be important to future Soviet economic growth.

DECISIONMAKING ON FOREIGN TECHNOLOGY

INSTITUTIONS INVOLVED IN THE ACQUISITION OF FOREIGN TECHNOLOGY

Decisions concerning the purchase of foreign technology, like any other economic decision in the Soviet Union, take place within the framework of a system of central economic planning. A brief catalog of the major institutions involved in this process suggests the variety of the interests involved in such purchases and the complexity of the process itself. These actors fall into two major categories, the State and the Communist Party apparatus.

State Apparatus and Technology Acquisition

The Council of Ministers.–At the top of the Soviet Government organization is the Council of Ministers of the U.S.S.R. This body is the formal repository of all State authority. As such, it is the theoretical locus of administrative responsibility for trade matters. In practice, however, decisions are usually taken in ministries and agencies that operate under the Council and are rubberstamped at the highest level. To administer the massive Soviet economy, the Government relies on the operation of a variety of general and specialized bodies.

Gosplan.–Gosplan, the State Planning Commission, is the central Government's chief agency for conducting the work of general economic planning. Part of its work consists of import planning, which is conducted by Gosplan's own Department of Foreign Trade. The primary responsibility of this Department is to integrate foreign trade into the national economic plans. In addition, Gosplan is responsible for planning R&D and innovation. This work is carried out in a separate Department for the Comprehensive Planning of the Introduction of New Technology into the National Economy.[6]

Gostekhnika.–Known in the West as the State Committee on Science and Technology (SCST), this organization bears primary responsibility for the coordination of R&D work throughout the economy.[7] It is chief advisor to the central Government on national technological policy. Part of the latter

[6]See Joseph S. Berliner, *The Innovation Decision in Soviet Industry* (Cambridge, Mass.: MIT Press, 1976).
[7]Ibid.

function consists of developing strategies to acquire Western technology and integrate it with domestic R&D capabilities. SCST participates in negotiation for the acquisition of sophisticated technology from the West, often providing technical expertise.

U.S.S.R. Academy of Sciences.—This body consists of about 600 members who bear the responsibility for supervising the greater part of scientific research work in the U.S.S.R. The Academy's jurisdiction includes about ZOO scientific establishments employing some 30,000 scientists. Through its Administration of Foreign Affairs, the Academy not only monitors scientific developments in the West, but plays an active role in scientific exchanges. While the Academy's primary concern is basic research, it is obliged to submit proposals to SCST concerning applied R&D leading to innovation.

Military Industrial Committee of the U.S.S.R. Council of Ministers.–The existence of this committee has never been officially confirmed, but it is probable that it holds primary responsibility in the State structure for the coordination of all activities in the area of armaments production. While the role of the Military Industrial Committee in technology acquisition is unclear, it undoubtedly participates in decisionmaking on technology purchases.

Ministries. –The central administration could not possibly directly supervise each of the 43,788 industrial enterprises that fall under the Soviet system of central planning. An intermediate level of administration is therefore provided by ministries, which are interposed between enterprises (or production associations) and the central and republic Governments.

Ministries are organized by branch and those dealing with the economy are differentiated by product (e.g., Petroleum Ministry) (see figure 12). A major function of the economic ministries is to formulate and implement technical policies in relevant sectors. This function is accomplished through the Main Technical Administration of each ministry. Each ministry also includes a Department of Foreign Affairs.

Different economic ministries are involved in acquisition decisions to the extent that foreign technology can be incorporated into their sectors. At present, the extractive industries, chemicals, and machine tools are especially active in foreign trade.

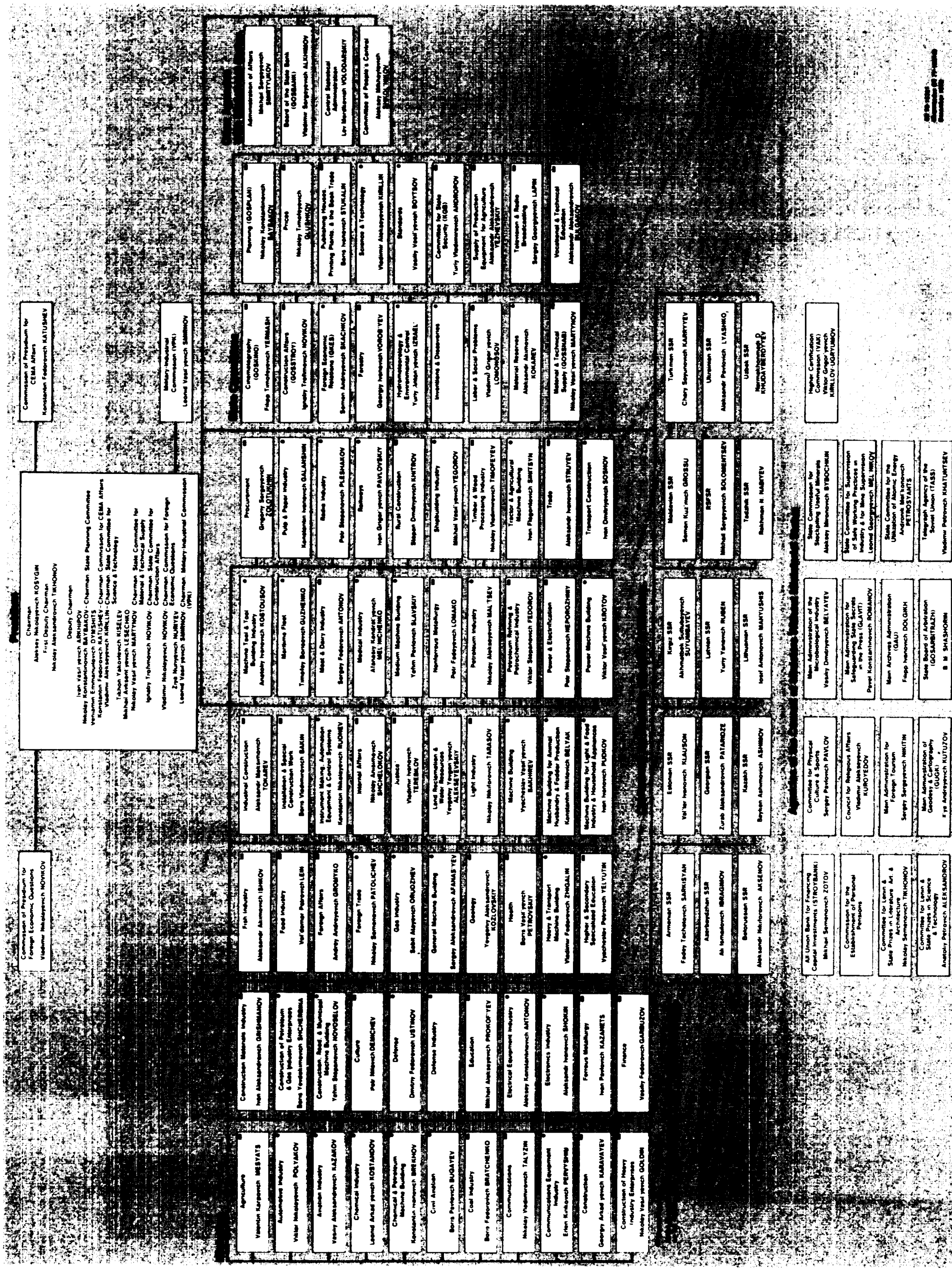
The Ministry of Foreign Trade administers all Soviet trade; no foreign trade operations can be processed outside of its structure. The Ministry encompasses dozens of import-export foreign trade associations organized according to product category. These associations act as intermediaries between relevant Soviet ministries and foreign firms and are empowered to sign contracts. They are governed by boards which are composed of specialists of the associations and representatives of the relevant ministries.

Administrative decisions in the Ministry of Foreign Trade are made through the cooperation of three internal divisions:

1. The trade-political administrations. These are divided by region. A separate trade-political administration exists for trade with the United States, while a second administration deals with all other capitalist countries.
2. Functional administrations for planning, currency, legal matters, etc.
3. Administrations for single commodity groups. A separate administration of this type exists for machinery and equipment imports from capitalist countries. The relationship of these administrations to their import-export associations is shown in figure 13.

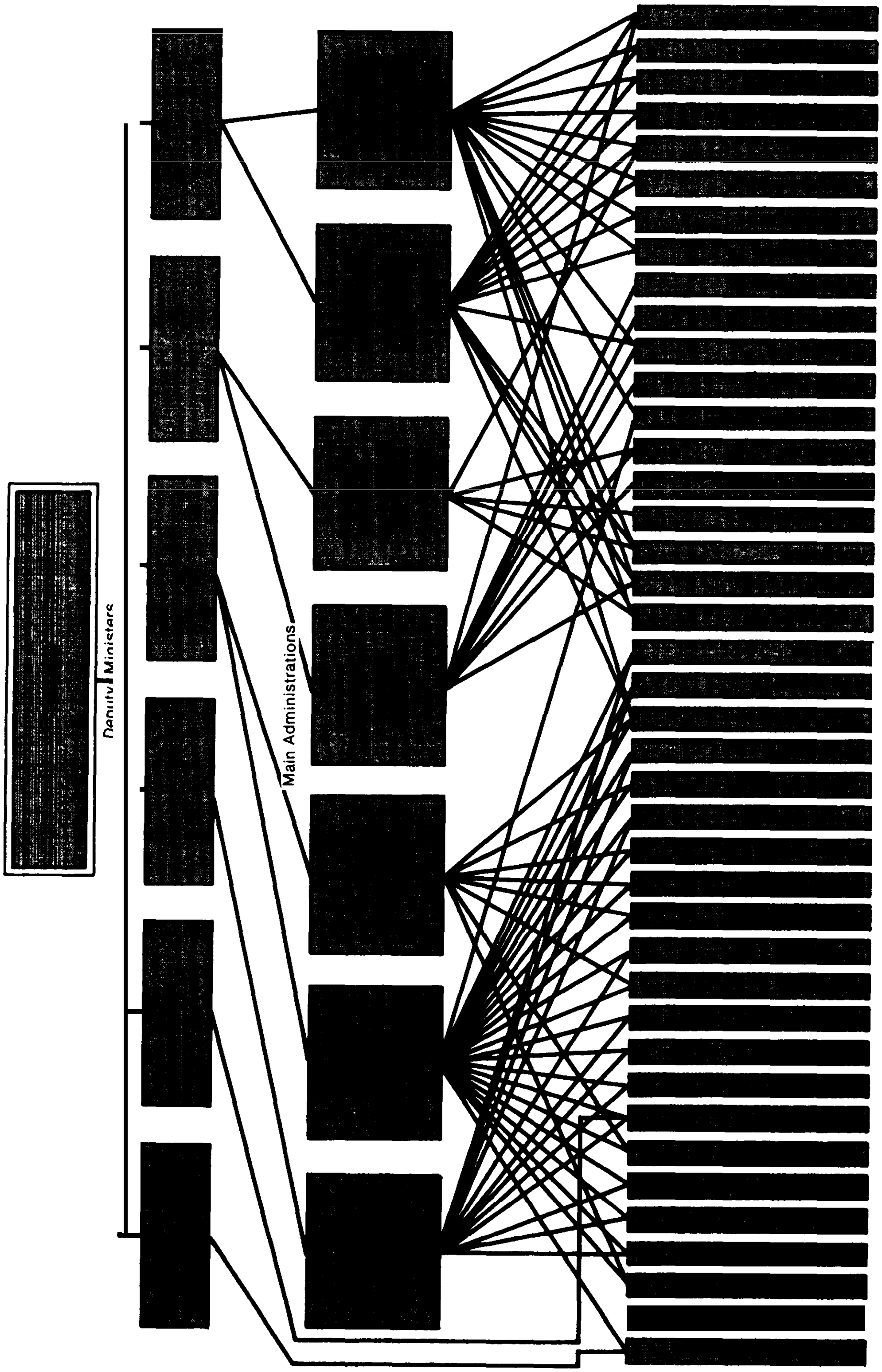
Other Agencies.–There are many other Government agencies involved in some portion of the process of technology acquisition. The Ministry of Finance participates in the development of hard-currency plans and administers their implementation. The Vneshtorgbank, or Bank of Foreign Trade, is subordinated to the State Bank. It gives credit to all Soviet organizations for foreign trade

Figure 12.—U.S.S.R. Council of Ministers



SOURCE: Central Intelligence Agency, December 1978.

