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The Soviet Motor Vehicle Industry: Improving Quality and Productivity

A Research Paper

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A Research Paper

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The Soviet Motor Vehicle Industry: Improving Quality and Productivity

Summary

Information available as of 30 June 1986 was used in this report.

The Soviet leadership has challenged the motor vehicle industry to raise vehicle quality and manufacturing productivity to world standards in support of economywide efforts to increase industrial efficiency. The industry has been directed to produce fuel-efficient, longer lived vehicles that will create the basis for a better balanced transportation system and reduce manpower and material requirements.

Although the industry has been a leader in the Soviet Union in developing and introducing new manufacturing technologies and processes and has served as a proving ground for industrial automation, efforts to modernize antiquated and overstaffed automobile plants have been complicated by the great diversity in plant size, level and origin of technology, and product mix. The plants are equipped with a patchwork of machinery drawn from various domestic and foreign sources and operate at widely varying levels of output and efficiency. Plants do not compete with each other because their vehicle lines for the most part are specialized to serve particular customers and because excess consumer demand assures individual producers a ready market. These conditions hinder the efforts of planners to bring about improved performance, particularly through the diffusion and assimilation of new production technology

Industry modernization in the 1980s builds on the achievements of a 1966-80 initiative that called for increased output of cars to enhance consumer welfare and increased production of heavy and light trucks to bring about better balance in the truck fleet. Investment during 1965-80 continued the traditional concentration on expanding capacity. This effort was highlighted by the construction of the Volga car plant (operational in 1971) and the Kama River truck plant (1976) and was supported by the acquisition of Western manufacturing equipment and technology worth approximately $4.3 billion. We estimate that completion of these two plants roughly doubled floorspace at final-production facilities during 1965-80. According to the Soviet Central Statistical Administration, vehicle production rose from just over 600,000 units in 1965 to almost 2 million in 1975

During the late 1970s and early 1980s, however, the Soviets chose to spread investment more evenly throughout the industry and increasingly opted to upgrade technology to improve productivity in established plants. According to the official automotive industry journal, during the late 1970s roughly 1,000 automated and 700 mechanized lines, 32 automated management systems, and 16 computer centers were installed throughout the

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industry, and during the early 1980s numerous numerically controlled tools, machining centers, robots, and process controls were installed. The Soviets chose to draw more evenly on Western, East European, and domestic sources for this equipment. Identified orders for Western equipment equaled about $1.6 billion during 1976-85, and machinery production within the motor vehicle industry—a major source for its own equipment—reportedly increased rapidly during 1976-80. The Soviets claim that by 1983 at least 80 percent of all manufacturing processes and 90 percent of all foundry operations were automated or mechanized and that, during the late 1970s and early 1980s, the introduction of automated processes and equipment eliminated about 100,000 jobs in the industry.

Although Moscow substantially raised the technological level of the industry and its products, we believe that both remain a decade or more behind the West. "Hard automation," in which machine tools are permanently arranged for most efficient production of long runs of specific parts, remains the most common approach. Even in their most modern plants, the Soviets have been almost 10 years behind the West in installing robots and automated material-handling devices. Moreover, these relatively advanced applications of Soviet automation impede production flexibility because lines and machines are rarely linked or computer controlled and therefore require continued operator intervention. From Western technical analysis of the key automotive components and subsystems, we estimate that the current generation of Soviet trucks is comparable to Western trucks of the mid-1970s.

Taking the late 1970s as a benchmark, expansion in the motor vehicle industry, the introduction of new vehicle models, and the installation of advanced automated production technology have yielded small gains in production, large gains in quality, and uneven gains in efficiency. The modernization effort itself interfered with vehicle production. By 1980 nearly all old production programs had matured, exhausting the potential for increases in output through more efficient use of fixed production resources, and obsolete vehicles were being phased out. The Soviets also were experiencing difficulties bringing new facilities—especially the Kama River plant—up to rated capacity. Heavy investment in the Kama River and Volga plants probably retarded productivity gains elsewhere in the industry. Consequently, during 1976-85 output rose only slightly, from 2 million to 2.3 million vehicles—an average annual growth rate of only 1.5 percent. Truck production declined in 1982 and car production fell in 1981-82; production of both then rose

The marked increase in the quality of Soviet vehicles produced since 1975, however, has improved the efficiency of the military and civilian transportation systems. Soviet consumers, institutions, and industries purchased about 75 percent of all cars—about 1 million cars per year over this period. We estimate that agriculture and the military each received about 25 percent of truck production, other civilian fleets received 45 percent, and exports accounted for about 5 percent. We estimate that, on average, trucks produced in 1985, versus those produced in 1975, can carry about 25 percent more cargo by weight, have about a 45-percent longer service life, are slightly more fuel efficient, and that the aggregate life-cycle carrying capacity of trucks produced in 1985 was almost 70 percent greater than that of those produced in 1975.

Motor vehicle industry productivity remains substantially below Western levels. Despite the introduction of laborsaving measures over the last decade, Soviet statements [redacted] indicate that many plant operations remain labor intensive by Western standards. The capital productivity measures we use suggest that the strides the industry has made over the past decade have been due largely to vehicle design innovations that have increased average service lives and payloads rather than to gains in manufacturing efficiency. Using final-assembly floorspace as a surrogate for capital endowment, we compare the value of output per unit of floorspace among plants according to four measures:

- The number of units produced reflects a plant's ability to organize production throughput. By this measure, productivity declined in the industry as a whole and at three truck plants and all car plants.

- The value derived from summing the current ruble wholesale prices for all vehicles produced provides an approximate measure of the resource cost of production. By this measure, productivity rose in truck production but fell in car production.

- The total weight of vehicles produced demonstrates a plant's ability to process material inputs. By this measure, productivity declined in the industry as a whole and at three truck and all car plants. Some of this decline, however, reflects Soviet design advances that have reduced the weight of individual vehicles, mostly to increase fuel economy.

- Life-cycle carrying capacity reflects the potential usefulness of trucks to the economy. By this measure, productivity rose in truck production as a whole and at all but two truck plants.

Moreover, capital productivity varies between plants by several hundred percent, depending on the measure. Finally, our detailed analysis indicates that the relatively modern Kama River plant is only 30 to 50 percent as productive as [ ] which produces similar vehicles and is similarly equipped—depending on the measure of capital or labor utilization.

To remedy this situation, the Soviets have set ambitious goals for the motor vehicle industry in the 12th Five-Year Plan (1986-90) and beyond. Labor productivity, which is expected to more than double, is slated to grow about 20 percent more rapidly than in the economy as a whole; and the value of output is to double. Plans also call for a new wave of basic vehicle designs, including new heavy diesel truck models—some especially for agriculture—and front-wheel-drive cars. By 1990, diesel trucks are to account for 85 percent of total production, up from about 25 percent in 1985.

To achieve these goals, Moscow plans to continue to reequip plants throughout the industry with more modern and productive machinery while building substantial new capacity. According to a deputy minister of the Automotive Ministry, 2,000 automatic lines, more than 300 flexible manufacturing systems, 5,500 robots, and numerous pieces of equipment for metal cutting and forming are to be installed by 1990. The Gor'kiy plant reportedly will be completely reconstructed and retooled at a cost of 1.2-1.4 billion rubles—probably the largest single revitalization project ever in the industry. In addition, as part of Moscow's increasing emphasis on using domestic sources of high-technology equipment, the Minsk, Volga, ZIL, and Gor'kiy motor vehicle plants are to greatly increase their production of machine tools for the automotive industry and for the economy as a whole.

Industry final-production floorspace in total probably will expand by at least an additional 15 percent over the coming decade. We estimate that completing the expansion of existing plants will account for two-thirds of the growth. The Soviets reportedly also plan to complete construction of two new major truck plants and make another addition to ZIL. One new plant, in Ivanovo (northeast of Moscow), will reportedly assemble 150,000

medium or heavy trucks per year. The other, in Kirovobad in the Azerbaijan Republic, will reportedly assemble 40,000 to 50,000 light trucks and vans per year. These new facilities will probably be completed and operational sometime in the mid-1990s.

We expect that vehicle production will grow moderately during 1986-90 as the industry continues to cope with the challenges of assimilating new programs, plants, and technology. Although we estimate that during this period production will rise only by roughly 10 percent, from 2.3 million to 2.5 million vehicles, recent trends in qualitative improvements will continue. By the mid-1990s, the Soviets will have created the conditions for more rapid increases in production. If they maintain momentum in current programs, output should rise as new production programs and technologies are assimilated. We estimate that by the mid-1990s—under optimal conditions—annual production could reach 1.2 million trucks, nearly 2 million cars, and 125,000 buses—a total of 3.3 million vehicles.

By the early 1990s, as production rises and more durable and efficient trucks remain longer in the inventory, the military may actually require delivery of fewer trucks each year. If more trucks are thus made available to agriculture and construction, motor transportation bottlenecks in these sectors could be relieved. We also believe that car exports to the West will receive greater priority over the next several years as Moscow uses sales of more attractive and efficient vehicles to balance hard currency losses attributable to poor performance in other sectors and to partially finance the industry's modernization program.

On balance, we believe that the modernization program of the last decade—albeit heavily oriented toward hard automation—will yield substantial gains in product quality and productivity well into the 1990s. Moreover, the improvements are well timed to support Gorbachev's objectives of economywide industrial modernization. But, to achieve the more ambitious objective of raising the motor vehicle industry to world standards, the Soviets must move to more flexible forms of automation that can more easily accommodate rapid product change. To do this, they must overcome or circumvent serious deficiences in key technologies that support factory automation, including arrays of linked minicomputers, sophisticated software engineering, microprocessor-operated controls, and high-speed telecommunications networks. In addition, the leadership will have to

accommodate associated changes in organizational, managerial, and employment practices that have been confronting Western automotive manufacturers for at least the past decade. Progress in the West, combined with Soviet deficiencies, suggests that the Soviet motor vehicle industry probably will not attain the standards of its Western counterparts in this century.

Contents

The Soviet Motor Vehicle Industry: Improving Quality and Productivity

Background

The Soviet motor vehicle industry is a prime target of Gorbachev's industrial modernization program. The trucks, cars, and buses it produces provide essential transport services to the military, industry, and the public, yet many vehicles are inefficient and tie down a large force of drivers and maintenance personnel and consume large quantities of scarce petroleum products.[1] Its plants are a major source of and customer for laborsaving machine tools and robotic systems but, by Western standards, are also overstaffed. Finally, its consumer goods production—especially the passenger automobile—provides major incentives to fuel the greater worker effort that Gorbachev is seeking

The industry Gorbachev has to work with reflects the main tenets of 60 years of Soviet development strategy. Stalinist pressure for rapid industrialization and appreciation for economies of scale brought about the construction in the late 1920s and early 1930s of massive factories manufacturing highly standard vehicle and slowly changing product lines. Construction of the Moscow (ZIL), Gor'kiy, and Yaroslavl' plants increased production from a few thousand vehicles in 1928 to 200,000 vehicles in 1937, nearly all of them trucks. Additional plant construction after World War II supported an average annual increase in vehicle production—mostly general purpose medium trucks—of almost 15 percent between 1946 and 1958.

Much of this extensive growth was sustained by the sometimes opportunistic import of Western technology, creating a patchwork of manufacturing plant and equipment. The ZIL, Gor'kiy, and Yaroslavl' plants were partly or totally built by Western firms. During the war, US Lend-Lease aid established several assembly plants and also included the delivery of about 417,000 complete vehicles, most of them all-wheel-drive trucks. German war reparations provided a considerable infusion of capital, and US truck and engine designs acquired through the Lend-Lease program were used to establish the postwar generation of vehicles.