Figure 13.—Organizational Structure of Operational Management of Foreign Trade



SOURCE: V P Gruzinov, *The USSR's Management of Foreign Trade* (Moscow, 1975).

in rubles and deals with clients in hard currency. The All-Union Chamber of Commerce primarily arranges exhibitions and contacts between foreign firms and Soviet organizations.

Within the Soviet R&D establishment, organizations exist which in many cases adapt Western technology purchases and advances in applied research to domestic production. Research and development institutes (under individual ministries) specialize in applied research in a specific technological area. Once a new product or process has been developed to a point where it is thought ready for commercial application, it is handed over to engineering-design organizations, which mark out the details of materials, grades, sizes, shapes, and other technical specifications of the final product and the precise machinery, assembly quality control, and other production arrangements for manufacturing it. If reverse engineering of a Western product is possible, these organizations will have the expertise to accomplish it. There are over 2,000 such organizations in the U.S.S.R. subordinated to various ministries.

In addition to the organizations listed, a number of other segments of the State structure intercede in the process of technology acquisition. In particular it is clear that the Ministry of Defense is not only concerned with Western technological achievements, but may have a deciding voice in individual import decisions. The precise structure of the relationship between the Ministry of Defense and the negotiations conducted by the Ministry of Foreign Trade is not, however, known in detail.

The Communist Party and Technology Acquisition

All levels of Soviet administration—including that of the Communist Party—may provide inputs in the process of foreign technology acquisition. In the most general sense the Government, including the planning bodies, exercises detailed control over planning and purchase of technology, and the Party bureaucracy avoids direct involvement in practical decisions once broad policy goals have been met. The relationship between State and Party in technology acquisition is, however, ambiguous and varies not only with time but with the political sensitivity of a given purchase. Under the present regime, Party organs ordinarily exercise a veto over initiatives made by the state bodies while eschewing contact with representatives of Western firms.

In addition to its functions of policy formulation and monitoring of administrative operations, the Party bureaucracy exercises ultimate control over technology acquisition as it would over any other Government function, through its absolute control of personnel in the State structure. All officials concerned with technology acquisition are carefully screened not only by State but also by relevant Party organs.

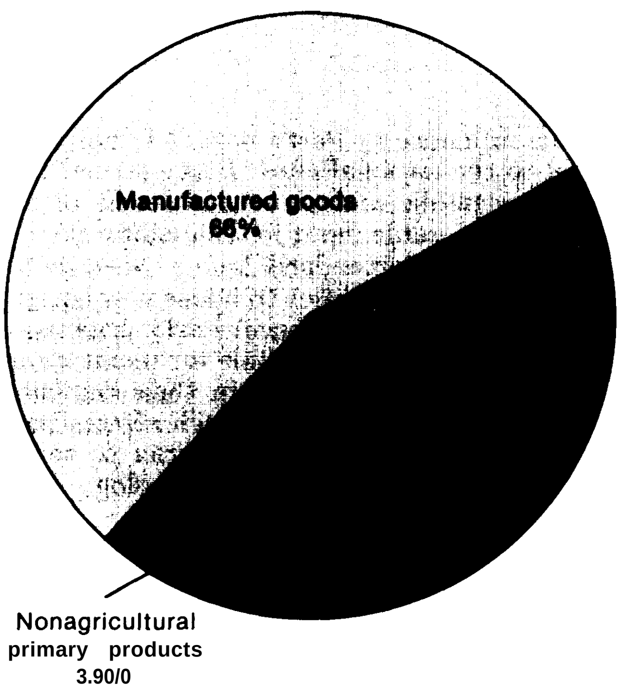
The influence of Party organs is not confined to the national level. Party structures on the republic and provincial levels often have considerable input in technology acquisition. This is particularly true in the case of construction of facilities to house new equipment and machinery. Local Party organizations are directly responsible for monitoring construction of all plants in their regions. Their inability to organize such efforts has often proved to be a major barrier to swift implementation of Western technology purchases.

TECHNOLOGY ACQUISITION AND PLANNING

There are indications that the role of foreign technology transfer in the foreign trade planning system as a whole is being reevaluated. At present, import decisions are made as part of annual planning cycles, and foreign trade is often utilized as a means of filling short-term planning shortfalls. The result of this is that, as figure 14 demonstrates, the vast majority of Soviet imports from the industrialized West have consisted of non-technology-intensive manufactured goods, and agricultural and other primary products. Attempts to more fully integrate current and prospective foreign trade plans into national economic plans are likely to result in a greater proportion of hard-currency expenditure devoted to more productive high-technology imports.

The acquisition of technology from the West is accomplished in two general stages. First, hard currency is allocated among sectors. Secondly, individual purchases are determined through the participation of ministries, their production associations, research institutes, and engineering-design bureaus. In sensitive cases, detailed decisions are formally made by higher levels of administration.

Figure 14.—Composition of Soviet Imports From the Industrialized West, 1977



SOURCE Off Ice of Technology Assessment

Both the distribution of hard currency and concrete purchases are accomplished either in the framework of the 1- and 5-year plans or through irregular (ad hoc) decrees of relevance to single industrial branches or enterprises. From year to year the allocation of hard currency—the primary quantitative determinant of imports—is basically preserved across sectors. Changes in particular priority targets or drastic reductions in the hard-currency stock do, however, periodically alter these proportions. World market prices quoted in hard currencies are utilized for export-import operations with the West.

As is true of all aspects of Soviet planning, hard-currency allocations are determined on the basis of level achieved—every year the allocation is marginally increased as compared to the preceding year (subject to high-level changes in national economic priorities).[8]

Engineering-design bureaus, which project new construction or modernization needs, determine which particular types of Western technologies can be used. They present to their ministries specifications of needed equipment and know-how. Ministries then send drafts of their requests to Gosplan and the Ministry of Foreign Trade.

If these requests are within the limits of the hard-currency plan, they are routinely approved and included in the trade plan. But this is usually not the case. Ministry requests often exceed the hard-currency allocation. Such discrepancies are resolved through bureaucratic negotiation between

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[8] **Igor** Birman, "From the Achieved Level, " *Soviet Studies*, **XXX** *(2).*

ministries, SCST, local Party organs, etc. If Gosplan cannot resolve the discord, it is usually settled by a Deputy Chairman or Chairman of the Council of Ministers and, in the most crucial cases, by the Politburo of the Party.

National economic plans specify only large purchases of Western technology. In addition, ministries are allocated limited amounts of hard currency with which to deal directly with the associations of the Ministry of Foreign Trade. In recent years some large enterprises engaged in the production of goods for export have similarly been permitted relatively small amounts of hard currency to be used at their own discretion for the purchase of capital goods.

Flexibility in planning is achieved through irregular decrees, issued every 3 to 7 years by the Central Committee of the Party and the Council of Ministers for each branch of the economy. Such decrees often plan shifts in the distribution of hard currency among sectors and are very concrete in nature, exactly itemizing equipment and technology to be imported. They are incorporated into subsequent national plans.

Decisionmaking on individual technology purchases is based on a coordinated system of collecting and processing Western scientific and technical information. This is supervised by SCST. Nearly all R&D bodies—in particular the engineering-design bureaus—and many large enterprises collect relevant information. In addition, each ministry includes at least one Institute of Scientific and Technical Information, one of the functions of which is to process available Western scientific and technical data

Under this system, Western technical literature is translated, published, and made available to relevant specialists in a relatively short time. Specialists who are sent abroad are required to report on Western technological achievements. Soviet intelligence services also engage in scientific and technical espionage.

As a buyer of Western technology, the U.S.S.R. actively encourages trade fairs and other exhibitions in which foreign firms may bring their most advanced and salable products to Moscow. While such exhibitions are accepted practice in overseas marketing, it is common Soviet practice to attempt to obtain as much detailed technical and operational data as possible on desired products without actually concluding purchase agreements.

The Soviet system of information gathering on Western technological developments, while not ideal, guarantees that the Soviet negotiator is relatively well-informed and cognizant of both the technical specifications and availability of a given product in different Western markets.

CRITERIA AND PRIORITIES FOR TECHNOLOGY PURCHASES

Writing in 1941, Soviet economist D. Mishustin summarized the basic aims of Soviet technology acquisition from the framework of import policy:

> The basic task of Soviet importation is to use foreign goods, and first of all machinery, for the rapid accomplishment of the plans of socialist construction and for the technical and economic independence of the U. S. S.R.[9]

Then, as now, one of the fundamental goals of Soviet import policy in general was to improve the technological base of production with the help of foreign technology while at the same time carefully avoiding dependence on those imports.

In the Brezhnev era the concept of comparative advantage has been added to the dominant theme of technical and economic independence:

> In the final analysis, the purpose of foreign trade is the procurement of imported goods and services a) which are not produced

[9] D. Mishustin, *Vneshnaya Torgovlya SSSR* (Moscow, 1941), p. 6.

within the country at all, b) are produced, as a result of whatever temporary reasons, in insufficient quantity and c) whose production within the country is more expensive than their purchase on the foreign market.[10]

After hard currency is distributed sectorally in the planning process, a number of criteria based on these general policies of technical independence and economic advantage are utilized to make individual purchase decisions. These criteria are not entirely economic. Since the middle of the 1960's, Soviet economists have attempted to determine the economic benefits of import choices through the use of foreign trade efficiency indices. These are formulae that provide a measure of the cost to the national economy of producing a good for export relative to the foreign exchange received abroad, or of the foreign exchange expended abroad in purchasing a good or technology relative to what it would have cost to produce the good domestically.[11] Thus far, such attempts have been singularly unsuccessful, and there is at present no reliable method of measuring foreign trade efficiency at the disposal of decisionmakers. At the heart of the problem lies the insulation of the Soviet price system from world markets and the failure of internal prices to reflect relative scarcity. In lieu of reliable economic evaluation of technology purchases, Soviet buyers simply attempt to minimize hard-currency cost within the context of a shifting set of preferences and priorities.

The first of these is military. All other factors being equal, those types of technology that directly or indirectly enhance military capabilities are given first priority. While many Soviet purchases do not, in fact, embody any military potential whatsoever, it is true that some transfers of an ostensibly purely civilian nature have been given higher allocation priority due to their potential contribution or convertibility to military use.

A second factor involves a general preference for disembodied as opposed to embodied technology, i.e., know-how as opposed to products. The transfer of disembodied technology may require a relatively high domestic contribution of R&D, but buying large amounts of hardware generally raises hard-currency costs. Since an individual ministry is allocated a fixed sum of hard currency, whenever possible it will attempt to minimize the cost of Western inputs while maximizing relative domestic inputs in the development of a given innovation.

Third, purchases of technological complexes are preferred to purchases of single items or processes, so long as the hard-currency cost is not prohibitive. Such systematic transfers ensure the swiftest and most productive utilization of foreign technology purchases.

Another element in setting technology purchase priorities is that preference be afforded those products and processes that can be easily duplicated for production in the U.S.S.R. This tendency stems from the desire to minimize increasing dependence on Western technology.

Finally, an increasingly important criteria for technology purchases involves their use in export industries. Since the generation of hard currency (and further imports) is directly dependent on export potential to the West, increasing priority has been given to projects producing goods for Western markets. It is impossible to definitely rank these criteria in order of their importance in the decisionmaking process. The factors influencing the choice of an individual technology purchase are often ambiguous and priorities vary according to situation. It is clear, however, that a lack of definitive economic formulae for import decisions allows for the influence of noneconomic–e.g., military –factors in the decisionmaking process.

[10] G. Smirnov, “K Voprosu Ob Otsenki Economicheskoi Effektivnosti Vneshnei Torgovlyi SSSR,” in *Voprosy Ekonomiki, No. 12 (1965),* p. *94.*

[11] See Lawrence J. Brainard, “Soviet Foreign Trade Planning'” in *Soviet Economy in a New Perspective,* Joint Economic Committee, 1976.

THE ROLE OF WESTERN TECHNOLOGY IN THE SOVIET ECONOMY

ABSORPTION AND DIFFUSION OF WESTERN TECHNOLOGY

A recent study of Soviet technological levels done under the auspices of the University of Birmingham (England),[12] found that in most of the industries it examined—armaments, nuclear, electric power, metallurgy, machine tools, computers, and chemicals—the technology gap between the U.S.S.R. and the West has not diminished substantially over the past 15 to 20 years, either at the prototype/commercial application stages or in diffusion of advanced technology. The Birmingham study further concluded that Soviet growth has been largely based on output using traditional technology. For example, the study points out that even though the higher technology sector of petrochemicals has grown relative to the chemical industry overall and dominates the total industry output, petrochemical products are manufactured with older, proven technologies.

This pattern of growth, a result of slow absorption and diffusion of new technology, can be seen in the areas in which Soviet industry has performed best. The U.S.S.R.'s most productive technological developments came in industries that were based on well-established technology, with advances coming primarily from successful scaling-up of existing technology. Advances in the metallurgy, power generation, and power transmission industries, for example, are the result more of engineering than of innovation in processes.

The pattern of better performance of those industries that are not based on rapidly changing technology is part of the reason behind the apparent shift in the technology import policies of the U.S.S.R. over the past decade. As the Soviet economy expanded during the early postrevolutionary years, and again following World War II, the industries most needed to support growth were traditional ones such as metallurgy, machine-building, machine tools, and the energy sector. The growth was produced by relying on slowly changing technologies, limited but sometimes essential imports of foreign technology, and massive increases in the supply of labor and capital.

This chapter has already shown that to bring about the rapid industrialization of the economy envisioned by the first 5-year plan which began in 1928, the U.S.S.R. turned to large imports of machinery and equipment. Prior to this period, such imports had averaged only about 0.3 billion rubles per year; during the next 5 years, they rose to an average of 1.4 billion rubles per year. Following the end of the first plan, imports of machinery and equipment dropped back to an average of 0.3 billion rubles per year.[13] Relations with Western firms supplying technology were designed to be short-lived, with the aim of minimizing Soviet dependence. This aim also guided the country's overall import and export policy.

The fear of relying on a potential adversary was one reason for the Soviets' strong desire to minimize dependence on the West for technology and products. In time, such technology transfers were also limited by constraints imposed by Western export controls.

The Soviets began to copy prototypes of equipment that they had been able to obtain from the West. The ultimate failure of this practice, coupled with an inability to rely on domestic innovation, has led to several changes in import policies during the past decade: an apparent shift toward greater reliance on Western technology; a willingness

[12] R. Amman, J. M. Cooper, and R. W. Davies, cd., *The Technological Level of Soviet Industry* (New Haven, Corm.: Yale University Press, 1 977).

[13] George Holliday, "The Role of Western Technology in the Soviet Economy," in *Issues in East-W es t {'commercial Relations*, Joint I+~conoic Committee, January 1979, p. 47.

to permit—in fact encourage–long-term agreements involving large volumes of foreign exchange with Western firms supplying technology; and in some cases, limited changes in Soviet management practices.

Although the Soviet Union is not willing to open its economy to full interdependence with the West, more extensive use of Western technology is no longer feared. At the same time, the West has also liberalized its constraints on export control. In the United States, for instance, the Export Administration Act of 1969 as amended has reduced the list and raised the permissible performance characteristics of controlled items (see chapter VII).

Soviet technology transfer policy is also strongly affected by the country's growth policy, which has been revised. The Soviet Union no Ionger enjoys vast pools of underutilized labor that could be mobilized for economic growth by transfers from the agricultural sector to industry or by increased labor participation rates of women. According to the Central Intelligence Agency's (CIA) projections, the Soviet Union will experience a sharp decline in the rate of expansion of its labor force in the 1980's to less than 1 percent per annum by 1982.[14] Other factors, such as the distribution of population, will further strain the amount of growth that can be obtained through larger labor inputs.

This labor constraint also comes at a time of decreasing productivity of capital inputs. Furthermore, an increasing share of Soviet capital investment is now going by necessity to agriculture, the consumer goods industries, and other sectors that do not directly increase the productive capacity of the economy. As a result, increases in labor productivity are expected to account for up to 90 percent of all growth in industrial output, and virtually all growth in the agricultural sector.

Technological improvement is to be the basis of planned increases in Soviet labor productivity. Industries based on traditional technology are becoming less important relative to those based on sophisticated, rapidly changing technology. These include the organic chemical, electronics, and computer industries. More traditional sectors, such as oil and gas and machine tools, are being modernized with technology from the electronics industry: computer numerical control for precision machine tools, computer analysis of seismic data, and automatic control of hydrocarbon production.

The growing importance of new technology, and the increasing importance of industries that are experiencing rapid advances in technology, coincides with a continuing weakness in the Soviet economic system's capacity to absorb and diffuse technology. The U.S.S.R. problems in this area increase the need for importing technology from the West, since the transformation of domestic innovation into new technology is often slow. On the other hand, the same problem reduces the effectiveness of imported technology. The problem lies not so much in the quality of Soviet basic research, nor in the level of theoretical knowledge, but rather in the system's inability to turn theoretical knowledge into prototypes, and even more importantly, to move rapidly from prototypes to large-scale industrial production. The reasons for this lie in such factors as insufficient incentive, poor organization, and the rigidities that result from central planning.[15]

In the West, innovation and new technology development are encouraged by a desire to beat the competition and thereby maximize profits and cut costs. Rewards for firms that innovate successfully, and competitive pressures felt by those firms that do not innovate or at least duplicate new technology a

“Central Intelligence Agency, *Soviet Economic Problems and Prospects: 1977,* p. ii.

[15] David Granick, *Soviet Introduction of New Technology: A Depiction of the Process,* Stanford Research Institute, January 1975.

short time after a competitor does so, provide sufficient incentive to ensure Western capabilities for development, absorption, and diffusion of new technology.

Large research institutes are responsible for R&D in the U. S. S. R., but such institutes lack incentives to consider adequately the practical application of their work. Planners determine the direction that scientific inquiry will follow in research institutions. They are encouraged to develop ideas that qualify as innovations, but not to apply the ideas to the production process. Separate institutions, called Engineering Design Organizations, have responsibility for applying new technologies, but their successes do not reflect as favorably on the research institutes as does the propagation of additional new ideas, whether practicable or not. Research and development receive the greatest emphasis, followed by application engineering and—with the least concentration of funds and effort–product development. In the West, the emphasis is reversed.

A number of other factors at the enterprise level also inhibit the introduction of new technology. The use of new processes and the development of new products involve risks; since not all attempts are successful in the West, the risks must be minimized and the rewards for success maximized in order to promote such efforts. The Soviet system works in reverse, maximizing risk and minimizing reward. Success for a production enterprise in the U.S.S.R. is measured primarily in ability to exceed the output quota set for the year, although recent reforms permit limited consideration of other factors in determining bonuses for workers and plant managers. The risk of trying a new technology or product is great, since an unsuccessful effort is bound to result in failure to meet the plant's output goal for the year. Even if the innovation is moderately successful, the increased output once the new equipment is operating may not be sufficient to offset the loss of output during conversion. The benefits of very successful efforts are short-lived, because while a jump in output due to the introduction of new technology will surely result in bonuses for managers during the first year, they will just as surely result in a jump in the plant's output quota the following year.

In the West, managers often try several new technologies before finding one that provides sufficient long-run benefits to justify the cost of all the experimental efforts. Similarly, managers find that new processes often require several years to work the "bugs" out of the system. The ability to judge a new technology on its return over a long period of time, and the willingness to accept the fact that most innovations will probably not prove to be successful, are major advantages of the Western competitive system over the Soviet model.

Cost reduction is a major incentive for innovation in the West. In the U. S. S. R., on the other hand, even otherwise successful innovations often produce unacceptably high overall costs due to the rigidities of central planning. A Soviet plant seeking to employ a new process often must rely on other plants to supply related new equipment, and may find the necessary equipment unavailable. In the latter case, the plant may be forced to develop the equipment on its own at relatively high cost. Similarly, a Soviet plant beginning to produce a new product does not have the right to determine the price at which the new product will be sold. This means that the centrally determined price may not cover the plant product development and production costs.

The rigidities of central planning lead to another problem which tends to inhibit the diffusion of technology. In the U.S.S.R. extensive use is made of vertical integration of production facilities. This minimizes the enterprise's dependence on outside suppliers. While this structure does encourage a firm to develop equipment and technology to meet its own needs, it also leads to a lack of standardization and to the inefficient production of equipment in small quantities. Furthermore, this horizontal independence means that new technology is less likely to be transferred to other plants that might benefit from it. "

In theory, the Soviet Union should have a distinct advantage over the West in the diffusion of technology, since new technologies developed in the U.S.S.R. are State property rather than trade secrets, and should be freely available to any enterprise able to use them. In practice, however, communication among Soviet production enterprises is poor, and there may be long delays in the publication and dissemination of information about new developments. The slowness of journals to publish research papers and report other developments may result in a great deal of duplicated effort. It has been reported that the average time between submission of a paper and its publication in the important Soviet journal "Electrochemistry" was as much as 2½ years, and individual articles have been delayed as long as 4 years.[17] Cooperation and communication among plants within the same industry, and between organizations in different industries, are seriously inadequate.

The factors mentioned above all inhibit the introduction and diffusion of new technology throughout the Soviet economy; as a result, the share of total output in the U.S.S.R. due to the introduction of new methods or new products is lower than the comparable share for other industrialized countries. When performance is measured solely in terms of increased output, there is little incentive to change the form of the output. This leads to production of unchanged equipment over a long period of time, often even after better equipment has been developed.

Other forces also encourage U.S.S.R. enterprises to continue using outdated production equipment. Because of shortages of equipment and the lack of direct connection between the cost of production and the cost of the final product, depreciation rates for Soviet equipment are set very low by Western standards. In the West, out-dated machinery is taken quickly out of production and replaced by newer equipment that will lower production costs. High depreciation rates for equipment encourage these shifts, as does a strong market for secondhand equipment. No such secondhand market exists in the U. S. S. R., so the equipment continues to be used at the plant. As a result, the replacement rate for Soviet equipment in most industries is much lower than in corresponding industries in the West.

Many of these same problems reduce the effective introduction of new technology imported into the U.S.S.R. from abroad. This seems to be particularly true for those technology transfers that require application of Soviet design and manufacturing engineering to the imported technologies and can best be seen in U.S.S.R. attempts to duplicate Western technology based on trade publications, product literature, plant tours, personal conversations, etc., or the import of a small number of product units to serve as models or prototypes for Soviet production. As previously noted, the U.S.S.R. also maintains an extensive collection of Western journals, some of which are systematically translated into Russian.