In the 1960s the Soviets sought to diversify and broaden the motor vehicle industry but continued to rely on massive vertically integrated facilities. Their 15-year transportation modernization plan announced in 1965 called for increasing production of automobiles and heavy trucks to boost consumer welfare and create a larger and more balanced truck fleet.[2] The Soviets reportedly allocated one-half of the estimated 7 billion rubles invested in the automotive industry during 1971-75 to the construction of the Volga car and Kama truck plants. Both plants are based almost entirely on Western technology and are the largest plants of their kind in the world

In the late 1970s—as the 15-year plan was drawing to a close—the Soviets modified their traditional approach of simply building additional plants to raise output. Soviet officials publicly acknowledged the need for continued growth in vehicle production, but they stressed the need for greater productivity and new vehicle designs to improve performance, utility, and operating efficiency. They allocated investment more evenly throughout the industry, expanding and refurbishing existing production facilities with Western, East European, and domestic production technologies. These themes have been generally reemphasized in Gorbachev's industrial modernization program

[1] According to a Soviet press account, in 1985 the motor transport sector consumed 70 million tons of fuel and employed 10.5 million people

[2] In this paper the three truck classes are: light (less than 2 metric tons carrying capacity), medium (2 to 5 tons), and heavy (over 5 tons). These are the definitions used in the USSR and differ from those used in the United States

This paper assesses the Soviets' progress toward and prospects for modernizing and expanding their automotive industry. We consider developments since the mid-1960s in Soviet facility construction and modernization, and the roles played by Western, domestic, and East European technology; the quality and quantity of vehicles, particularly trucks; and trends in manufacturing efficiency. We also consider the impact of ongoing improvement on the Soviet economy and military.

Development of the Motor Vehicle Industry, 1975-85

The Ministry of the Automotive Industry (Minavtoprom) operates about 300 plants and numerous research and development (R&D) organizations.[1] Most key facilities belong to a production association, and most associations consist of a lead final-assembly plant and numerous satellite plants[2] (see figure 1 and table 1). Eight production associations produce nearly all trucks and about one-half of all buses; four produce almost all Soviet passenger cars. In the mid-1980s the ministry produced about 250 truck, 60 automobile, and 35 bus models and modifications and 50 types of trailers and attachments. The ministry also maintains its own internal R&D base for vehicle design and production technology development (see inset)

The pattern of expansion and modernization over the past six decades has created considerable diversity across the industry in production technology, the degree of vertical integration, and product mix:

- Most of the truck assembly plants and one car plant—the Volga plant—are highly vertically integrated, producing many of the truck and car components in on-site foundries, forges, machine shops, engine plants, and other facilities. These plants have varying access to satellite plants that produce other components (such as transmissions and electrical equipment) or assemble specialized vehicles, and rely on production technology that varies greatly in vintage and origin.
- The remaining automobile and bus plants rely extensively on other facilities for the supply of components and subassemblies. In production technology, the Volga and Moskvich plants, which were built by Italy's Fiat and modernized by France's Renault, have little in common with their counterparts.

Differences among plants are accentuated by the extreme specialization of each product line. There is relatively little overlap among the customer requirements that each production association is designed to serve.

Soviet literature indicates that the plants also operate at widely varying levels of efficiency, which complicates industrial management. For example, in the early 1970s Soviet authors claimed that labor productivity in the Kama plant would be two to three times greater than productivity in older Soviet passenger car plants. These wide differences make it difficult for planners to distinguish between bad management and factors beyond the plant manager's control. The differences particularly frustrate efforts to induce technical innovation. Plant managers cannot be readily evaluated against the same performance norms, and the patchwork of equipment means that technology needs vary by facility. Soviet literature reveals frustration over the limited successes of campaign-style efforts to introduce new production machinery—much of it Western—at older plants to increase production efficiency

[1] Before 1965 the automotive industry was subordinate to several different administrative organizations including: the Central Administration of State Automotive Plants (1922-41); the People's Commissariat for Medium Machine Building (1941-45); the Ministry of the Automobile Industry (1945-47); the Ministry of the Automobile and Tractor Industry (1947-53); the Ministry of Machine Building (1953-54); and the Ministry of the Automobile Industry (1955-57). In 1957 most industrial ministries were abolished and replaced with regional economic councils. In 1965 the present ministerial structure was introduced.

[2] Production associations were introduced in the mid-1960s to increase manufacturing efficiency through a unified administrative structure that usually brings together in a single enterprise a major manufacturer and its principal suppliers. This structure is supposed to provide coordinated production programs among cooperating plants, more efficient use of resources, and more rapid assimilation of technological advances

Figure 1
Major Soviet Motor Vehicle Plants

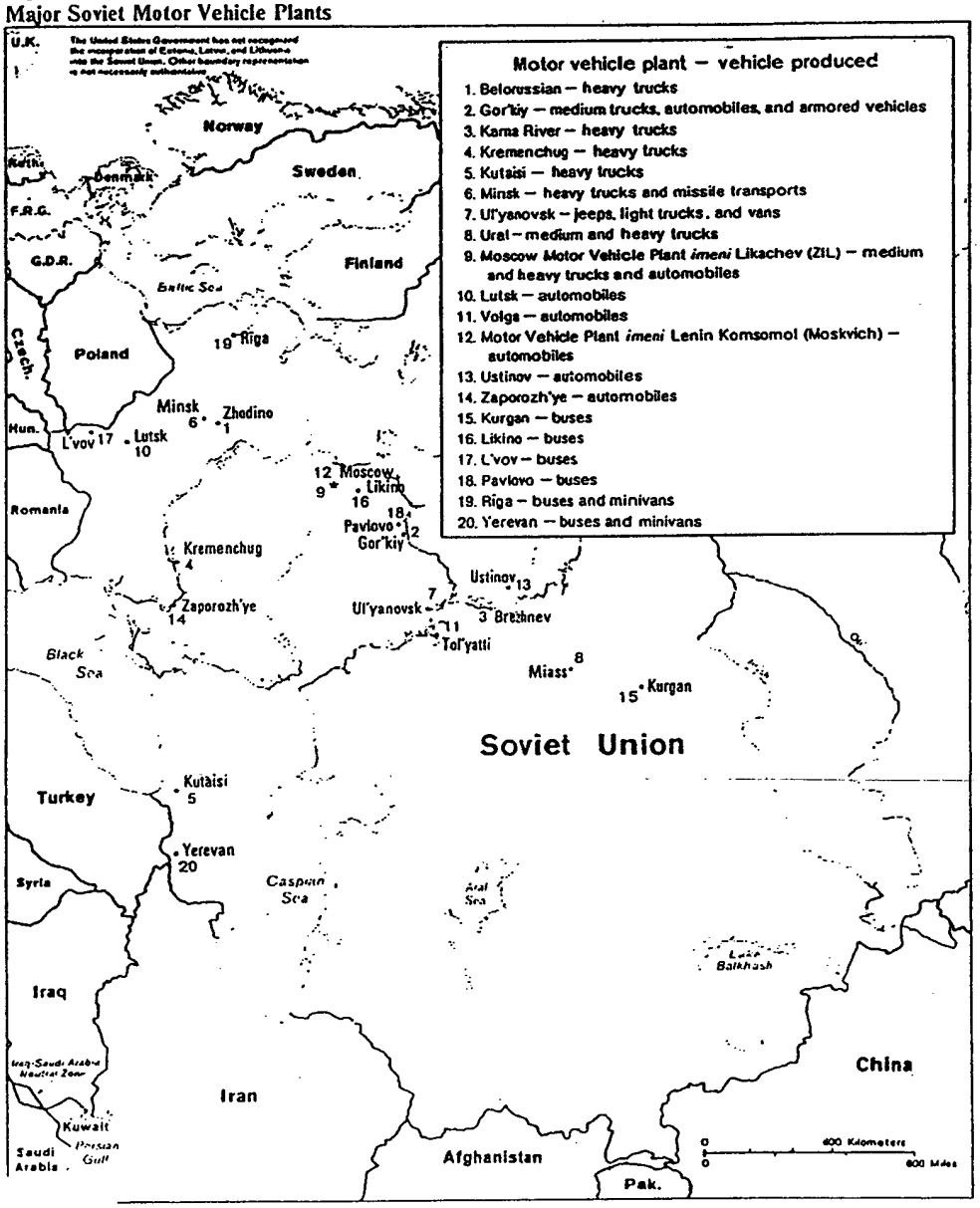


Table 1
Major Production Facilities in the Soviet Motor Vehicle Industry

Production Association	Plant Name and Acronym	Buildings Engaged in Specific Manufacturing Activities					
		Final Assembly	Machining	Fabrication	Forging	Foundry	Number of Identified Satellite Plants
BelavtoMAZ	Belorussian Motor Vehicle Plant (BelAZ)	2	1		1	1	
AvtoGAZ	Gor'kiy Motor Vehicle Plant (GAZ)	5	2	2	2	4	
AvtoKamAZ	Kama River Motor Vehicle Plant (KamAZ)	2	3	1	6	5	14
AvtoKrAZ	Kremenchug Motor Vehicle Plant (KrAZ)	3	3	3	1	1	1
AvtoKAZ	Kutaisi Motor Vehicle Plant (KAZ)	5	3		1	3	1
BelavtoMAZ	Minsk Motor Vehicle Plant (MAZ)	3	2	6	1	3	
AvtoUAZ	Ul'yanovsk Motor Vehicle Plant (UAZ)	2	2	8	1	4	4
AvtoUralAZ	Ural Motor Vehicle Plant (UralAZ)	4	4	2	4	4	1
AvtoZIL	Moscow Motor Vehicle Plant *Imeni* Likachev (ZIL)	4	7	1	3	2	17
AvtoZAZ	Lutsk Motor Vehicle Plant (LuAZ)	2	2				
AvtoVAZ	Volga Motor Vehicle Plant (VAZ)	2	2	2	1	4	5
AvtoMosk-vich	Motor Vehicle Plant Lenin Komsomol (AZLK)	2	1				3
	Ustinov Motor Vehicle Plant	1	1			0	
AvtoZAZ	Zaporozh'ye Motor Vehicle Plant (ZAZ)	3	1	2	1	4	3
AvtoGAZ	Kurgan Motor Vehicle Plant (KuAZ)	2	1				
	Likino Motor Vehicle Plant (LiAZ)	2	1				
	L'vov Motor Vehicle Plant (LAZ)	3	1				
AvtoGAZ	Pavlovo Motor Vehicle Plant (PAZ)	2	1				
	Riga Motor Vehicle Plant (RAF)	1	2				
	Yerevan Motor Vehicle Plant	2	1				

Automotive Research and Development

Automotive R&D is conducted by two specialized independent scientific research institutes and by the R&D departments of the principal plants:

- *The Central Scientific Research Institute for Automobiles (NAMI) researches vehicle design, materials, and components. NAMI's scientists consult and cooperate with plant designers—especially regarding vehicle quality and service life—but do not have primary responsibility for developing vehicles.*
- *The Scientific Research Institute for the Technology of the Automotive Industry (NIITavtoprom) researches new production processes, equipment, and management techniques and helps to facilitate their introduction into production at the plants. NIITavtoprom conducts research on technologies—such as machine tools, robotics, and factory automation—that are applicable to many industries and formulates technical standards for automotive production technology*

Vehicle design bureaus at selected production plants generally integrate technology and make the final decisions on overall product and process design, although they do interact extensively with NAMI and NIITavtoprom. Several plant design bureaus also influence development and thus affect likely paths for diffusion of technology throughout the industry:

- *ZIL is generally acknowledged as the leader of the industry and as one of the technical leaders of all Soviet machine building. The Kriger Design Bureau at ZIL has designed since at least the early 1950s all military and civilian medium and heavy ZIL trucks (except the 8x8 missile transporter-erector-launchers), as well as trucks being built at the Kama, Kutaisi, and Ural truck plants. ZIL also is a leader in automated machining technology.*
- *Gor'kiy is a leading developer of light and medium trucks, passenger cars, gasoline engines, and armored personnel carriers. It designs the jeeps made at the Ul'yanovsk plant and the trucks assembled at its subordinate Saransk and Frunze truck assembly plants.*
- *The Minsk truck plant develops very heavy trucks, several of which have no Western counterparts.*
- *The Volga car plant is a leading developer of manufacturing technologies, particularly industrial robots.*
- *The Yaroslavl' engine plant is the leading developer of Soviet diesel engines.*

Foreign R&D organizations still support car and bus design, but the Soviets no longer slavishly copy Western truck designs. For example, Italy's Fiat built the Volga car plant and designed all its cars except the new VAZ 2108, which was designed by West Germany's Porsche. France's Renault reconstructed and equipped the Moskvich car plant in the late 1970s and designed new Moskvich cars. Hungary's bus manufacturer Ikarus has influenced Soviet bus design. Conversely, Soviet trucks, although still showing signs of their Ford and Studebaker heritage, are largely Soviet in design

Articles in the Soviet press suggest that the industry's R&D base is uneven in quality. ZIL is almost universally praised. Others—like Gor'kiy—are accused of having a weak scientific and technological experimental base, inadequate to bring it up to par with leading world automotive manufacturing technologies. NAMI and, even more, NIITavtoprom are accused of not meeting the needs of the industry, and individual plants are urged to develop stronger in-house R&D facilities.