While the use of Western equipment as prototypes for production of new technology reduces the need for Soviet R&D, it still requires significant application of domestic effort, particularly in terms of developing production methods. For rare pieces of equipment or products that can be dismantled so as to uncover production techniques by examination, "reverse engineering" is relatively simple. With more sophisticated products, such as integrated circuits or petrochemicals, however, reverse engineering is much more difficult and impractical.

One of the highest cost components in innovation in the West, and one of the great advantages of the competitive market sys-

[16] John Hardt and George Holliday, "Technology Transfer and Change in the Soviet Economic System, " *Issues in East-West Commercial Relations*, Joint Economic Committee, January 1979, p. 74.

[17] M. Perakh, "Utilization of Western Technological Advances in Soviet Industry, " in *East-West Technological Cooperation* (Geneva: NATO Colloquium, 1976), p. 179.

tern over central planning, is the determination of which products and processes will eventually prove to be economically and technically viable. In the West, the market system makes this selection based on efficiency and profitability, thus screening out innovations that are not worth further development. The work done on products and processes that never reach the final stage of commercial introduction and acceptance is as much a cost of technological advancement as the work done on successful innovations. Marx considered this process to be a major flaw in the capitalist economy–a wasteful misallocation of resources. The innovation engendered by this method of selection, however, tends in the long run to more than compensate for its real costs. Thus, by concentrating their efforts only on those new products or processes that have already been screened by the Western market mechanism, the U.S.S.R. is able to avoid the cost of following infeasible or uneconomical ideas.

According to East European officials, an average of 5 to 7 years elapses between the beginning of efforts to copy a Western product and successfully readying it for production in worthwhile quantities.[18] This timelag means that the copied equipment is often outdated, at least in Western terms, by the time it is used. This period may, however, be shorter than the time it would have taken for the U.S.S.R. to develop the product completely on its own.

But the U.S.S.R. is increasingly interested in obtaining from the West technology of the type that is difficult to copy without assistance. The Soviet desire and willingness to seek more active forms of technology transfer is enhanced by the rate at which Western technology is advancing in such leading industrial fields as petrochemicals, electronics, and precision instruments. In the past, if the technology embodied in a piece of equipment could be duplicated within a few years, the U.S.S.R. could remain only slightly behind the level of technology being used in the West. Now, where technology is advancing rapidly, keeping up with the West is more difficult, and there is pressure to increase the speed with which technology is imported from abroad, assimilated, and diffused. These circumstances also encourage greater emphasis on more efficient selection of technology imports.

Studies by Western specialists have noted several factors that make Soviet technology acquisition less efficient than it could be. One frequently voiced criticism is the length of time it takes for the Soviet Union, once a decision has been made to import certain equipment or technology, to decide which nation and firm will supply it, and then to accept delivery and get the equipment set up and into working order. One study has compared the time required for the U.S.S.R. to accomplish this with the average time required in the West in the chemical and machine-tool sectors. It found first, that the U.S.S.R. required about twice as long to sign a contract for a particular need as would have been the case in the West. This was due to several factors. Initial inquiries from the Soviet Union were frequently vague, and the form of the final order was often different from the original specifications. The study concluded that vagueness at the initial stage probably results from a genuine lack of Soviet knowledge or decision on what will be the best choice, rather than from any deliberate attempt to make the process more difficult.

Second, the Soviets require much more extensive documentation than other countries. While some of this may be attributed to a lack of trust on the part of Soviet trade officials, there is no doubt that the additional documents ultimately make it easier for the U.S.S.R. to assimilate and possibly duplicate the technology being provided.

Third, there is no direct contact between the supplier of technology and the final user. This is an important source of delay in the acquisition process. The supplier must work with the Foreign Trade Organization which

[18] Business International S. A., *Selling Technology and Know-How to Eastern Europe: Practices and Problems* (Geneva, Switzerland, November 1978), p. 6.

handles that type of equipment, and communication between the supplier and user takes much longer and is subject to greater possibilities of misunderstanding than would be the case in the West. Inexperience in the installation, operation, and maintenance of complex equipment, along with poor management and planning, frequent shortages of adequately trained personnel to learn to operate and repair equipment, and problems with the quality of raw materials or other inputs to be processed with the new equipment, are additional factors that lengthen the time between equipment delivery and proper startup. [19]

Delays, the desire to reach certain production levels within a set period of time, and the inability of Soviet industry to supply sufficient equipment to meet those goals, are also important factors in the Soviet decision to import machine tools and chemical equipment. Once a decision to import is made, the user typically seeks the best equipment available. This leads to the purchase of equipment with performance characteristics that exceed anything the U.S.S.R. is itself capable of producing.

The Soviet Union seems to be increasingly aware of the need to use foreign trade and technology acquisition to improve its economic performance. Foreign trade is no longer viewed as a necessary evil; in fact, there is a growing awareness that the demands of Western markets can have a positive effect on the quality of goods produced for export, and thus on the level of quality in the entire economy. Some of the hard currency earned by an enterprise's exports is being returned to the enterprise, providing an incentive to improve the technology used by the plant, as well as the means by which the enterprise can afford to import additional Western technology.[20] Importing Western technology has become more attractive during the 1970's, as Western suppliers have competed for the Soviet market, as long-term credits have been made increasingly available, and as Western firms have become increasingly willing to accept product buyback provisions as a means of financing technology imports.

The increased attractiveness of technology transfer, coupled with the U.S.S.R.'s growing need, has resulted in more purchases of machinery and equipment from the West, together with the use of cooperation agreements and other arrangements with Western firms and countries to promote technology transfer. The CIA and other sources have estimated that as much as 10 to 12 percent of total Soviet investment in machinery and equipment has come from abroad during the 1970's. While purchases of equipment from the West have increased rapidly, purchases of licenses have been growing quickly as well; according to Soviet officials, license purchases are expected to increase even faster than equipment purchases.[21]

The U.S.S.R. has signed Government-to-Government cooperation agreements with most countries of the West since its initial agreement with the United States in 1972. Some 150 authorized projects are either underway or planned on the basis of these technology agreements with the United States. A number of American, West European, and Japanese firms have also signed private cooperation agreements with the State Committee for Science and Technology. These cooperation agreements have been concentrated in high-technology areas such as electronics, computers, instruments, and various types of engineering.

But while the U.S.S.R. has expanded the number and variety of technology transfer mechanisms available to it, the most effective form of technology transfer, the joint venture, has not been permitted. Joint ventures with Western interests have been used in Yugoslavia since 1967, in Romania since 1971, and in Hungary since 1972.

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[19] Philip Hanson and M. R. Hill, unpublished manuscript.
[20] Holliday, op. cit., p. 55.

[21] Z. Zeman, "East-West Technology Transfers and Their Impact in Eastern Europe," in *East-West Technological Cooperation*, op. cit., p. 171.

It is very difficult to estimate the actual impact of Western equipment and technology on the performance of the Soviet economy. The available information does not even permit an accurate determination of the share of Soviet capital equipment that comes from the West, although most specialists who have studied this problem estimate the share to be between 4 and 6 percent. This low level is the combined result of the shortage of hard currency in the U. S. S. R., the Soviet policy of wanting to avoid excessive dependence on the West, and Western export controls.

In sum, however, a general picture of Soviet import policies and their effectiveness may be drawn. The U.S.S.R. has had a long history of systematically utilizing Western technology to compensate for domestic economic shortcomings. The present system through which decisions regarding imported technology are made is incompletely understood in the West, and is characterized by its complexity and slowness. The prioritization of technology for import seems to be dominated by the availability of hard currency and the potential economic and military impacts of the technology, but no consistent and universally applicable set of criteria has emerged. The Soviets are well-informed, however, about Western technologies under consideration and their selections usually reflect careful evaluation of the properties of the technology relative to their specific needs.

The absorption and diffusion of Western technology in the U.S.S.R. have been retarded by structural features of the Soviet economy and the rigidities inherent in central planning. The Soviets appear to be aware of these defects and may attempt to correct them with further purchases of Western management and other know-how. Meanwhile, the economic impact of imported technology is not as great as it might have been on a Western nation purchasing on a similar scale.

THE ECONOMIC IMPACTS OF WESTERN TECHNOLOGY

Several factors affect the degree of economic benefit to be derived from the purchase of any technology. Obviously the initial selection is important. In situations where the availability of hard currency poses restraints on the amount of technology that can be acquired, a Communist country can ill afford to make a poor choice—either in terms of the industry or sector singled out as liable to benefit from Western technology, or in the selection of a particular machine or process from all those available in the West. The criteria that ideally govern this choice include fundamental investment decisions (the choice of capital versus labor-intensive technologies); the sophistication of available domestic technology relative to the imported technology; the indigenous capabilities of the country's R&D sector; and the available infrastructure.

A Western technology may prove economically beneficial in several ways. First, assuming the existence of the necessary infrastructure, including trained manpower, the productive capacity of an industry may be enhanced. Even if no diffusion of the technology occurs, this may be a net gain to the economy. Of course, in the absence of infrastructure, the new technology may produce a net loss in macroeconomic terms. This is the case with "resource-demanding' technologies, i.e., those that require substantial capital or labor inputs before they become operative.

Second, the economic benefits of the technology may be enhanced if it can be used to increase productivity in other industrial sectors, or if the technology embodied in imported equipment can be replicated in equipment produced by the domestic economy. Such diffusion requires certain capabilities in the domestic R&12 sector, yet this alone is not sufficient to close a technology lag or gap. The true test of the effectiveness of technology transfer is not only whether imported technology can be diffused at a technological level comparable to that of the West, but if it can also be the basis of domestic R&D efforts to upgrade it. It is only when imported technology can be fully absorbed in the economy—and improved on—that technology gaps can be reduced.

It is generally true that innovations in the Soviet economy have followed their introduction in the West. This impression is supported by a number of studies, some of them concentrating on a single industry, others taking a broader perspective and attempting to measure the effects of technology transfer on Soviet productivity, income, and technological level.

The impact of Western capital equipment on Soviet economic performance appears to be much larger than the small Western share of total capital stock would suggest. The decision to import technology and equipment is based on the judgment that it will produce better results than if that money were spent on domestic equipment. Thus, theoretically at least, the worth of a given unit of imported equipment has a greater effect on economic performance than the same unit's worth of the domestic equipment for which it is being substituted.

Whether all import decisions are made with net productivity as the deciding factor is, however, open to question. Import decisions are based partly on noneconomic criteria, and the Foreign Trade Organization negotiating a purchase often does not know the grounds for the decision or the net effect of the purchase on the industrial sector. This is not only due to a lack of communication between organizations responsible for putting any new process into production, but also to the administered price system which does not reflect relative scarcities. Within the Council for Mutual Economic Assistance (CMEA), a growing body of literature on the use of foreign trade indexes, which would address this problem, has appeared. But such indexes are not used extensively and provide only one of many kinds of information on which import decisions are based. It must be noted, however, that in spite of the Soviets' inability to determine precisely the profitability of proposed technology imports, they have rarely had to make decisions on projects of marginal value. Owing to the relatively small volume of trade, the Soviets have had their choice of transactions in which productivity gains were clearly high.

An econometric study conducted jointly at the Stanford Research Institute and Wharton School constructed an input-output model of the Soviet economy (SovMod), which attempted to determine the effect of the growth in equipment and technology imports from the West between 1968 and 1972 on Soviet overall economic performance.[22] The study concluded that if Western exports during this period had stayed at 1968 levels, the Soviet Union would have had an installed stock of Western equipment that was 20 percent below the actual 1973 level, and that Soviet growth during this period would have dropped from 32.1 to 29.6 percent. This conclusion implies that Western equipment accounted for approximately 2.5 percent of the U.S.S.R.'s rate of growth during this period, or several times the share of this equipment in Soviet capital investment.