Expanding Capacity

We estimate that floorspace available at motor vehicle industry final-production facilities increased by about 50 percent between 1975 and 1985 and roughly doubled between 1965 and 1980—the period of the transportation plan [1] (see figure 2). We base this estimate on an analysis [redacted] the 20 major motor vehicle assembly plants, which account for nearly three-quarters of all motor vehicle industry floorspace. [redacted] Soviet press statements indicate that several of the remaining motor vehicle facilities have grown at about the same rate over the past several years. One-third of the expansion at the 20 major facilities took place in final-assembly buildings and the remainder in chemical and thermal processing, machining, foundry, stamping, and subassembly operations

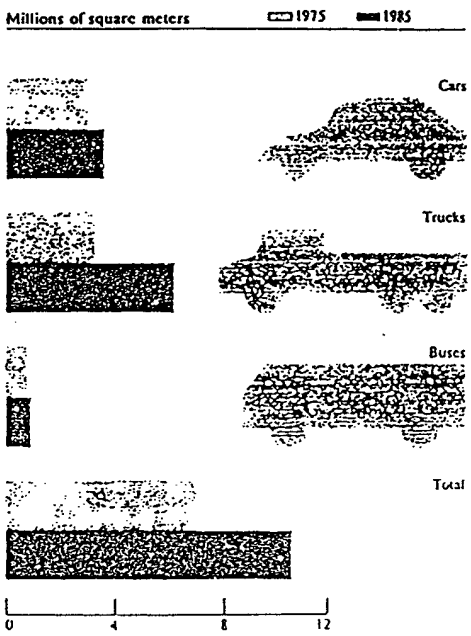
A near doubling of truck production facilities accounts for about three-fourths of industry expansion. Most of the growth occurred at the five heavy truck plants in preparation for new models of heavy, diesel-powered general purpose trucks or special-purpose offroad trucks for lumbering, mining, and agriculture, where, according to numerous Soviet press accounts, there is an acute shortage of adequate transport capabilities. The key projects included and the vehicles they support are:

- *Kama River truck plant.* The facility—operational in 1976—accounted for 75 percent of the growth in the truck industry and about 60 percent of the growth in motor vehicle industry facilities during 1976-85. KamAZ-5320 and -4310 general purpose cargo and tractor trucks account for much of the increase in Soviet heavy truck production

- *Kremenchug truck plant.* Two new assembly buildings were added to support production of the general purpose KrAZ-250 and -260 heavy trucks.

[1] We estimate expansion by measuring the floorspace of new production buildings completed. Production floorspace includes foundries, forges, machine shops, and component, subassembly, and final-assembly buildings. It excludes administrative, engineering, storage, and power facilities

Figure 2
Estimated Soviet Motor Vehicle Plant Floorspace, 1975 and 1985[a]



[a] These data are only for the 20 motor plants listed in figure 1.

- *Kutaisi truck plant.* Assembly floorspace grew by 55 percent to support production of the KAZ-4540, a 5.5-ton-capacity vehicle used primarily for agriculture.

- *Minsk truck plant.* Production floorspace grew by 40 percent to support the introduction in the early 1980s of new MAZ-6422, -7310, -7510, and -7910 cargo, tractor, and special-purpose heavy trucks.

- *Belorussian truck plant.* Production floorspace nearly doubled between 1975 and 1985 to support the introduction in the early 1980s of new 75-, 110-, and 180-ton-capacity dump trucks used in mining and construction (see appendix A)

Overall, automobile plant production floorspace grew by nearly 25 percent during 1976-85, modest growth compared with the previous decade when completion of the Volga car plant roughly doubled its production floorspace. About one-half of the capacity added during 1976-85 represented further expansion of the Volga plant, while the considerably smaller Moskvich, Ustinov, Lutsk, and Zaporozh'ye car plants expanded by between 20 and 50 percent.

Bus final-production facilities grew by about 25 percent, but only two of the six bus assembly plants were affected. The L'vov plant more than doubled in size in 1976-80, and the Kurgan plant has expanded by almost three-quarters since 1980. The growth was concentrated in final-assembly areas and is to support production of new bus models in the late 1980s.

Overall, between 1975 and 1985 we estimate that truck and automotive plant production floorspace increased at an average annual rate of a little more than 4 percent, faster than the 3-percent expansion rate of the previous decade. If Kama is excluded, however, average annual growth would fall to less than 2 percent

Advancing Production Technology

Soviet investment in the motor vehicle industry between 1965 and 1980 supported facility modernization as well as expansion of production capacity. Many new vehicles had been introduced in the 1960s, but Soviet literature, [redacted] indicate they were produced in labor-intensive operations using equipment that frequently dated from the 1950s and even earlier. Foundry, stamping, pressing, and machining operations were only partially mechanized and almost never truly automated. The first Soviet numerically controlled (NC) machine tools were not available for installation until the late 1960s (see inset).

During 1966-80 the Soviets turned to the West for a quick infusion of modern production technology. We estimate that, during the late 1960s to middle 1970s, outlays for foreign technology for the Volga and Kama plants totaled about $4.3 billion. Automated machining, forging, pressing, processing, and welding constituted more than 60 percent of the total value of Western technology acquired for these plants. The Soviets procured hundreds of automated lines for machining, foundry, stamping, and material handling, as well as hundreds of NC and computer numerically controlled (CNC) machine tools. Soviet literature indicates that between 1965 and 1975 the share of the vehicle industry work force engaged in mechanized or automated manufacturing operations increased from less than two-thirds to more than three-quarters.

Modernization of the motor vehicle industry continued in the 1975-80 period. According to Soviet industry journals, about 1,000 automated and continuous production lines for assembly, foundry, stamping, and machining operations were added, an increase of 40 percent. By 1980 the 3,600 automated lines in the automotive industry represented almost 15 percent of the roughly 25,000 automated and semiautomated lines reportedly in use in the USSR in mid-1980. Nearly 700 new mechanized lines also were installed, a 15-percent increase that brought the total in operation to 5,300. Computer systems were introduced to manage production resources. Between 1976 and 1980, automated management systems were installed at 32 locations, 16 computer centers were built for centralized automated data-processing services, and 12,000 people were employed in computer-related jobs. Automated processes and equipment installed during 1976-80 eliminated some 80,000 jobs in the industry—almost 10 percent of the estimated total industry work force during this time

We believe modernization became more selective and broad based in the 11th Five-Year Plan (FYP) (1981-85). The focus shifted to installation of individual NC tools, machining centers, transfer lines, welding and

Soviet Machine Tool and Automation Technologies

Machinery

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

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

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

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

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

Integrated Production Operations

Transfer line. *A series of machine tools each of which performs a specific operation linked by conveyors and holding devices equipped with automatic controls. Gear cutting lines are common examples.*

Mechanized line. *Any combination of machine tools or processes linked by common mechanical material handling systems such as conveyors.*

Automated or automatic line. *Either a transfer or continuous production line with automatic controls.*

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

Computerized Management Systems

Automated management systems (ASUs). *Computerized systems for the management of a wide variety of production and planning operations for processing information in accounting, analysis, planning, organizing, and design. ASUs, in theory, are implemented at the ministerial or production association level.*

Automated management systems for technical processes (ASUTP). *Used for the management of a particular production process.*

painting robots, and process controls—and away from new major production lines and plants. Soviet industry publications claimed that in 1983 at least 80 percent of all manufacturing processes and 90 percent of foundry processes were either automated or mechanized. The introduction of more productive automated processes and equipment reportedly replaced some 22,000 jobs in the automotive industry during 1981-83 alone. Specific examples included:

- At Gor'kiy and ZIL, welding lines incorporating some 1,000 robots were installed during 1981-85, although many were essentially manipulators and not programmable. In 1985 a Soviet automotive industry journal estimated that each Soviet robot can replace between a half and one and a half production workers.

- At Kama and Volga, 88 percent of all casting and 96 percent of all stamping operations were automated by 1985. At ZIL, Kama, Volga, and Ul'yanovsk new high-speed automated lines were producing 3,000 hot stampings per hour and reportedly were up to 10 times more productive than the processes they replaced.

- During 1981-84, introduction of microprocessor-controlled, automated hot stamping lines reportedly eliminated the need for 1,300 jobs industrywide.

- Another 9,500 jobs were reportedly eliminated in 1981-84 by improvements in automated control of material handling and warehousing systems.

- The total number of automated process control systems in use in the industry nearly doubled to 72.

Unlike the technology introduced in the late 1960s to middle 1970s—which depended heavily on purchases of Western technology—the more broadly based modernization effort since then has drawn more evenly from Western, East European, and domestic sources. Identified orders for Western automotive production technology totaled about $1.6 billion during 1976-85, less than one-half of total purchases during 1971-75, when Kama and Volga were being equipped. In contrast to the 1970s—when integrated turnkey lines were imported to establish basic manufacturing capabilities—purchases in the early 1980s were more selective and specialized. Robots, digital process and conveyor controls, gear cutters, machining centers, and transfer lines were most frequently purchased. Although the United States and West Germany supplied a large share of Western technology to the industry during the 1970s, Japan, Italy, and France became the leading Western suppliers by the early 1980s (see table 2)

Eastern Europe has also been a large supplier of production technology to the Soviet automotive industry since at least the 1960s. For example, during the 10th FYP (1976-80) about 125 metal-cutting and -forming lines—reportedly more than 10 percent of all such lines installed in the industry during this period—came from East Germany. As the pace of Western acquisitions slowed after the mid-1970s, Eastern Europe became a more important supplier of technology. During the early 1980s, CEMA countries, mainly East Germany and Czechoslovakia, exported to the USSR thousands of NC tools and hundreds of transfer lines for machining and forging. In 1984, for example, East Germany supplied 20 transfer lines to the Minsk truck plant and six automated press forging lines to the Moskvich car plant. East Germany also has supplied process controls for automated lines and components for flexible manufacturing systems. In 1984 it was slated to deliver a flexible manufacturing system (FMS) for shaping gears—consisting of 20 automated lines controlled by computer—and agreed to supply a complete flexible manufacturing facility worth 23 million rubles.

The Soviet automotive industry also further developed its own capabilities to produce advanced manufacturing equipment. During 1976-80, production of manufacturing equipment for internal use reportedly increased rapidly, with industrial robots, manipulators, and automated welding lines accounting for most of the growth. In 1985, industry production of FMSs

Table 2
Identified Soviet Orders for Western Automotive Technology, 1976-85

Major Equipment Orders	Date	Country	Value (million US $)
1980-85			
Diesel engine piston manufacturing equipment	January 1980	West Germany	10.4
Crankshaft grinding machines	April 1980	Japan	15.0
Gear manufacturing equipment	April 1980	United States	40.0
Industrial robots	November 1980	Japan	50.0
Metal treating equipment	February 1981	West Germany	14.0
Automatic transfer lines	April 1981	West Germany and Italy	30.0
License and equipment for manufacturing car components	May 1981	France	14.8
Carburetors and carburetor production equipment	July 1981	France	27.2
Equipment and licensing for carburetor production	October 1981	France	96.0
Engine and cylinder-head assembly lines	April 1982	Italy	25.0
Piston-ring manufacturing equipment	February 1983	Japan	25.2
Expansion of Moskvich car plant and design of Moskvich 2104 car	November 1983	France	37.0
Automatic drilling and robotic welding lines	July 1984	Italy	40.0
Crankshaft grinding equipment	November 1984	Japan	12.0
Fiberglass production equipment	April 1985	Italy	14.1
Press lines	May 1985	Japan	19.7
Machine tools to modernize the Moskvich plant	October 1985	France	58.0
Subtotal			528.4
Value of other known orders, 1980-85			219.1
Value of known orders, 1976-79			844.0
Total			1,591.5

also began.[a] The Volga and ZIL associations have emerged as the industry leaders:

- Volga reportedly increased its output of production equipment for use in the automotive industry by 20 times during 1980-84. Since 1979, Volga has become the largest Soviet manufacturer of industrial robots. By 1985 it produced 7,000 units—about 15 percent of the USSR's total production. These robots are used in welding, machining, casting, and assembly operations throughout industry. The total value of production equipment manufactured at Volga during the 11th FYP reportedly was 190 million rubles.
- ZIL continues to fill its traditional role as the proving ground for state-of-the-art automotive production technology such as FMSs. One of the first domestically developed and produced FMS cells—consisting of several forge presses supported by automated feeding and transport systems—was installed in 1984 for forging the crankshafts and axle beams for the ZIL-130 truck. In addition, many of the Western FMSs that the Soviets have purchased or are seeking for the automotive industry are earmarked for ZIL.

[a] We are unsure of the total production of machine tools by the motor vehicle industry. As in the West, because of requirements for dedicated, sophisticated machinery—like robots and flexible manufacturing systems—vehicle makers build some of their own equipment

Overall, Moscow has substantially raised the technological level of its automotive industry, but we believe the industry remains about 10 years behind the West. For example, in the most modern facilities the Soviets installed a large number of welding robots in the early 1980s to increase productivity and quality, almost a decade after a similar thrust in the West. Materials handling, heavily mechanized or automated in the West since the early 1970s, is still quite labor intensive in many parts of Soviet industry.

The Soviet preference for "hard automation" also impedes production flexibility. In 1985 a typical Soviet transfer line consisted of a series of permanently installed machine tools linked by mechanical conveyors to move work pieces from one tool to the next using pneumatic or electrohydraulic control mechanisms. An electrical "status board" might display, but not control, the manufacturing process. A great many manual operations remained, and continuing operator intervention was needed. Because converting to a significantly different product would require major reconstruction, the usual arrangement of the production line encourages the high-volume and long production runs that characterize Soviet vehicle programs. In contrast, Western automakers are installing flexible lines that can produce a variety of similar parts. Quick die change press lines pioneered by the Japanese have become commonplace in the West, reducing part changeover times from hours to minutes as well as reducing the number of presses needed. Since presses can be set up quickly, factories can carry smaller inventories of pressed parts, which also helps to reduce plant space. Emphasis on quality, induced by increased competitive pressure, has also taken workers completely out of the process for some operations in Western facilities such as body welding and painting, now done in advanced plants entirely with robots.

Advanced Soviet automotive facilities use mainframe computers to help manage inventory control, material handling, and production scheduling, but generally do not use networks of interactive minicomputers and mainframes to integrate manufacturing operations. Information is updated periodically at a remote location rather than processed immediately on the plant floor. In contrast, Western automotive plants by the early 1980s were already using computer-operated local area networks and information management systems to both monitor and control processes in near-real time and to plan and schedule production. Computer links to certain suppliers enable a "just-in-time" material flow, and computers and advances in manufacturing technology allow almost total automated inspection at many stages, with inspection systems often using machine vision and robots. Western state-of-the-art computer integration is represented by General Motors' Manufacturing Automation Protocol. This effort promises to provide for almost total integration of each factory's burgeoning number of computers and computer-controlled operations into a comprehensive network for better and more timely management of manufacturing operations.

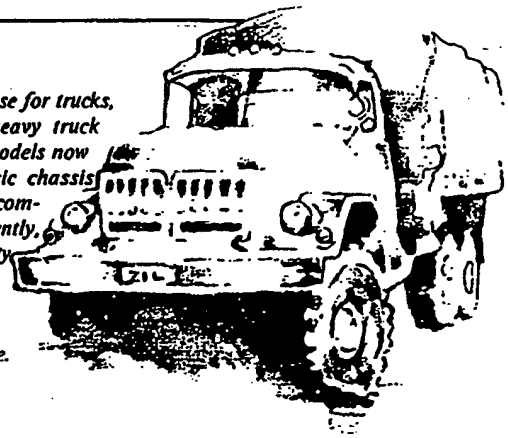
Impact of Expansion and Modernization

Since the late 1970s, expansion in the Soviet automotive industry, the introduction of new vehicle models, and the installation of advanced automated production technology have yielded small gains in production, large gains in quality, and uneven gains in efficiency. New automated assembly, molding, machining, forging, welding, and materials handling lines, as well as NC tools and machining centers, have reportedly raised output, reduced labor requirements, and cut inventories of work in progress. These newer technologies also allow the Soviets to fabricate more complex, varied, and precise parts. Moreover, quality control has become a more integral part of the manufacturing process because product specifications must be closely monitored to allow automated systems to function smoothly. This improves overall vehicle quality and probably has contributed to the significantly improved performance, service life, and fuel efficiency of Soviet trucks, cars, and buses

Production

Over the past decade the Soviets have continued to emphasize long production runs of a few basic vehicle models, relying on numerous minor modifications and

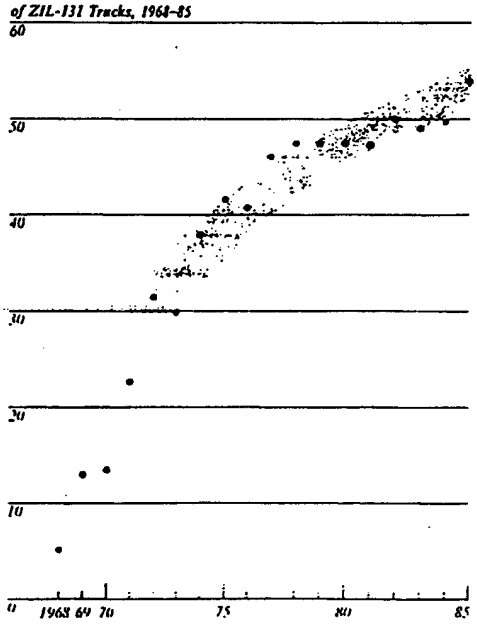
The ZIL-131 Medium Truck:
Reaping the Benefits of Long Production Runs



Some Soviet vehicle production runs, especially those for trucks, have lasted 20 years. Except for the Kama heavy truck program, nearly all of the general purpose truck models now in production are based on a dozen or so basic chassis designs that date from the 1960s or earlier. The components of these basic designs are modified frequently, and the basic models are often fitted with a variety of bodies and freight platforms for special applications. Because each configuration usually has its own model designator, about 250 variations of truck models are in production at any given time.

Long production runs have important advantages. First, production lines can be equipped with less expensive, fixed tooling optimized for high output of a single product. The Soviets realize economies of large-scale production and, for at least the first several years of a new production program, benefit from "learning" effects as process flows, machining, fabrication, and assembly practices are improved and save labor and materials. Because Soviet plant labor and fixed capital allocations usually vary little from year to year, such improvements generally yield increasing production over the first several years of a program. A good example is the production profile of the ZIL-131—an all-wheel-drive medium truck that entered production in 1966 and makes up a significant share of the Soviet military truck inventory.

Estimated Annual Production of ZIL-131 Trucks, 1968–85

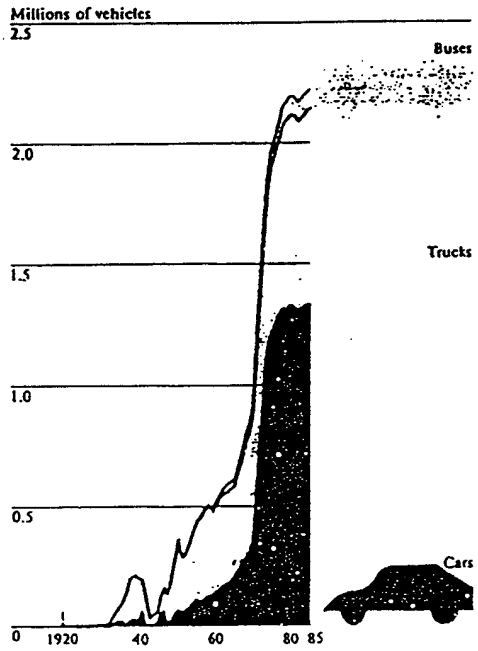


[redacted] *ZIL-131 production demonstrated an 80-percent learning effect. In other words, each doubling of cumulative production coincided with a 20-percent decline in the man-hours and machine hours required to produce a single truck.*

special bodies to accommodate particular applications. For example, only four basic designs—the ZIL-130 and -131 and the GAZ-53 and -66—accounted for two-thirds of all trucks produced in 1975. The new heavier Kama truck line is used in the same way, with numerous configurations built on three chassis designs. In 1985, ZIL, Gor'kiy, and Kama trucks accounted for over two-thirds of all trucks produced. Although this high degree of standardization probably imposes some costs on users, it enables the Soviet producers to realize the benefits of high-volume, long production runs (see inset).

We estimate that between 1975 and 1985 the total number of vehicles produced in the USSR increased by only about 15 percent—or at about 1.5 percent per year—reaching 2.3 million vehicles. Growth proceeded slowly in trucks, automobiles, and buses, with only the Kama truck plant and Riga bus plant registering sizable increases (see figure 4 and table 3). (We estimate production by plant on the basis of published Soviet production statistics, [redacted] and the comments of [redacted].) Truck production stagnated during 1978-82 and then declined, while automobile and bus production declined slightly after 1981 as new models were introduced. Truck and car output rose following the decline. This indifferent quantitative performance—as opposed to a continued boost in qualitative indicators—may have led the Soviets to discontinue publishing truck production statistics in 1982 and bus statistics in 1983.

Figure 4
USSR: Estimated Motor Vehicle Production, 1924-85



We believe these trends reflect a major transition in the motor vehicle industry:

- During the early and middle 1970s, massive investment in Kama probably preempted some investment in new plant and equipment elsewhere in the industry, thereby retarding overall productivity improvement.
- By the late 1970s, nearly all production programs under way in the industry had matured and largely exhausted the potential to increase production because of "learning" effects and economies of scale.
- In the early 1980s, the Soviets began the withdrawal of obsolete vehicles, and the wide-ranging effort to modernize equipment will support increased production of new vehicles in the middle and late 1980s.

Vehicle Quality

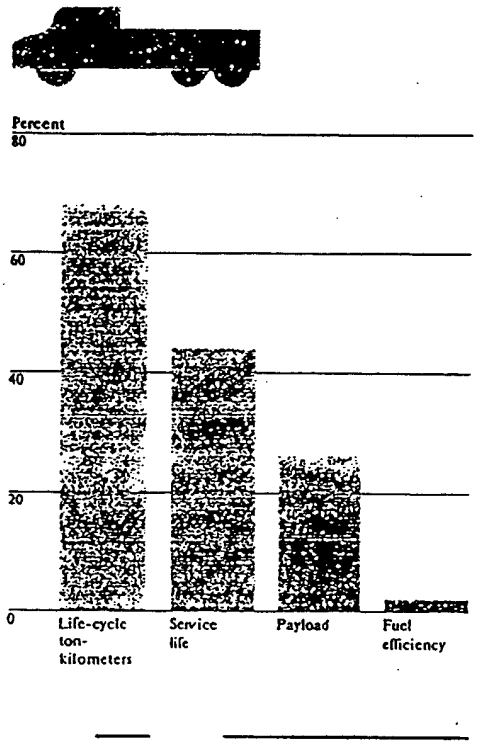
From an analysis of reported Soviet vehicle performance characteristics, we calculate that the performance and durability of trucks entering Soviet fleets

Table 3
USSR: Estimated Motor Vehicle Production by Plant

Thousands of vehicles

	1975	1985
Trucks		
ZIL	205.0	210.0
Gor'kiy	264.4	232.0
Ul'yanovsk	120.0	130.0
Ural	29.2	35.0
Kama River		115.0
Kremenchug	24.3	28.0
Minsk	31.0	35.0
Belorussian	4.4	6.0
Kutaisi	17.7	19.0
Subtotal	696.0	810.0
Cars		
Volga	667.1	735.0
Moskvich	162.0	200.0
Ustinov	173.7	196.0
Zaporozh'ye	123.2	149.0
Gor'kiy	63.2	72.5
Lutsk	12.0	17.0
ZIL	.5	.5
Subtotal	1,201.7	1,370.0
Buses		
Pavlovo	23.0	17.0
Kurgan	13.0	17.0
Riga	7.1	19.0
Likino	10.4	14.0
L'vov	13.5	16.0
Subtotal	67.0	83.0
Total	1,964.7	2,263.0

Figure 5
Estimated Improvement in Soviet General Purpose Trucks, 1975-85



increased markedly from 1975 to 1985. The average service life of all trucks produced in 1985 was about 45 percent greater than the average for trucks produced in 1975. While the average gross vehicle weight of newly produced trucks increased by less than 10 percent between 1975 and 1985, the average vehicle payload, or carrying capacity, rose by 25 percent, and fuel efficiency rose slightly. Because of this combination of longer average service life and greater carrying capacity, the average lifetime carrying capacity of trucks (the tons of payload that a vehicle can carry over its projected service life) added to the fleet in 1985 increased nearly 70 percent over the 1975 level (see figure 5).