Studies like this are controversial, however. The assumptions on which the model is based have been questioned and other researchers have reached significantly different conclusions using the same data. It has been contended, for instance, that the existence of significant differences between the productivity of Western and Soviet capital equipment is not supported by statistical analysis.[23] This finding implies that the contribution of Western equipment to the per-

"See Herbert Levine and Donald W. Green, "Implications of Technology Transfer for the U. S. S.R.," in *East-West Technological Cooperation*, op. cit.

"Philip Hanson and M. R. Hill, unpublished manuscript.

formance of the Soviet economy is not significantly different from the contribution of Soviet equipment. More than anything else, the conflicting results obtained from these macroeconomic approaches point to the wisdom of reverting to the study of the actual effect of Western equipment and technology on the capacity of individual sectors of the Soviet economy. A disaggregate approach in which each industry is examined individually to determine what equipment and technology has been transferred, how well and how quickly it has been absorbed and diffused, and what changes there have been in comparative levels of technology, may be more productive and accurate. It must be noted that such information is very difficult to obtain even in the West, where access to information is relatively free. The details assembled here must necessarily be taken as partial and impressionistic. This report will concentrate on two in-depth examinations of the industries in which Western technology is most important—the oil and gas equipment industry, and the computer industry. This will be preceded by brief discussions of the other Soviet industries that have received significant attention from researchers concerned with Western technology transfer; they are chemicals, machine tools, and motor vehicles.

Chemicals

The Soviet chemical industry has been long and heavily dependent on the West as a source of both technology and productive capacity. The subsectors of the chemical industry in which technology has remained fairly traditional–basic inorganic chemicals and the production of phosphates and potash fertilizers—have performed relatively well. But performance in petrochemicals and nitrogenous fertilizers has lagged considerably. In the latter two areas, modern technology in the West has changed rapidly in ways that have allowed a significant expansion of plant size at reduced production costs. The Soviet chemical industry has been unable both to duplicate the technology and to keep up with the constant development of new processes and products in the petrochemical field. The demand for Western technology in these areas is significant, not only for this reason, but also because these are areas in which the U.S.S.R. has sought to rapidly expand output. These two factors have combined to demand large expenditures of foreign currency for turnkey plants that will provide modern technology and rapidly expand the industry's productive capacity.

In the late 1950's and early 1960's, when the U.S.S.R. initiated its drive to import technology in chemicals, the Soviet chemical industry seemed likely to remain about 10 years behind the West in a number of areas. It was then taking 6 to 7 years to import and absorb technology that was already about 3 or 4 years old in the West. In recent years, however, the chemical industries of the West have experienced excess capacity and the rate at which new plants and equipment employing the latest technology have been coming onstream has slowed considerably. The chemical engineering companies that provide new technology and equipment have not slowed their innovations, and have been selling their latest technology to any customers in the market for new capacity. As a result, some of the new plants being built in the U.S.S.R. incorporate technology that is as advanced as that coming onstream in the West.

But despite significant contributions from Western plants, the Soviet chemical industry continues to lag considerably in the introduction of new products and technologies, and the output profile of the industry remains biased toward the production of chemicals based on older and simpler technologies.

In the case of plastics, for example, there has not been a single documented instance in which the U.S.S.R. first produced a major plastic material; in fact, the U.S.S.R. is usually the last industrialized economy to begin commercial production of each major group.[24] In synthetic fibers, total production in the U.S.S.R. between 1955 and 1973 expanded at a more rapid rate than in Western countries, but it took 11 years for synthetics to increase from 10 to 33 percent of all chemical fibers produced, while in the United States, Japan, Britain, and West Germany, this diffusion of new technology took only 5 to 8 years.[25] Even when synthetic fibers reached a significant share of total chemical fibers, output was dominated by those synthetics based on older technology.

These impressions were confirmed in the CIA's recent report on the sale of turnkey plants to the Soviet chemical industry and the share of Soviet chemical output accounted for by Western plants.[26] This study, based on a survey of more than 100 turnkey chemical plants purchased from the West between 1971 and 1977, concluded that the Soviet Union depends heavily on Western chemical technology. The U.S.S.R. placed orders for slightly more than $3.5 billion worth of turnkey chemical plants between 1971 and 1975, and ordered an additional $3 billion or more during the following 2 years. The study concluded that these imports did not lead to a noticeable advance in the level of overall plant technology in the U.S.S.R. Although since plants ordered as early as 1971 have only been in place for a few years, the effect of technological diffusion from them may only begin to show up over the next several years. The study also concluded that gains in overall efficiency and product quality have come more slowly and at greater cost than Soviet planners had anticipated.

The value of Western plants ordered between 1971 and 1975 equaled an estimated 20 to 25 percent of total Soviet investment in chemical industry equipment during that period, an amount that may have been higher than planners had in mind. When domestic and East European equipment suppliers were unable to meet commitments, the U.S.S.R. was forced to increase orders from the West in order to meet planned output goals. The East European chemical industry has concentrated in the more traditional technology areas of basic chemicals and fertilizers. Soviet output based on plants from Eastern Europe is significant for several types of chemicals, with 20 percent of sulfuric acid output, 25 percent of ammonia output, and 40 percent of urea production in 1975.

In comparison, the CIA estimated that plants supplied by the West accounted in 1975 for 40 percent of the Soviet output of complex fertilizers, 60 percent of polyethylene production, and 75 to 85 percent of polyester fiber output. In addition, they were responsible for 72 percent of new ammonia production capacity to come onstream from 1971. to 1975, and 85 percent of the scheduled new ammonia capacity for 1976-80. Some plants supplied by Eastern Europe also incorporated some Western technology which was thereby transferred to the U.S.S.R. indirectly.

The largest share of chemical plants supplied to the U.S.S.R. from the West came from Italy (26.4 percent), followed by France (22 percent), West Germany (17.5 percent), the United States (14.3 percent), and Japan (14 percent). The prominence of Western European nations is largely explained by their willingness to accept product buy-back provisions in payment,

All Soviet orders for U.S. plants came while the U.S.S.R. had Export-Import Bank (Eximbank) credits available, but technology has also been supplied by American multinational firms with subsidiaries in countries that provide the U.S.S.R. with competitive financing. This means that although American chemical firms supply the technology, the United States does not receive the economic benefits of major equipment orders and is unlikely to do so until Eximbank financing is once again available to the U.S.S.R.

The CIA conjectures that the U.S.S.R. has had only limited success in attempts to

[24] Amman, Cooper, and Davies, op. cit., p. 275.
[25] 1 bid., p. 53.
[26] Central Intelligence Agency, "Soviet Chemical **Equip**ment Purchases From the West: Impact on Production and Foreign Trade, " October 1978.

copy Western chemical technology, although it is still possible that the new ethylene plants being built by the U.S.S.R. might incorporate some features of larger ethylene plants that have been supplied by the West. The increasing complexity of modern equipment not only makes it more difficult for the technology in the equipment to be copied, but also makes it increasingly difficult to determine the origin of a given technology.

Technology transfer in the chemical sector has also been felt indirectly in other sectors, particularly agriculture. A recent study by Philip Hanson of the University of Birmingham attempted to measure the economic impact of Western technology in the Soviet mineral fertilizer industry by first estimating the increased fertilizer output that could be attributed to Western plants, and then estimating the increased agricultural output attributable to expanded supplies of these fertilizers. Hanson concluded that between 1970 and 1975 the Soviet Union achieved approximately 4 billion rubles of additional agricultural output by using fertilizer plants imported from the West and installed between 1960 and 1975, at a cost of approximately 2 billion rubles.[27]

All studies of the Soviet chemical industry conclude that the problems experienced by the U.S.S.R. are in developing technology and bringing it into industrial production in areas where technology is changing rapidly, where there must be close communication between research and production work, and where the number of unsuccessful experiments is high compared with the limited number of successful innovations. In the future, the Soviet chemical industry may need to choose between continued reliance on Western technology and turnkey plant capacity, or scaled-down targets for production growth, concentrating on increases based primarily on current technology.

Machine Tools

The Soviet Union has the largest stock of machine tools in the world; in the early 1970's, its inventory of metal-cutting machine tools was about one-third larger than that of the United States. Soviet metalforming equipment also outsizes the comparable U.S. stock. When measured in terms of performance and capability, however, even Soviet specialists have admitted that American machine tools exceed their Soviet counterparts .2'

Demand for machine tools still far exceeds supply in the U.S.S.R. This is due in part to the inefficient use of existing equipment. Soviet machine-tool output is dominated by relatively simple, general purpose machines, which are more easily built than the more complex equipment that machine-tool users increasingly demand. More than 60 percent of Soviet machine tools have been mass-produced with few design changes over many years.[29] In contrast, most machine tools in the United States are specialized models designed for a specific purpose and built in small quantities according to the needs of each customer.

The shortage of specialized machine tools, combined with the need for many plants to be self-sufficient, means that specialized machine tools built in the U.S.S.R. are often designed and produced by the users themselves. In these circumstances it is relatively unlikely that any machine-tool innovations will be diffused through the industry as rapidly as they would be if a regular machine-tool supplier had produced the innovation. The user-builder has no incentive to deploy new technology elsewhere.

Studies of the machine-tool industry concur that traditional Soviet machine tools—drills; lathes; boring, grinding, milling equipment; and transfer lines—do not differ sig-

"Philip Hanson, "The Impact of Western Technology: A Case-Study of the Soviet Mineral Fertilizer Industry, " presented at the Conference on Integration in Eastern Europe and East-West Trade, Bloomington, I rid., October 1976.

[28]Amman, Cooper, and Davies, op. cit., p. 122.

"'James Grant, "Soviet Machine Tools: Lagging Technolog and Rising I reports,"" unpublished paper, p. 25.

nificantly from those used in the West, although Western models often perform better in terms of operating speed, tolerances, or durability. The greatest difference between Soviet and Western technology lies in the area of advanced machine tools, such as numerically controlled equipment. Due to technological lags in the Soviet electronics industry in the 1960's, Soviet numerically controlled machine tools began to fall increasingly behind the Western technology. In 1968 the Ministry of Machine Tools and the Ministry of the Aviation Industry–the latter an important user of numerically controlled equipment—decided to step up production. As a result, output of these machine tools in the U.S.S.R. jumped from 200 units in 1968—about 7 percent of U.S. production—to about 2,500 in 1971, exceeding the level of American output.[30]

This rate of growth was made possible by assistance from the West. Since 1968, the U.S.S.R. has signed agreements with firms in Japan, France, and West Germany. At the same time, Soviet cooperation with East European enterprises in this field has also increased. East Germany has been a leader in the development of computer numerical control having shown models at the Leipzig Fairs as early as 1972.[31] Computer numerical control, which first appeared in the United States in the late-1960's, allows a great deal of flexibility and precision. There are no indications that the Soviets have been able to improve on this technology, however.

Furthermore, even with these boosts, and despite lengthy effort, the U.S.S.R. has experienced a great difficulty in trying to copy Western gear-cutting and grinding technology. This may be an indication that the Soviet Union will continue to find it difficult to raise the productivity, reliability, and level of precision of conventional machine tools, and will have problems keeping abreast of technological development in sophisticated models .32

The latter have been restricted by Western export controls, but during the past few years, as export regulations on advanced machine tools have been liberalized, the share of advanced machine-tool imports has risen.

Motor Vehicles

The Ford Motor Company first helped provide technology and equipment for Soviet automobile plants at Gorky and Moscow in the 1920's; since then, the U.S.S.R. has continued to look to the West for assistance with motor vehicle production. The initial contract signed by Ford called for the company to transfer any new technology developed during the 9 contract years, yet the U.S.S.R. chose not to introduce the V-8 engine developed by Ford during this period, electing instead to stay with older and somewhat simpler technology. Soviet specialists reportedly recognized limits to their technological capabilities and the problems they might have in absorbing new technology .33 These problems have persisted. Adequate R&D facilities have never been established in this field and the Soviets have difficulty keeping abreast of technological innovations.