Most of the increase in lifetime carrying capacity was represented by the growing share of Kama trucks. A Kama heavy truck has roughly double the life-cycle carrying capacity of the 1975-era medium truck that

it typically replaces. Kama vehicles—although only 15 percent of all new trucks—accounted for about 45 percent of the total life-cycle carrying capacity of Soviet trucks produced in 1985. This improvement will be sustained as Kama production reaches its planned capacity of 150,000, probably about 1990.[1]

In addition, because of higher output of light trucks, vans, and heavy trucks, the fleet is more flexible and better able to meet the transport demands of the economy, particularly on long-haul intercity and urban routes. In the past, for short urban hauls the Soviets relied predominantly on medium trucks that would typically carry only a small fraction of their payload capacity. Light trucks require less fuel to operate and, given Soviet motor transport inefficiencies, generally carry a much larger percentage of their rated payload than that of the medium trucks while moving the same freight. Similarly, heavy trucks moving large payloads over long hauls consume less fuel per ton of freight moved than do medium trucks.

In investment terms, the life-cycle procurement cost per ton of payload—or the factory wholesale price divided by the number of ton-kilometers the vehicle could move over its service life—actually fell by more than 15 percent between 1975 and 1985. While the average current wholesale price of a truck rose by more than 70 percent, much of the increase reflected the introduction of higher quality trucks with greater carrying capacities and longer service lives.[1] The longer lives and less frequent routine maintenance needs of the new trucks also significantly reduce outlays for spare parts, maintenance supplies, facilities, and personnel per ton-kilometer of freight moved.

The large gains in fuel efficiency have significant implications for energy conservation in the USSR. Although the new trucks are on average heavier and can carry larger loads than older ones, we estimate that their average fuel consumption per kilometer traveled is lower. We estimate that savings for gasoline-powered trucks averaged less than 5 percent, due mainly to slightly more efficient engines. The growing share of diesel trucks in total production had a greater impact because they consume 25 to 30 percent less fuel per kilometer than gasoline-powered trucks. The largest gains in fuel efficiency were recorded in models with the greatest carrying capacity, so on the average 25 percent less fuel was required per ton-kilometer of freight moved for trucks produced in 1985 than for those produced in 1975. More important, because diesel trucks now represent a much larger share of the trucks produced and diesel fuel is much less costly than gasoline in the USSR, the fuel cost to move a ton-kilometer of freight fell even more.

Deliveries of these larger and more efficient trucks to the Soviet military have already yielded significant gains in greater lift capacity, fuel efficiency, and simplified logistics. Kama trucks outperform the gasoline-powered ZIL and Ural medium and heavy trucks they are replacing. For example, during 1981-84 alone, deliveries of Kama trucks to Soviet units stationed in East Germany raised the lift capacity in identified units by 60 percent.[1] Combined with increases in fuel stores held in forward areas, this significantly improves the sustainability of motor transport support to military operations. Moreover, because the Kama trucks have longer service lives, they can operate for longer periods between routine maintenance, and, using the same fuel as many armored vehicles, they are easier to support than the gasoline-powered trucks they replace.

[1] This relationship is expressed in current-year rubles with no adjustment for the implicit inflation we believe exists. Therefore, in real (constant price) terms, the increase in procurement costs is probably overstated and cost savings per ton-kilometer are likely to be understated

The succession of new Soviet truck models introduced over the past decade has narrowed the technology gap with the West. From Western technical studies of the quality and performance of key vehicle components, we estimate that Soviet trucks produced in 1985 roughly equal Western standards of 1975. In contrast, Soviet truck models produced in the mid-1970s were roughly equivalent to Western models of about 1960—a lag of about 15 years. Currently, automatic transmissions and diesel engines are the two component technology areas in which the Soviets are furthest behind.

More modern production methods and equipment have also contributed to raising the quality of passenger automobiles, mainly in the Volga, Moskvich, and Ustinov facilities. New Soviet automobiles also have longer service lives and greater fuel efficiency than the vehicles they replace. Most of these quality gains are rooted in Western technology. The Volga plant is a complete Western turnkey facility producing an Italian-designed car. The Moskvich automobile, produced at the Moskvich and Ustinov plants, is of French design and is manufactured with large amounts of equipment imported from the West.

Qualitative improvement of Soviet buses has not been a high priority over the decade. Nevertheless, the advances in service life and fuel efficiency for Soviet trucks have carried over to buses, since truck plants provided some chassis and engines for buses. Buses produced at the Kurgan plant probably made the largest gains in service life and efficiency, largely because they use engines produced at Kama.

Allocation of Vehicle Production

During the virtual stagnation in vehicle production between 1975 and 1985, we detected no major shift in the allocation of vehicles to major customers. The military continued to receive a large share of the most modern productive trucks. Sustained annual production of over 1 million passenger cars brought them for the first time within reach of large numbers of Soviet citizens. The Soviets continued to be net exporters of vehicles, delivering trucks to client states and earning some hard currency with cars.

Mainly on the basis of Soviet statistics and analysis of imagery, we estimate that about 10 percent of all Soviet vehicles produced between 1975 and 1985 were delivered to the military (almost all of them trucks),* 16 percent were exported (mostly cars), and the remaining 74 percent were delivered to primarily civil uses—government agencies, civilian industry, agriculture, transport, and private citizens. Exports have fluctuated widely since 1975, declining to about 260,000 in 1982 from more than 425,000 in both 1978 and 1979 (see figure 6).

The Soviet military relies primarily on medium ZIL, Gor'kiy, and Ural cargo trucks, but heavy trucks—many from the Kama plant—have accounted for a rising share of its acquisitions since the early 1980s (see inset). Overall, we estimate that deliveries to the military rose from about 195,000 trucks in 1975 to 220,000 trucks in 1985, less than the 1.5-percent annual growth in total truck production. We estimate that during this period the inventory of trucks in the Soviet military increased by more than 10 percent to nearly 1.2 million vehicles (see figure 7 and appendix B)

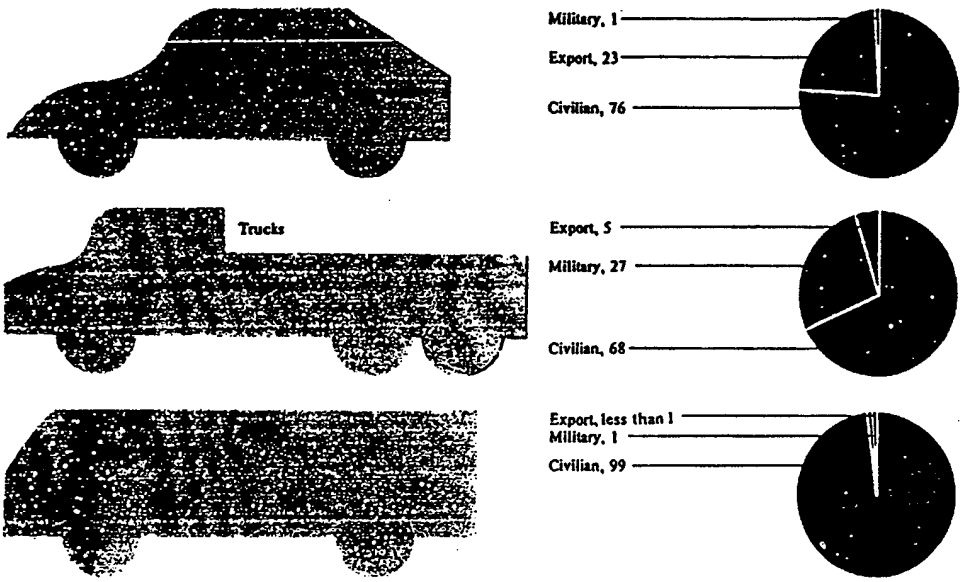
We estimate that total Soviet truck, car, and bus exports have declined by about 10 percent since 1975 and now account for about 15 percent of total vehicle production:

- On the basis of an analysis of Soviet trade data, cars accounted for about 85 percent of the 300,000 vehicles exported in 1985, and about 90 percent of total vehicle exports since 1975. Most of these were from the Moskvich and Volga plants and a majority were sold to Eastern Europe.

- Analysis of Soviet trade data and Soviet automotive industry publications indicates that only about 5 percent of Soviet truck production was exported in 1985. Most were general purpose cargo vehicles, but

* This category includes paramilitary and national-security-related uses such as civil defense, KGB border guards, and transportation and construction units comprised of military conscripts

Figure 6
Estimated Shares of Deliveries of Soviet Motor Vehicles, 1975-85



exports included jeeps and heavy mining trucks from the Belorussian truck plant. Most were exported to Eastern Europe and other Soviet client states such as Cuba and Syria.

- Buses valued at 17 million rubles were exported in 1985, which we estimate represents several hundred buses.

Declining exports reflect the obsolescence of Soviet vehicles, Soviet difficulty in providing a reliable supply of spare parts and maintenance services, and domestic shortfalls that probably induced the Soviets to scale down exports to allies

Standardization in Soviet Truck Design: Military and Civilian Applications

The USSR generally builds both highway (limited-mobility) and offhighway (heightened-mobility) trucks from the same basic design. The highway models are primarily for the civilian sector, and the offhighway models are primarily for the military, as well as the agriculture, mining, and timber industries (see figure 8). The military uses limited-mobility trucks for logistic support in rear areas on paved roads and highways, and heightened-mobility models usually go to tactical or forward-area units. The military also uses significant numbers of trucks adapted for special purposes, including petroleum, oil, and lubricant (POL) tankers; rocket and missile launch vehicles; box-bodied trucks filled with communications equipment; and maintenance vans.

The military offhighway variants usually have all-wheel drive, winches, reinforced frames, locking differentials, all-terrain tires, heavy-duty generators, hermetically sealed assemblies and electrical equipment for deep fording, and tire inflation and deflation systems controlled by the driver from the cab. These features allow the trucks to operate year round on a variety of terrains.

Even though most of the vehicle components are the same, military variants are normally produced about three to five years after the civilian models. As a result, many of the unforeseen design and manufacturing problems that normally arise in the early stages of new production programs are solved before military production begins, and military production programs benefit from the resulting learning effects and economies of scale, which tend to lower production costs. Nevertheless, because military all-wheel-drive trucks are generally more complex and capable of operating under a variety of conditions, they usually cost more than civilian versions.

Figure 7
USSR: Deliveries of Trucks to the Military, 1975-85

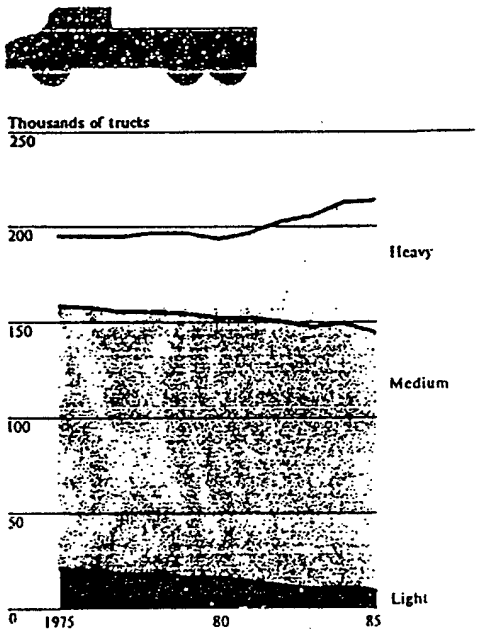
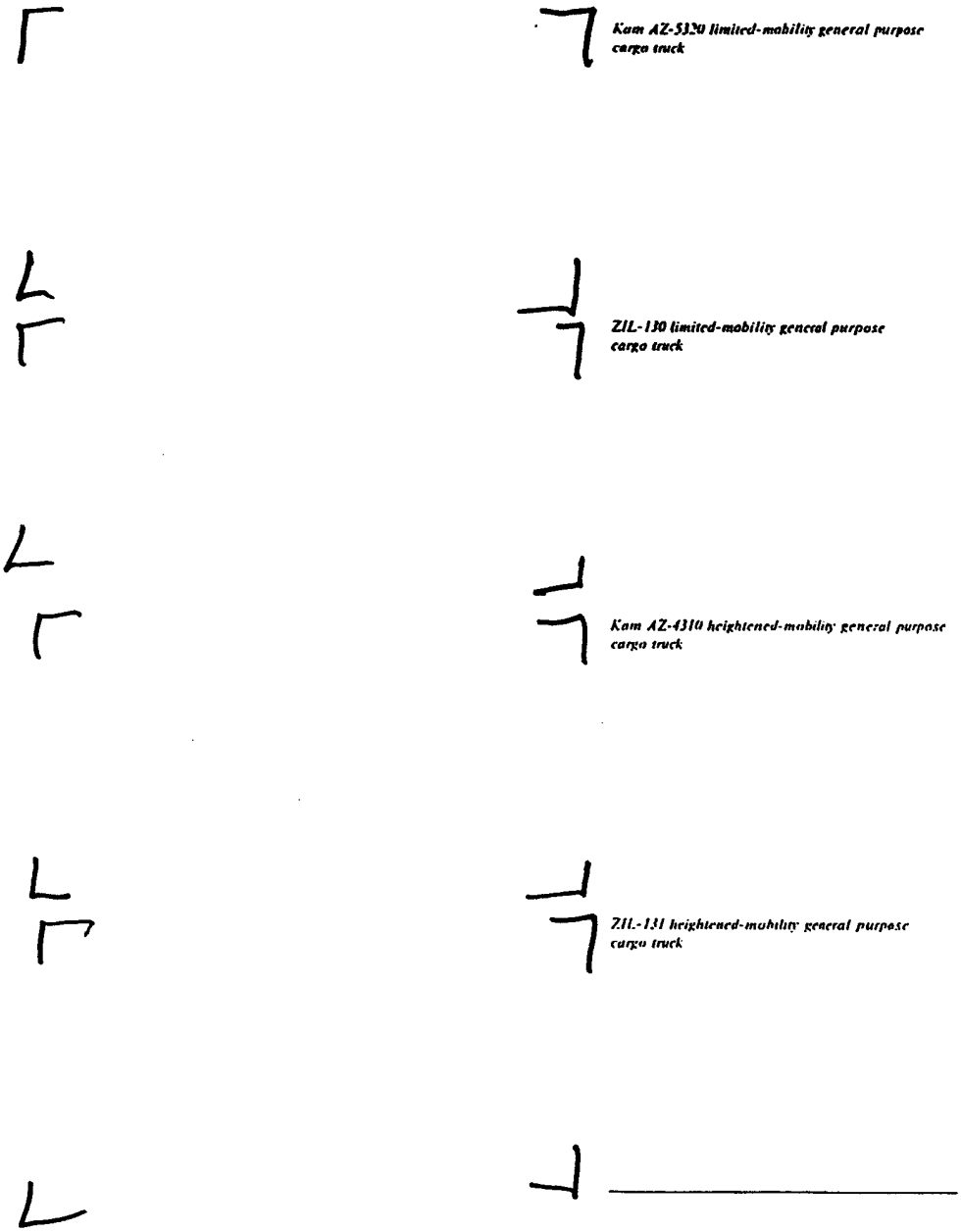


Figure 8:
Limited- and Heightened-Mobility Trucks



Kam AZ-5320 limited-mobility general purpose cargo truck

ZIL-130 limited-mobility general purpose cargo truck

Kam AZ-4310 heightened-mobility general purpose cargo truck

ZIL-131 heightened-mobility general purpose cargo truck

There have been fewer imports of vehicles—except buses—than exports. On the basis of an analysis of Soviet trade data, we estimate that 10,000 trucks were imported in 1985. Probably more than one-half of these were medium and heavy Tatra trucks, as well as other trucks and vans from Czechoslovakia. The Soviets also imported large mining, construction, and lumbering trucks from the United States and Japan. A small number of cars are probably imported for R&D and official or other special uses, although, according to Soviet trade data, none were imported. Conversely, in 1984, buses worth about 450 million rubles were imported, including at least 6,000 Hungarian Ikarus buses and probably at least several hundred buses from Poland, East Germany, and Czechoslovakia. These large imports probably reflect inadequate Soviet bus production capacity, as well as the CEMA decision to have Hungary specialize in manufacturing buses.

We estimate deliveries to civilian customers by subtracting military deliveries and net exports from total production. This calculation indicates that civilian customers received nearly three-quarters of all trucks and cars and nearly all of the buses produced in the USSR between 1975 and 1985. The share of production directed to the civilian economy has been roughly stable over the period

We cannot precisely estimate the distribution of new trucks among industrial and agricultural users. According to the Soviet Central Statistical Administration, an annual average of 220,000 trucks were delivered to agriculture from 1975 to 1982, but this probably includes used military trucks. A Soviet automotive industry journal reported that 196,000 newly produced trucks were delivered to agriculture in 1981 (versus 216,500 total deliveries reported)—or about 25 percent of total production. By applying this share to the 1975-85 period, we estimate that agriculture received about 192,000 new trucks per year—reasonable given the 220,000 figure above. The remaining 45 percent of truck production is delivered to common-carrier fleets, industrial ministries, plants, and the construction industry. Most of these are general purpose cargo and tractor trucks but also include special-purpose vehicles for mining, lumbering, and geological work. The gains from larger deliveries of higher quality vehicles to the civilian truck inventory have yet to be fully captured by Soviet transport services, however (see inset).

Passenger cars that are not exported or used by officials are generally available to the population. The personal automobile has consistently been used as an incentive. Workers with an exceptional performance record and those who accepted work on priority projects in undesirable locations are given priority on waiting lists for cars. Without such priority, Soviet citizens eagerly wait four or more years to spend the equivalent, on average, of 40 months of the average industrial wage—in cash—on a basic Zhiguli automobile from the Volga plant."

Manufacturing Productivity

Labor productivity, or output per worker, is a key performance indicator in national, ministry, and enterprise planning. Plan targets specify desired increases in labor productivity, and meeting these plan targets influences employee compensation. The Soviets frequently express the benefits of advancing technology in terms of workers freed for other duties.

We are not able to estimate labor productivity for Soviet vehicle manufacture as a whole, but data on individual plants suggest that productivity is considerably lower than Western levels. [redacted] report that the advanced ZIL (210,000 trucks in 1985) and Kama (115,000) plants employ, respectively, 70,000 and 100,000 personnel at their main facilities. A typical US truck plant that produces 70,000 to 100,000 heavy and medium trucks per year employs 3,000 to 5,000 workers in direct labor and a smaller number in support functions. Some of the differences can be accounted for by greater vertical integration in the Soviet facilities, which include engine plants, foundries, and component production facilities. Nevertheless, Soviet plants are only two to four times larger than their Western counterparts in terms of

[redacted]

Declining Soviet Highway Freight Traffic: An Apparent Contradiction

Figures released annually by the Soviet Central Statistical Administration indicate that Soviet highway freight traffic—measured in tons hauled—declined in 1983, 1984, and 1985. In terms of ton-kilometers, traffic declined in 1984 and then recovered slightly in 1985. We believe this highway freight traffic includes all common-carrier and industrial deliveries, and some from the agricultural sector. It does not include any military traffic, and we believe it does not include intrafarm hauling.

These figures indicate that production during the 1980s of more efficient vehicles with larger load capacities has yet to support an increase in freight traffic. We believe the Soviets have taken several measures that retard growth in freight-carrying capacity:

- *Many of the new trucks are delivered to defense and agriculture, and their services are not reflected in the highway freight figures.*
- *The Soviet truck fleets represented in the statistics may be slightly shrinking as older and smaller trucks are replaced in some instances on a less than 1-for-1 basis.*
- *Frequent complaints in the press suggest that trucks are used inefficiently. Occasional fuel shortages reportedly disrupt transport operations, as may ongoing attempts to further centralize control of motor transport. New trucks, because of a lack of trained maintenance personnel or parts shortages, may be at least initially relatively difficult to maintain.*

At the same time, the numbers may reflect some Soviet progress in making motor transport more efficient. More important, however, the newer trucks will increasingly have an impact on transport operations over the late 1980s. By then, these larger and longer lived trucks should make up a majority of the fleet

	Billions of Tons	Annual Growth Rate (percent)	Billions of Ton-kilometers	Annual Growth Rate (percent)
1970	14.6		220.8	
1975	20.9	7.4	337.9	8.9
1980	24.1	2.9	432.1	5.0
1981	25.0	3.7	459.9	6.4
1982	26.5	6.0	485.3	5.5
1983	26.4	−0.4	485.8	0.1
1984	25.6	−3.0	475.1	−2.2
1985	25.5	−0.4	477.3	0.5

production floorspace, and [redacted] who visit even the most productive plants report that several times as many workers are used for specific processes.

We are able to provide a measure of capital productivity in the truck industry by comparing the size of each plant's capital endowment to its output. We use production floorspace as a surrogate for capital endowment, and, indeed, physical output per unit of production floorspace is a commonly used planning factor in the West. While we believe that employment levels at the major truck plants have changed very little over the past decade, the Soviets invested substantially in capital equipment. In these conditions, the technological capability of a truck plant's capital equipment and the effectiveness of its use have largely governed trends in output. To adjust for differences between plants in the level of vertical integration, we use only final-assembly floorspace, regardless of whether it is located at a single facility or spread among several facilities (see inset)

We use a variety of measures to quantify plant output. The value of output—the sum of the current ruble wholesale price for all vehicles produced—provides an approximate measure of resource cost of production. But we believe that implicit inflation tends to distort these prices over time. Therefore, we also provide three alternate physical measures: the lifetime vehicle carrying capacity represented by annual production, reflecting the potential usefulness of the product to the economy; the total weight of trucks produced, reflecting a plant's ability to process material inputs; and the number of trucks produced, reflecting a plant's ability to organize production throughput.

In general, the relationship between output and floorspace reflects managerial performance in using capital. But it is also affected by:

- Plant design and the potential for economies of scale. Soviet literature indicates that in smaller plants some of the necessary equipment is underutilized so that as plant size decreases the ratio of floorspace to output should increase.
- Increasing sophistication and flexibility of manufacturing technologies, which generally means that less floorspace is needed for a given level of output.
- Savings in direct labor and materials, where fewer tools, smaller inventories, and consequently less space may be required to achieve a given level of output.

The capital productivity measures suggest that the strides the Soviet motor vehicle industry have made have stemmed largely from design innovations that have increased average vehicle payloads and service lives. For example, life-cycle ton-kilometers—a surrogate for economic utility—produced per square meter of production floorspace increased everywhere except at the Kutaisi and Ural plants (see figure 9). Both kilograms and trucks produced per square meter increased everywhere except at the Gor'kiy, Kutaisi, and Ural plants.