Although the stock of trucks in Western economies is usually several times smaller than that of private automobiles, until a decade ago Soviet vehicle output was dominated by trucks. Owing to lack of production capacity, Soviet planners very early on restricted private ownership of automobiles. In the late-1960's, however, in response to a plan to increase worker incentives through major concessions to consumers, the decision was made to rapidly increase the production of cars.

In order to accomplish this, the Soviet Union's automobile industry received *a* massive infusion of Western technology. It

[30] 1 bid., p. 20.
[31] Amman, Cooper, and Davies, op. cit., p. 190.
"Grant, op. cit., p. 38.

[33] John Hardt and George Holliday, "Technology Transfer and Change in the Soviet Economic System, " in *Issues in East-West Commercial Relations,* Joint Economic Committee, January 1979, p. 71.

contracted with Fiat for a huge automobile plant at Tolgliatti . The Italians coordinated the selection and integration of technology from various sources. Some $550 million in Western equipment, primarily machine tools, were purchased from the West for the plant, with additional Soviet investment, including plant construction, coming to at least another $1 billion. ”

Fiat was also asked to provide a large number of technicians and to train others in Italy. Ultimately 2,500 Western technicians assisted in equipment installation, training, and startup, and 2,500 Soviet technicians were trained in Italy .35 This direct personal contact was instrumental in reducing the problems of absorbing the new technology.

One important test of the U.S.S.R.'s ability to absorb and diffuse the Fiat and other Western technology would measure improvements in the technology employed at the Tolgliatti plant and duplications of the technology at other plants. Significantly, the U.S.S.R. has twice chosen to renew the contract with Fiat, first in 1970 and again in 1975. It would appear from this that the technology employed at the plant has not been significantly improved upon by the Soviets and that further Western imports are needed. Moreover, in the Soviet motor vehicle industry, as in most other industries, output increases more from the expansion of existing plants than from the construction of new ones. The technical level of the expanded plant tends to be similar to that of the original plant, leading to growth, but little modernization.[36]

A desire for new production technology, and for a rapid expansion in capacity, led to a second major project involving the transfer of Western technology to the Soviet motor vehicle industry in the past decade. In building the huge Kama River truck plant with assistance from the West, the U.S.S.R. had hoped to entice a Western truck manufacturer to provide the same leadership that Fiat had for the Tolgliatti plant. But no Western firm was willing to act as general contractor. This was probably due to a number of factors, including the size of the project and awareness of the difficulties experienced by Fiat in dealing with the Soviet system. At the time, the U.S. Secretary of Defense opposed having an American company act as contractor for a plant capable of producing vehicles that might eventually be used for military purposes. The U.S.S.R. therefore served as its own general contractor, selecting firms to supply the major components of the plant, who then chose subcontractors in turn.

Problems at Kama River appear not to have resulted from the choice of major suppliers, but from poor coordination and integration of technologies from different sources. This is a frequent problem and appears to be a major reason behind Soviet willingness to spend so much of its hard currency for Western turnkey plants. The U.S.S.R. is as much in need of expertise in integrating technologies and systems into efficient, highly automated plants as it is in need of new technology.

These industries—chemicals, machine tools, and motor vehicles—have been the most dependent on technology and production capacity of Western origin. Although Western technology has made crucial contributions in all three, it has neither eliminated Soviet lags with the West nor apparently much aided domestic abilities to absorb, diffuse, and improve on the technology. The Soviet computer industry has also been technologically dependent on the West, but Western export controls and corporate interests have limited the computer production capacity that could be imported by the U.S.S.R. The question of technology transfer has become vital in the Soviet oil and gas equipment industry, due to Soviet needs and the state of energy supplies worldwide. These two industries are reviewed in depth below, in discussions of the comparative level of technology in these industries, the extent of technology transfer from the West, the predominant forms that these transfers

"i bid.. p. 68.
"'I bid., p 77
"I bid., p. 75.

have taken, and the overall impact of Western technology transfer on industry performance.

Computers[37]

To an increasing extent, the computer industry plays a key role in the overall planning, development, and capabilities of the Soviet economy. Because of the usefulness and interchangeability of computer systems in both civilian and military applications, the question of technology transfer is relevant to U.S. policy for both economic and security reasons.

The United States is presently the leading developer of computer technology, a position it has held since the early 1950's. For foreign producers, American dominance in the industry has meant not only extensive contact with American products and services, but also problems of competition from American firms in overseas markets. Restriction of American inroads by competing States would, in practical terms, have meant depriving themselves of the advantages that access to American technology could offer.

During the early years of the development of the U.S.-dominated international computer community, the U.S.S.R. remained at a distance. This choice reflected both Soviet desire to develop an indigenous capability and a narrow perception of the potential value of computers. In the late-1950's, however, the Soviet view of the computer began to change. Beyond its capabilities in the military sector, computer technology was now seen as crucial to low-level data processing and industrial process control.

The Soviets thus discovered that some contact with Western computer producers was necessary to develop a domestic computer industry suitable to the needs of their economy. While they possessed significant domestic potential for hardware R&D, they chose to utilize the Western market mechanism to weed out those new processes and technologies that were not viable. This policy was particularly useful in the computer industry, with its rapid rate of technical innovation. Thus it is not surprising that the Soviets developed a close relationship with the Western world in this industry.

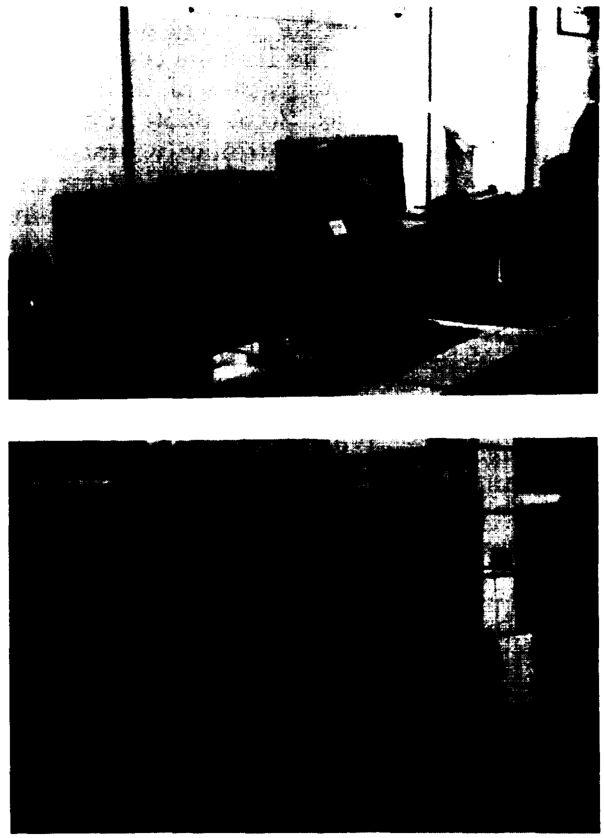

Photo credits: Control Data Corporation

Soviet computer equipment displayed in a recent trade fair

The Soviet-U.S. computer technology gap has grown over the years. In 1951, the first Soviet stored program electronic digital computer became operational, less than a year after its American counterpart. The machine was put into serial production only 2 years later, again less than a year behind the United States. These early successes suggested a substantial indigenous computer capability.

[37]See Seymour E. Goodman, "Soviet Computing and Technology Transfer: An Overview, " in *World Politics,* vol. **XX**-XI, **No.** 4, **July** 1979, pp. 539-570.

There was little transfer of technology during this period, despite a certain similarity between Western and Soviet hardware. Technical literature was the major vehicle for what little interaction took place.

Unlike the United States, the Soviet Union did not have a well-developed business equipment industry, nor an established organizational structure of user support. Close interaction between the designers and final users of equipment is typical with market-oriented firms like IBM; such relationships are virtually nonexistent in the U.S.S.R. This interaction is vital in the competitive and fast-changing business equipment market, and it provided a crucial advantage to U.S. firms in developing new and usable technology.

The Soviet military could have diverted sufficient resources into the computer industry to close the widening gap with the United States in the early 1960's; apparently it chose not to do so. While the Soviets followed the basic pattern of Western technical achievement, the pace of innovation in the U.S.S.R. fell far behind. It produced no major new practical contributions and it built functional equivalents of some Western products long after they had originally been introduced.

The Soviets began to change their attitude toward the computer in the early 1960's, when recordkeeping and data-processing tasks required the production of an upward-compatible series of computers. Such a system consists of a sequence of increasingly powerful computers that have been designed so that programs and data run on a smaller machine can also be run on the larger ones. The first Soviet attempt to produce such a series came in 1965. The U.S. functional counterpart to this machine had appeared in 1960. Here the U.S.S.R. initiated its policy of minimizing technological risk by using a proven U.S. system as a model for its own efforts.

In 1966-67, the Soviets began working on another upward-compatible series of computers, which attempted to copy the architecture of an IBM system that had appeared in 1965. The attempt was abandoned after the production of several machines.

In its next attempt, however, the U.S.S.R. organized a cooperative effort with five other CMEA countries–Bulgaria, East Germany, Hungary, Poland, and Czechoslovakia–all of which had computer industries. East Germany enjoyed access to IBM technology.

The fruits of this collaboration, the Ryad computers, began appearing in late-1972. They are not reverse-engineered from the IBM model; rather, they are functional duplications. The Soviet-led consortium required as long to design the Ryad computers, put them into production, and adopt them to IBM operating software as it took IBM to design, produce, and place the original family in operation. In spite of this, the Ryad system represents a significant achievement. It gives the U.S.S.R. and Eastern Europe a much improved indigenous capability for the production of computers, and has provided extensive experience in the design of computers based on foreign models. Ryad computers are still not produced at the rate at which IBM produced the original line, nor is the performance of the Ryad equipment strictly up to the standards of the IBM models. Nevertheless, U.S.S.R. and East European satisfaction with this program is indicated by the decision to move ahead with Ryad 2, also based on IBM models. By early 1977 most of these new models were well into the design stage, and the first prototypes of some models began appearing in 1978.[38]

The Ryad 2 program will concentrate on increased production of higher quality peripheral equipment, an area of significant technology lag and a source of past complaints by customers in the U.S.S.R. The core memory capacity for most Soviet computers is relatively small compared with the operating speed of the central processing

[38] N. C. Davis and S. E. Goodman, "The Soviet Bloc's Unified System of Computers," in *Computing Surveys*, June 1978, pp. 109-110.

unit, thus limiting system capabilities. It is hoped that core storage for Ryad computers in this new series should at least be doubled, if not quadrupled.[39]

The U.S.S.R. also cannot match the West in the quality and availability of magnetic tapes and disks. IBM introduced the first magnetic disk in the early 1960's, permitting the storage and readier availability of vast quantities of information compared to tape. The first Soviet computers to use disk storage may have appeared as early as 1970, but it was not until 1973 that such equipment regularly appeared with any models .40

Large memory capacities and input-output devices are important for a variety of data-processing applications. A larger proportion of Soviet input continues to be of the papertape and cardreader types, varieties that are being progressively phased out in the West. Soviet output devices, such as printers, plotters, and graphic displays, also leave much to be desired compared with Western systems. Much of the best Eastern-bloc input-output equipment is produced in Eastern Europe rather than in the U. S. S. R.; a number of models are produced under license from Western firms. Soviet software capabilities have been limited by each of the above-mentioned factors. By making use of the IBM operating system for the Ryad computers, the U.S.S.R. was able to gain access to software which required only minor modification for use on Ryad hardware, compared with what would have been involved in developing such software independently. Designing its own software is a major Soviet goal, yet it is questionable whether such copying aids this process.

Application programs tell the computer how to process data that is entered. Problems with hardware have held back application software development in the U. S. S. R., despite recent improvements. The lag between Soviet and Western software capabilities, as in other areas, has systemic origins. The Soviets lack the Western motivation to look for more efficient and less expensive ways to accomplish given tasks.

Calculating the precise value of computers shipped from the West to the U.S.S.R. is difficult, due to the nature of Western and Soviet trade data. Neither provides breakdowns into categories for computers, and case-by-case information about sales is limited. One report, based on detailed trade data for each Western country that supplies computers to the U. S. S. R., has produced the figures shown in table 36. Several industry experts believe these figures to be misleadingly low, particularly as regards products transferred by American firms via their Western European subsidiaries. These sales are not completely accounted for in Department of Commerce statistics. Orders placed in 1977 and later indicate that the downward trend observed in 1977 has been reversed, and 1978 U.S. data show a near return to the record 1976 levels.

The commercial interests of Western computer manufacturers and export controls have together strictly limited the transfer of manufacturing technology to the U.S.S.R. Only one Soviet plant order–for purchase of a Japanese facility for production of minicomputer memory devices—has been recorded. In addition, Romania and Poland (and perhaps other East European nations) have purchased Western licenses for production of several computers and peripheral equipment.

Table 36.—Western and U.S. Computer Sales to the U. S. S. R., 1972-77 (in millions of dollars)

	Sales from United States	Total sales from the West
1972	$ 4.1	$ 16.1
1973	4.0	15.7
1974	37	201
1975	9.4	28.3
1976	17.2	41.6
1977	5.7	28.3
1972-77 total.	$441	$1501

SOURCE IRD, Inc. *The Market for Computers in the PRC and the* USSR (New Canaan Corm January 1979)

[39] Amman, Davies, and Cooper, op. cit., p. 386.
[40] Da 'is and Goodman, op. cit., p. 98.

Although the Soviet Union has not acquired any licenses, some of the production technology obtained by Eastern Europe is likely to have been made available to it. The U.S.S.R. has thus derived its greatest benefits from importing computer systems to provide models of new technology to aid the Soviet computer R&D sector and provide capabilities otherwise unavailable. Export controls prevent the U.S.S.R. from importing the most advanced Western computers, although some sales have given them units with better reliability, software, and input-output capabilities than the best Soviet models.

Except for 1977, the 1970's have seen an upward trend in Soviet purchases of computers from the West (see table 36). Most computer sales are of systems costing several million dollars each. Users of large Western computer systems in recent years have included reservation systems for Intourist and Aeroflot, analysts of seismic data for geological prospecting, controllers of large industrial enterprises (particularly in the motor vehicle sector), and systems for inventory control and management. All these applications involve handling and managing large amounts of data. Soviet computers are less well-suited to such work in terms of memory and input/output capabilities, and the software required to perform such functions is frequently unavailable in the U.S.S.R. The purchase of these systems may sometimes be motivated as much by the desire to gain access to software as to hardware. The most important factor in a purchase decision, however, is generally the desire of the end-user management to obtain an entire system that, with a minimum of risk, will safely, effectively, and reliably address applications problems.

Scientific institutes and Government planners also buy Western computers to obtain good computer capability. These smaller sales receive much less press coverage than the headline-making orders for million-dollar computers. But as planners and scientific users have become more aware of the many uses to which computers can be put and given higher priority to the purchase of Western equipment, such sales have grown in importance.

Turnkey plants imported from the West also frequently include computers or sets of computers as part of the process control system. Almost without exception, the U.S.S.R. has insisted that plants imported from the West contain the latest process control and automation equipment. While this request may be partly motivated by the desire to obtain the embodied technology, it is also a reflection of the U.S.S.R. acute shortage of skilled operators for many industrial sectors; such automation is seen as an efficient means of reducing the labor requirements of new plants.

Because of its desire for maximum feasible self-sufficiency in such a strategic field, the U.S.S.R. cannot be expected to become a very large customer of Western computers. The Soviets will continue to rely on Western imports to meet certain needs. Such purchases may even reach a level several times higher than that of the past, but computer needs will compete with needs for other equipment and materials. Imports will tend to be restricted to those cases where the cost of doing the work without a computer is exceptionally high.

In addition to these constraints on the Soviet side, Western export license restrictions inhibit West-to-East computer sales. Often, the sales that are prohibited are the very ones which the U.S.S.R. desires most, i.e., they are sales of systems with those capabilities that the U.S.S.R. finds it most difficult to produce domestically. If export restrictions were eased, it is likely that the purchase of these systems would be of sufficiently high priority that hard currency would almost certainly be allocated for them. Under these conditions, the volume of such imports would probably rise sharply.

Computer sales to the U.S.S.R. tend to be won by those firms that are most aggressive in pursuing the Soviet market. Thus, the market share for American computers is much lower in the U.S.S.R. than in other markets around the world. The Japanese, like the Americans, have not yet pursued the Soviet computer market vigorously, but the West Europeans–particularly the British and French—have long sought involvement in the market.

The United States does enjoy a distinct advantage over competitors in the quality of its computer technology. This advantage is partially offset, however, by the strong disadvantage of uncertainty and delay due to export control. Only the United States fails to provide its companies with early indications that a license can or cannot be obtained. Only the United States will block a sale for political rather than strategic reasons. The United States takes longer than any other nation to approve a license, and regularly enforces stricter licensing regulations than those set by CoCom. As a result, American firms are sought as suppliers when they are able to provide products markedly better than those available from Japan or Western Europe, but not as suppliers of first choice when all else is equal. The difficulties experienced by American computer exporters lead to much of their business being handled out of Europe, since at least some of the problems are then avoided.

In many industries, the amount of time required for delivery is a factor in the selection of a supplier. American computer manufacturers should compete very well with suppliers from other Western countries in this regard, since U.S. firms often have more experience in putting together custom-designed systems. This potential advantage is frequently more than offset, however, by the regulatory delays a U.S. supplier may face. Even if the license is ultimately approved within a reasonably short time, the initial uncertainty of the outcome of the licensing procedure can chill the negotiations between an American computer supplier and the U.S.S.R. and can impose higher costs on the supplier, the Soviet Foreign Trade Organization negotiating the contract, and the Soviet user waiting for delivery of the equipment.

Financing is a factor only in those cases involving sales of computers for process control. The United States sells very few process control computers. The selection of turnkey plant suppliers is highly dependent on financing and on the willingness of the supplier to accept buy-back contracts for products produced at the plant. In both regards, the United States is at a disadvantage. Often, even though a plant is based on U.S. technology and incorporates an American license, it is financed and equipped by a Japanese or Western European firm. In such a case, the computer for process control, like all the other equipment for the plant, will come from the country that is supplying the credits for the plant. All U.S. turnkey plants that have been supplied to the Soviet chemical industry during the past few years resulted from orders that qualified for Eximbank credits, which have since been disallowed. No further chemical turnkey plants–and no process control computers for Soviet chemical plants—have been purchased from the United States since then.

It is difficult to assess the impact of Western computer sales on the economic performance of the U.S.S.R. The effect of any computer is difficult to measure in quantitative economic terms, but one can identify those areas of the Soviet economy that have benefited the most from Western computers. Western computers have had a strong impact on the motor vehicle manufacturing sector, as British and, more recently, American computers have been used to control production processes at a number of plants. Western computers have also become important for the analysis of seismic data, thus benefiting the identification of oil and gas reserves. Other sectors of the economy that have benefited include the chemical industry, from both the process control computers in imported turnkey plants, and the Ministry of the Chemical Industry's purchase of several computers to assist in the design of new chemical plants. Gosplan has received some Western computers, but has not used them with optimum efficiency. The greatest beneficiaries of Western imports have probably been scientific organizations, particularly those involved with nuclear physics.

In conclusion, virtually all major developments in Soviet computer technology have first taken place in the West. The U.S.S.R. has been a follower rather than an innovator in the computer technology field. Once a new technology has appeared in the West, the U.S.S.R. has usually succeeded in reproducing the technology domestically, although the timelag between Western and Soviet introduction of similar technologies has not diminished over time (see table 37).

As long as the U.S.S.R. continues in the role of follower, the technological lead of the West is assured. Even if the difficulties of moving swiftly through development stages into actual production of hardware are solved, the Soviets will still face difficulties in diffusing and effectively using the hardware they produce. Such problems do not lend themselves to ready solutions.

Oil and Gas

The U.S.S.R. is the world's leading producer of oil, and one of the largest suppliers of natural gas. Most of the equipment used for exploration, drilling, and extraction comes from within the U. S. S. R., with its relatively strong oil and gas equipment industry. The bulk of Soviet reserves of oil and gas is located in relatively shallow and very large fields, making it possible to reach high production levels without the most advanced technology.

Table 37. —First Production of Comparable Soviet and American Computers

American computer	Similar Soviet model	Date of appearance in the U.S.S.R.	Lag (in years)
IBM 650,	Ural 1	1955	1
IBM 702,	Ural 4	1962	7
IBM 1620, : :	Nairi I	1964	4
IBM 7094	BESM-6	1966	4
IBM 360 series	ES series	1972-3	6-8

Soviet lag in entering successive generations of computers

	First generation	Second generation	Third generation
First Soviet computer	1952	1961	1972
First American computer	1946	1957	1965
Lag (in years)	6	4	7

aComparison of dates of first American commercial Installation and first Soviet Indusrial production

SOURCE M Cave Computer Technology in *The Technological Level of Sovief Industry,* Amann Cooper and Davies eds (London 1977)

But the Soviet concentration on these shallow deposits reflects the country's limited geological prospecting capabilities, which make the exploration of deeper reserves difficult. Recently, the U.S.S.R. has shown interest in acquiring more advanced Western prospecting equipment, such as sophisticated seismic mapping equipment and field units to assist in the recovery and analysis of seismic data. A number of computers have been sold to the U.S.S.R. to provide this analytical capability.

The turbodrill has long facilitated significant advances in the productivity of Soviet drilling. About 85 percent of Soviet drilling was done by turbodrills in the early 1960's; since 1970, the share has stabilized near 74 percent. Turbodrill technology was attractive because it permitted the industry to use pipe and tool joints which were readily available, while reducing breakdowns and increasing speed. Unfortunately, however, the drill loses effectiveness when deeper drilling is required. The high drill speed required for efficient use of the pumps that run the drill results in comparatively short drill-bit life, so the deeper the well, the more time lost in replacing bits. The power transfer to the bit also becomes less effective when used with jet bits. Finally, while good for drilling in hardrock formations, the drill is far less effective in soft formations. The Soviet oil and gas equipment industry has addressed these problems by providing improved designs for new turbodrills, rather than by increasing production of rotary drills, which are most common in the West, even though as early as 1960 some planners recommended development work on rotary drills .4*

"Robert Campbell, *Trends in the Soviet Oil and Gas Industry* {Baltimore, Md., 1976), pp. 20-22.

A 1977 CIA study of the Soviet oil industry pinpointed the inefficiency of Soviet drilling as a major reason for probable problems in meeting future production goals.[42] The CIA estimates that the U.S.S.R. will need 50 percent more drilling rigs by 1980 to meet its drilling targets. The U.S.S.R. hopes, however, to reach its increased drilling goals primarily through improved rig productivity.

The quality of Soviet drill bits has also been blamed for poor drilling performance. The U.S.S.R. recently agreed to purchase a turnkey drill-bit plant from U.S.-based Dresser Industries to help remedy this situation.

Soviet technology for wellhead equipment is reasonably good, although better wellhead equipment is reportedly needed when the oil or gas being extracted is particularly corrosive or under very high pressure. There has also been a lag in the U.S.S.R. development of multiple completion equipment. This equipment permits a number of producing wells to exist on the same structure.