Of the three largest Soviet truck plants—Kama, ZIL, and Gor'kiy—by our measures ZIL was the most productive in 1985. We attribute much of this improved performance at ZIL to a much larger influx of new production technology there, as well as differences in the structure of production operations. ZIL is also probably relatively more efficient because most of the truck models built there were designed in house and have been in production much longer than the trucks manufactured at Kama. Therefore, more time and engineering support have been spent in learning how to best employ production resources. Moreover, the ZIL association has well-established sources of parts and subassemblies, so supply does not constrain final-assembly operations as much as may be the case at the Gor'kiy and Kama plants

Kama continues to be hampered by the failure to bring the plant up to rated design capacity. Assembly operations are constrained by problems in reaching rated capacity for manufacturing engines and other components, about three-quarters of which are produced at the main plant. Much of the technology at

Comparing US and Soviet Efficiency: Kama River and the [ ] Truck Plants

Kama and the [ ] Truck Plant [ ] provide a good basis for comparing US and Soviet industrial practices. Both plants were built at about the same time and equipped with production lines and machinery using Western technology from the late 1960s and early 1970s. [ ] builds [ ] trucks, which resemble Kama heavy trucks in design and capacity, as well as some heavier tractor trucks. [ ] however, is essentially an assembly facility, receiving components such as engines and transmissions from other plants. Kama is more vertically integrated, producing engines and many other components on site.

[ ] still operates and is equipped in much the same way as it was when it came on line [ ] It is not extensively automated, using only three welding robots and a computerized network linking assembly operations with component suppliers. The two lines that assemble the [ ] trucks operate at 15 units per hour; a third line, which makes the heavy tractor trucks, operates at 3.3 units per hour.[a] Production in 1985 represented 36 vehicles per assembly employee, or just over one truck per square meter of final-assembly floorspace, operated for one shift. At its maximum in the late 1970s, production reached nearly two trucks per square meter.

Kama reportedly operates two lines, two shifts per day at an average rate of about 23 trucks per hour. If reports are accurate that about 10,000 of Kama's 100,000 workers are engaged in final-assembly operations, then 1985 production would equal 11 trucks per assembly employee, or about one truck per square meter of floorspace. At a rated capacity of 150,000 trucks per year, Kama would produce 15 trucks per employee and 1.25 trucks per square meter.

[a] The third line also can run at least 15 units per hour of the [ ] giving the plant a current maximum rate of 45 trucks per hour.

	KamAZ	[ ]
Year operational	1976	1969
Assembly floorspace (square meters)	119,000	63,100
Final assembly	62,400	39,000
Paint	21,300	16,700
Finishing and inspection	36,000	7,400
Gross weight of trucks produced (metric tons)	8 to 12	8.5 to over 15
Output		
Annually	115,000	72,000[a]
Daily	450	300
Shift	225	300
Hourly	28	33.3
Plant designed capacity: number of trucks per year	150,000	NA[b]
Truck assembly employees	10,000 (reported)	2,000 (actual)

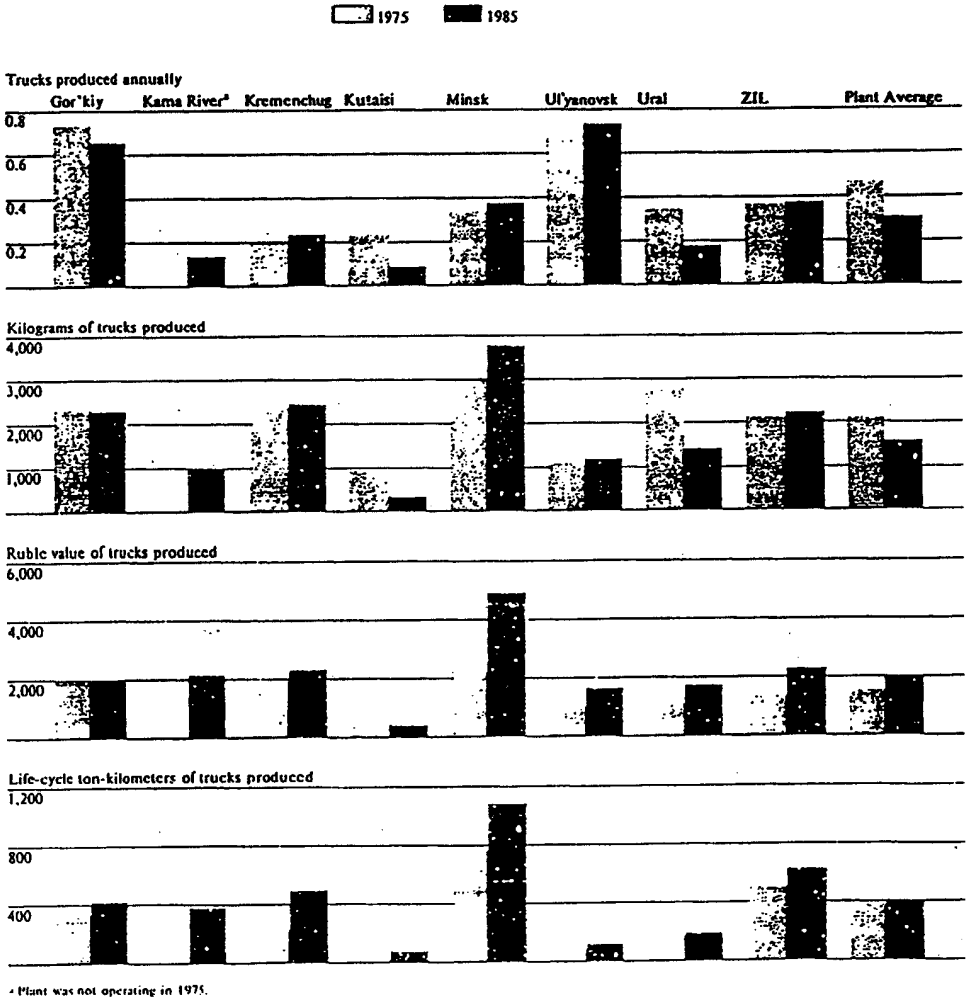
[a] The plant reached its highest annual production—just over 100,000—in the late 1970s with the same size labor force.

[b] [ ] was originally configured to produce 26 trucks per hour.

Kama is less than one-third as productive [ ] in terms of labor productivity but more closely approaches [ ] performance in using assembly capacity because Kama operates two shifts. Kama, however, does not manufacture any vehicles like [ ] heavy over-the-road tractor trucks, which weigh more than 15 tons and require more resources than the smaller 8-ton trucks. If the third line produced [ ] trucks at the same rate as the other two lines, and the plant operated two shifts like Kama [ ] production would equal almost 49 trucks per assembly employee, or about 3.4 trucks annually per square meter of assembly floorspace—almost three times Kama's productivity level.

Figure 9
Productivity at Selected Soviet Truck Plants, 1975 and 1985

Per square meter of final-assembly floorspace



[a] Plant was not operating in 1975.

Kama dates back to the late 1960s and early or middle 1970s and is probably generally less productive than some of the newer equipment installed at ZIL. In addition, engineering support capabilities are relatively limited at Kama as compared with ZIL.

Of the three plants, productivity grew least at Gor'kiy in 1976-85. This record undoubtedly contributed to the Soviet decision to undertake the planned massive modernization program recently announced for Gor'kiy. The Soviets openly admit that the level and quality of capital equipment at the plant is far behind the industry standard. For example, 40 percent of the plant's equipment is 25 years old, and some equipment dates from the late 1920s, when the plant was built. In addition, we believe that production of trucks at the plant has been decreasing for the past several years.

In the car industry, manufacturing productivity gains during 1975-85 were mixed. None of the four major plants—Moskvich, Ustinov, Volga, Zaporozh'ye—was able to increase car production in terms of square meters of production floorspace. In terms of ruble value, Volga and Ustinov increased slightly their output per unit of final-assembly floorspace. By the same measure, output at Moskvich fell by 35 percent and at Zaporozh'ye by 55 percent (see figure 10).

Plans and Prospects

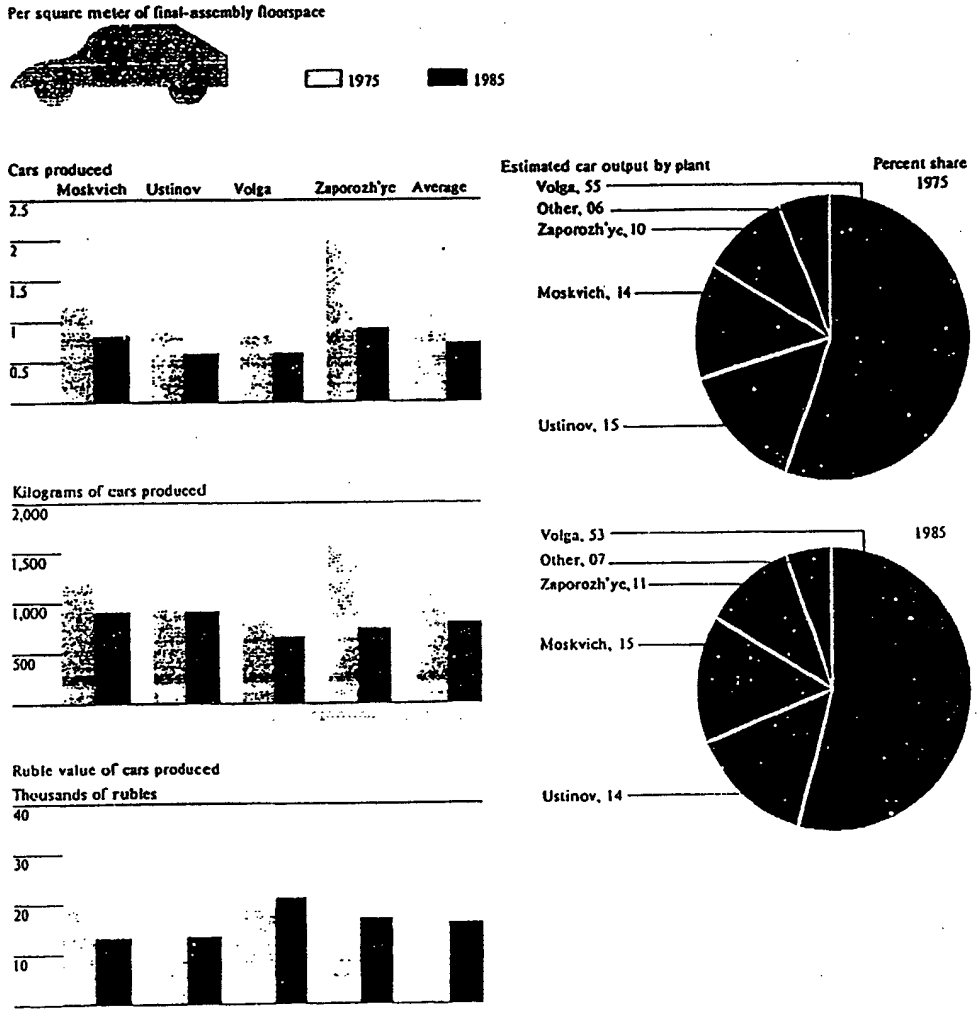
Soviet Goals

According to a recent article in the official journal of the Ministry of the Automotive Industry, Moscow would like to bring the Soviet automotive industry up to world standards, presumably in both quality of output and in manufacturing efficiency. To achieve this, the ministry will be under increasing pressure to modernize its facilities and to introduce new, more fuel-efficient, productive, durable, and maintainable vehicle designs. In the past the industry has been regarded as a traditional leader in technology development. Appointment of the first deputy director of the Automotive Ministry to be a deputy director of the new Machine Building Bureau—a new organization the Politburo created to oversee interministerial cooperation in development of machine-building technology—suggests that Moscow still holds this view. Overall, the gross value of industry output is projected to double during 1986-2000. (The gross value of industry output also doubled from 1971 to 1985.)