Soviet oilfields are being depleted rapidly but with a relatively poor rate of recovery. The Soviet economic system, with its production quotas and demands for immediate results, is one reason why fields in the U.S.S.R. are exploited quickly. Soviets inject water into wells on about 80 percent of U.S.S.R. fields to increase immediate production rates. This practice, known as secondary recovery, increases field pressure and the flow rate of the well, and may increase the ultimate field recovery. According to the CIA, however, this method may also reduce the field's long-term production potential and result in a serious fluid-lifting problem. Centrifugal pumps must be installed to pump out the water and oil; while the Soviet Union produces such pumps, their capacity and service life do not match that of the equipment produced in the United States.

Alternatively, secondary recovery might involve the injection of detergents, polymers, steam, or carbon dioxide instead of water. To learn more about these methods, the U.S.S.R. has increased its testing of such procedures and has imported equipment and material from the West.

Soviet experience and technology lag far behind that of the West in all phases of offshore work. The U.S.S.R.'s offshore drilling and production has been limited largely to activity on fixed platforms in shallow coastal waters of the Caspian and Baltic Seas, with only limited experience in jack-up drilling. The Soviet Union has avoided work further offshore because of technological difficulties and much higher production costs. The U.S.S.R. buys a larger share of its offshore equipment from the West than for any other phase of the oil and gas industry. U. S. S. R.-built equipment can only be used in limited water depths and for relatively shallow wells. The U.S.S.R. also lacks experience in subsea completion equipment, which is at the forefront of current Western technology, in underwater storage and transport, and in other advanced phases of offshore activity.

An offshore development project off Sakhalin Island, north of Japan, has produced the most active joint cooperation to date between the U.S.S.R. and the West. Japan is the U.S.S.R.'s principal partner in the project, although Gulf Oil plays a small part in it. In exchange for providing the technology and financing the exploration, the Western partners are assured a share of any resulting oil or gas production. The U.S.S.R. experience in this project will help it in further efforts to expand offshore drilling and production.

A similar arrangement will permit the joint development of gas onshore in Yakutia, in Eastern Siberia. For this project, Japanese and two American firms hold shares amounting to 50 percent of the project, with the U.S.S.R. retaining the other 50 percent. The progress on this project has been slow, largely because Eximbank financing for the American share of the cost is unavailable, and because sufficient gas reserves at the site to justify the project have yet to be proven. If successful, the project will entail

[42] See Central Intelligence Agency, *The Soviet Oil Industry*, April 1977; and *The Soviet Oil Industry: A Supplementary Analysis*, June 1977.

the construction of a pipeline to the U.S.S.R.'s Pacific coast, a distance of some 3,100 kilometers. The U.S.S.R. claims one trillion cubic meters of reserves exist at Yakutia.

The Yakutia project will require sizable quantities of Western technology for the construction of the pipeline, and for drilling and extraction under extremely cold conditions. To exploit the field on its own, the Soviets would face much higher costs in both time and money, and time may be the critical factor. To meet increased production goals, the U.S.S.R. needs both increased supplies of equipment that is in short supply, and better technology. If the United States restricts the sale of certain types of equipment or technology, it is likely that the U.S.S.R. will seek it from other Western sources (see chapter IV).

The difficulties of measuring the amount of equipment and technology sold by the West to the Soviet oil and gas exploration and extraction sector is shown by the wide discrepancies between Soviet data and Western estimates, as shown in tables 38 and 39.

The Soviet-supplied data in table 38 excludes pumps, but this omission does not fully account for the discrepancies between it and CIA figures. The problem is further compounded by a third source, the New York-based consulting firm of Frost and Sullivan, whose recent study contained the following figures for U.S. sales of oil and gas exploration and extraction equipment to the U. S. S. R.: $3.7 million in 1973, $28.5 million in 1974, $10.9 million in 1975, and $34.0 million in 1976. The CIA data covered orders placed as sales, while the other two sources recorded actual deliveries. Subsequent investigation has shown that the CIA figure for submersible pumps was high by about $50 million, partly because of an order that was never filled.

Table 38.—Soviet Imports of Western Oil and Gas Exploration and Extraction Equipment (in millions of dollars)

	Purchases from United States	Total purchases from the West
1972	$4.6	$ 19.4
1973	43	23.5
1974	5	9.0
1975	49.5	150.1
1976	406	2265
1977	29.3	1210

NOTE These figures do not include turnkey manufacturing equipment
SOURCE Vneshnaya Torgovlaya (Soviet Trade Data) category 128

Table 39.—Breakdown of U.S. Oil and Gas Equipment Sales to the U.S.S.R. (1972-76) (in millions of dollars)

Category	Value
Pipelines	$304
Submersible oil pumps	148
Offshore and refining equipment	49
Other	49
Total	$550

SOURCE Central Intelligence Agency *The Soviet Oil Industry* A Supplemental Analysis June 1977

It can be said with certainty that since 1976, the volume of Soviet orders for Western oil and gas equipment has risen significantly. There has also been a shift toward turnkey projects, either for plants to produce equipment or materials required by the industry, or for full-service contracts with firms to provide all equipment needs for an entire project. A recent order to a U.S. firm to supply gas equipment for wells in Western Siberia is an example of the latter.

The U.S.S.R. clearly realizes that it must import this equipment and technology to increase production of oil and natural gas at rates that meet domestic needs and allow it to sell surpluses to Eastern Europe and to the West, thereby earning hard currency. The sale of oil and gas has accounted for approximately half of all Soviet hard-currency earnings in recent years. These earnings are used for financing continued imports of Western grain, equipment, and technology.

Failure to meet oil and gas production goals would involve extreme costs in the loss of this earning power. But, if the U.S.S.R. were extremely concerned about its future oil and gas production, it would be logical for it to permit greater involvement of Western firms in joint production projects to speed up development of reserves. Instead, the U.S.S.R. has chosen for the present to concentrate on acquiring equipment and technology beneficial to the long-run production capabilities of the country, with special emphasis on technology that requires only relatively short leadtimes to produce increases in output of oil or gas.

The selection of equipment and technology suppliers for the Soviet oil and gas industry is based on a number of factors, including financing and the kind and quality of technology. The oil and gas industry, as a major earner of hard currency, receives a very high priority when it comes to the allocation of foreign exchange for imports. When the technology offered by different suppliers is relatively the same, financing terms may determine the chosen supplier. In most cases, however, differences in technology will provide the basis of the choice. When a multinational firm can have equipment produced in a country that will provide better financing than the United States, the package becomes more attractive to the U. S. S. R.; American firms have done this a number of times.

The Carter administration decided in mid-1978 (during and presumably because of the Soviet dissidents' trials) to place all oilfield equipment on the Commodity Control List. This action may have affected Soviet perceptions of American firms as reliable suppliers. Although no sales of oil and gas equipment have been denied licenses since the order was given, in some cases the U.S.S.R. may have decided not to pursue negotiations with American firms to avoid the possibility that the license might be blocked for political reasons.

In other cases involving equipment such as seismic prospecting instruments or computers used to analyze seismic data, the stricter controls placed on American suppliers are more than offset by the superior American technology, which ensures that the American firm is the most likely choice as supplier.

In summary, the U.S.S.R.'s pattern of relying on Western technology to rapidly increase its capabilities in offshore operations and secondary recovery suggests that the primary interest of the U.S.S.R. in importing this equipment and technology is more to gain the productive capacity which the equipment represents than to obtain the opportunity to duplicate new technology. For the most part, oil and gas equipment imported from the West has not been integrated with Soviet equipment, partially because equipment purchases have primarily included complete units. This approach allows the U.S.S.R. to achieve the greatest possible productive capacity with the equipment it imports. The recent shift toward imports of turnkey plants will, however, increase the U.S.S.R.'s exposure to Western technology, and may speed the rate at which this equipment is absorbed by the Soviet industry.

It is still too early to tell how efficiently the U.S.S.R. will absorb most of the equipment and technology it has imported for oil and gas development. It may be expected that the rate of active oil and gas technology transfer between the West and the U.S.S.R. will increase in the future, particularly as Sakhalin Island, Yakutia, and other projects advance.

CONCLUSIONS

Western technology has made a marked impact on each of the Soviet industrial sectors considered here—chemicals, machine tools, automobiles, computers, and oil. Generalizations, however, either concerning aggregate economic effects of Western imports or motivations for importing Western technology are misleading. There are two basic rationales for importing foreign industrial technology and/or products: 1) such items could not, under any circumstances, be produced domestically and 2) it is economical to import rather than to produce domestically. But the role of imports in each particular industry is markedly different. Thus, a sophisticated and useful approach to sectoral impact of imports must recognize that between these two points lie a range of rationales for individual import decisions in any given sector. Motivations for foreign imports are closely associated with the capabilities of domestic industry. The range of categories of imports relative to domestic productive capacity is as follows:

1. technology and/or products that cannot be domestically developed or produced at any cost;
2. technology and/or products that can be developed or produced domestically at great cost in time and resources, and the lack of which create bottlenecks in other productive processes;
3. technology and/or products that can be developed at great expense in time and resources, but do not create bottlenecks;
4. more productive versions of technology or products similar to those already available in the U. S. S. R.; and
5. technologies that can lead to capacity increases in products equivalent to those available domestically or products providing marginal economic returns.

This range of choices may be regarded as a continuum, and the rationale for individual imports from the West may fall anywhere along it. Given the decision by Soviet planners to increase production in all the sectors under consideration, those imports that fall in the initial categories will be most beneficial in an economic sense. But products of technologies that the Soviets are incapable of producing at any cost are extremely rare. Most analysts have concluded that only time and commitment separate the Soviets from any given advance otherwise available to them through imports. At the opposite end of the spectrum, it is highly unlikely that import decisions are often made for cases of marginal returns, both because a wide range of more productive processes are always available in the West and because of Soviet propensity to avoid expending hard currency on cases of doubtful return.

The relative role of Western imports in individual sectors may be determined by where in the range of import types purchases of Western products and processes cluster. In the chemical industry imports are generally used as a vehicle to acquire new equipment and processes that could be produced in the U. S. S. R., but at great R&D cost. Chemical output is also central in capacity increases in other crucial sectors—agriculture in particular. Imports in the chemical industry tend to occur in the higher range of import choices; equipment and processes acquired are consequently crucial to planned growth in the industry.

While imports in the automotive sector are made at all levels of the choice range, large imports tend to be made both for productivity and capacity increases. The Soviets are perfectly capable of producing automobiles with domestic technology, but Western imports increase the speed, efficiency, and overall capacity of their industry.

In the area of machine tools, productivity and capacity increases also appear to be the major factors behind imports. In this sector as well as in the oil industry, a relatively strong domestic industrial base exists. The Soviets have, however, planned large capacity increases in both. The fastest and most efficient way to accomplish this goal is through imports of Western capital, which transfer Western technological advance in addition to adding to capacity.

Soviet computer imports fall into the higher range of import types; R&D costs in this industry would be immense in the U.S.S.R. This is due both to the speed with which innovations are developed and the fact that they are often motivated by the needs of the user. A centrally planned economy is particularly unsuited to high levels of innovation in this industry. Soviet practice has been to wait for major innovations to be proven viable in Western markets before attempting to incorporate them into its own production.

In conclusion, the impact of Western imports differs significantly across sectors, both from a qualitative and quantitative point of view. There can be no doubt that economic benefits have accrued to all the industries under consideration as a result of imports from the West; the process by which this has been accomplished is complex and differs from industry to industry. It is clear that any policy aimed at affecting the economic impact of Western technology in the East must be tailored to achieve specific effects in specific industries.