In keeping with Secretary Gorbachev's emphasis on refurbishing existing rather than building new facilities, the industry has plans for a large infusion of more modern and productive machinery in old plants. According to the deputy minister of the Ministry of the Automotive Industry, the 1986-90 Plan calls for installation of 2,000 automatic lines, more than 300 flexible manufacturing systems, 5,500 robots (including 200 robotic complexes), and a "large amount" of new metal-cutting, forging, pressing, and casting equipment throughout the industry. In addition, 40,000 pieces of existing machinery are to be "modernized," increasing their productivity by a projected 15 to 20 percent. As a result, industry labor productivity, which is slated to more than double, will grow about 20 percent more than in the economy as a whole. The Soviets expect the greatest labor productivity improvements from mechanization and automation of warehousing and assembly operations. Warehousing reportedly accounts for about 15 percent of the automotive industry labor force, and assembly, about 25 percent. In warehouse transport operations alone, 13,000 workers will reportedly be released for other duties.

We judge that Eastern Europe and the West will still help tool and equip new and existing facilities, but Moscow is increasingly stressing domestic sources of high-technology production equipment. During 1986-90, in addition to serving as the proving ground for more efficient technologies, the motor vehicle industry is tasked to increase its production of machine tools, flexible manufacturing systems, and robotics—key technologies highlighted in Gorbachev's call for accelerated technological progress. For example, the Volga car plant is slated to increase its output of production

Figure 10
Productivity at Selected Soviet Car Plants, 1975 and 1985



equipment by 80 percent, including 930 welding robots, 75 complete automatic lines, and 6,500 manipulators. At the Minsk truck plant, machine tool production is to be tripled, and 60 percent of the capital stock will reportedly be modernized.

The Gor'kiy plant has been directed (in a Politburo-endorsed announcement) to assume a much greater role as a technology supplier and is to be completely reconstructed and retooled by 1990. The 12th FYP calls for the plant's output of production equipment for the motor vehicle industry to triple. As part of this effort, Gor'kiy has begun to produce a new domestically designed flexible manufacturing module, the IR500, on license from the Ivanovo Machine Tool Plant, a leader in Soviet machine tool development. Production reportedly began in November 1985, and six units were scheduled to be built by February 1986. An official—in a speech at the 27th CPSU Congress in March 1986—indicated that reconstructing and retooling at Gor'kiy would cost 1.2-1.4 billion rubles. Committing such massive resources to refurbish an existing plant is unprecedented in the Soviet motor vehicle industry.

This industrywide infusion of new equipment is to support a wave of new basic vehicle designs during 1986-90 that will probably be in production until after the year 2000. New programs include:

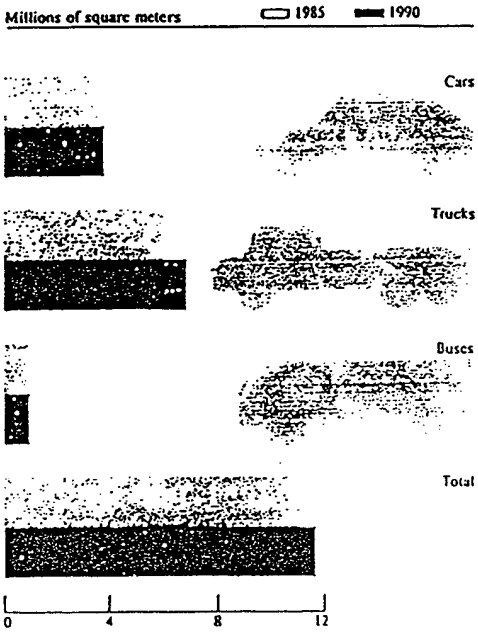
- Two basic new general purpose diesel trucks scheduled to enter production at the ZIL and Gor'kiy plants.
- New specialized trucks, including an agricultural truck with tilting bed at Kutaisi and heavy dump trucks for construction and roadbuilding at ZIL, Kremenchug, and Minsk.
- Two new front-wheel-drive cars of foreign design for production at Volga and Moskvich. A third domestically designed car will be jointly produced by Kama and Volga. Volga officials plan to introduce a new car every five years, three years faster than it currently takes.

Construction activities to support this ambitious modernization effort are already under way. Given the size, pace, and likely purpose of identified construction projects under way, we estimate that Soviet motor vehicle industry production floorspace will continue to expand substantially through 1990. We project that during 1986-90:

- Total production floorspace at the 16 major vehicle plants will expand by an estimated 10 percent—to almost 12 million square meters (see figure 11).
- Nearly all truck plants will expand, resulting in a targeted 13-percent overall increase. Two-thirds of the floorspace is being added for final-assembly operations at six plants preparing to introduce new trucks.
- Automobile production facilities are slated to grow about 6 percent, reflecting expansion to accommodate new models and higher production rates at all but one of the six car plants. The Moskvich plant will expand by more than 30 percent, and the Lutsk and Zaporozh'ye plants will each increase by 20 percent. Volga will grow by less than 5 percent but will account for 50 percent of the floorspace that will be added.
- Growth in the bus industry will be limited to a nearly 50-percent expansion of the Pavlovo plant, which will assemble a new diesel bus.

In addition, the Soviets plan to build at least two new major final-assembly plants. According to Soviet press reports, construction of a new light truck plant began in 1985, in Kirovobad in the Azerbaijan Republic. It will be part of the Ul'yanovsk production association and probably rely on the main plant in Ul'yanovsk for components, including engines. [redacted] The Kirovobad facility will reportedly be complete by 1990, and when it reaches rated capacity—probably a few years after that—it will manufacture 40,000 to 50,000 general purpose, all-wheel-drive, 1.5-ton trucks and vans per year

Figure 11
Estimated Soviet Motor Vehicle Plant Floorspace, 1985 and 1990*



*These data are only for the 20 motor plants listed in figure 1. They do not reflect any additions to floorspace from the Kirovabad and Ivanovo plants.

[redacted] reported that in late 1985 the deputy director of ZIL said that a new truck plant was being built in Ivanovo, 150 miles northeast of Moscow. He claimed that the plant will be completed by the end of the decade and will have an annual capacity of 150,000 trucks[redacted]

[redacted], probably is for the truck plant. The reported association with ZIL suggests that the plant will probably assemble medium or heavy trucks and produce spare parts.[redacted] reported that in the next few years a new 200,000-square-meter building will be erected at the main ZIL plant in Moscow, but we have not been able to confirm this project.

We believe that these new facilities will not be completed by 1990—the projected deadline. If the Soviets follow their standard construction practices and pace, we estimate that the plants will not be operational until the early or middle 1990s and probably will not reach rated capacity until at least a few years later.

Given the size [redacted] Kirovobad and Ivanovo, the types of vehicles that are likely to be assembled there, and the ratio of floorspace to the total plant size at existing Soviet motor vehicle plants, we estimate that the Kirovobad facility will comprise roughly 250,000 square meters of production floorspace, and the Ivanovo facility roughly 450,000 square meters. If these estimates are accurate, completion of these two facilities (and the 200,000-square-meter ZIL building) would increase total motor vehicle production floorspace by an additional 8 percent and truck production floorspace about 13 percent. Moreover, ZIL officials—in late 1985—approached a US machine tool and automation company with a proposal for turnkey equipment of the plant. If Moscow chooses to equip the plant with Western technology, we estimate outlays could exceed $1 billion. The Soviets spent in excess of $1.5 billion 10 years ago to equip the vertically integrated Kama River plant—a facility of comparable capacity

The Soviets expect new longer lived, higher quality vehicle designs to be significantly more fuel efficient and require less maintenance support than current models, thereby contributing to greater productivity in transport operations. Current plans call for diesel-powered trucks to account for 85 percent of all truck production by 1990, although these trucks reportedly represented only about 25 percent of 1985 output. According to a Soviet official, civilian vehicles in the USSR consumed about 52 million metric tons of gasoline and 11 million tons of diesel fuel in 1980. In the mid-1990s, when more than 1.5 million more efficient Kama diesel engines will be in service in

trucks and buses, a total of 11 million tons of fuel will be conserved in the civilian and military fleets. In addition, Kama heavy trucks can travel more than 50 percent farther between routine checkups and 25 percent farther between major overhauls. As a result, the productivity of motor transport in the economy should improve in two ways: maintenance support overhead in terms of equipment and personnel will be lower per vehicle, and each driver will be able to move more freight per hour worked given larger average vehicle payloads and less downtime for maintenance and repairs.

Outlook

We expect that total vehicle production will grow moderately until 1990 and then more rapidly as plant renovation is completed. If the Soviets maintain the momentum of current production programs and succeed in bringing Kama up to rated capacity, we estimate total output could rise from 2.3 million vehicles in 1985 to 2.5 million vehicles in 1990. We project truck output may increase more than 10 percent, from 810,000 to 900,000 units; cars nearly 10 percent, from 1.4 million to 1.5 million; and buses about 20 percent, from 83,000 to 100,000. By the early 1990s, production growth should increase as the many new programs are assimilated, as more efficient manufacturing technology begins to pay off, and as the new Kirovobad and Ivanovo facilities come on line. In an optimistic scenario, by the late 1990s, truck production could reach 1.1 million units; cars, nearly 2 million; and buses, 125,000--a total of more than 3.2 million vehicles.

We estimate that deliveries of Kama and other new trucks probably will support a moderate expansion of the Soviet military truck fleet over the next 10 years—from 1,174,000 in 1985 to more than 1,335,000 in the mid-1990s. The annual growth may be slower than in the 1970s and 1980s, and annual deliveries of trucks to the military may actually decline slightly—from about 220,000 in 1985 to about 205,000 in the mid-1990s. (This assumes no major change in the structure or size of the Soviet military by the mid-1990s; that older trucks will be replaced with newer ones on a 1-for-1 basis; and that trucks will continue to be used at about the same rate and in the same manner as they are now.) We believe that the current fleet of trucks will be almost completely recycled by the early 1990s and that the newer, longer lasting vehicles will not need to be replaced as rapidly as those now in the fleet.

The primary beneficiaries of any reduced deliveries of trucks to the military would probably be the agricultural sector and the construction industry, which, like the military, rely heavily on all-wheel-drive vehicles. Larger numbers of used trucks in better condition will also be available for agriculture and industry. Coupled with increased production of special-purpose vehicles designed for agriculture, this suggests that motor vehicle transportation bottlenecks in agriculture may lessen in the early or middle 1990s. Moreover, motor transport generally will be in a better position to take on a larger share of Soviet freight shipments.

The dual benefits that the introduction of new, more fuel-efficient front-wheel-drive automobiles are likely to provide in the late 1980s and beyond may force the Soviets to choose between competing demands. On the one hand, these high-quality, compact, stylish cars—some of Wes European design—could be competitive on export markets (see figure 12). Such sales would generate hard currency needed to purchase advanced Western technology for industrial modernization. As an experiment along these lines, the Soviets announced in mid-1985 that the Volga car plant now has the authority to use almost half of its hard currency export earnings to purchase Western technology. In the spring of 1986, the Soviets announced that the experiment was successful and being expanded to other plants throughout industry. Conversely, the availability of more automobiles domestically would afford a very attractive incentive to energize Soviet workers, a key tenet of Gorbachev's modernization initiative.

Soviet plans nevertheless entail great challenges, particularly because of the required high investment levels. For example, we estimate that reconstruction of the Gor'kiy plant and construction and equipping of the Ivanovo and Kirovobad facilities—key projects for the next 10 years—probably will cost the equivalent

Figure 12. The New Lada-2108. This car was designed by the German car manufacturer Porsche, and was put into series production in 1985 at the Volga Motor Vehicle Plant in Tolyatti.

of several billion dollars. Simultaneously addressing the extensive modernization needs at other motor vehicle plants could drive investment requirements well above levels committed during previous cycles of modernization. By way of comparison, the USSR spent 7 billion rubles (roughly equivalent to $10 billion) during 1971-75, when the giant Kama River and Volga car plants were being equipped.

Even investment on this scale probably would not be sufficient to bring the Soviet automotive industry up to Western levels, where industry is modernizing at a rapid pace. For example, during 1980-85, US motor vehicle and parts manufacturers reported that they spent an estimated $57 billion on new plant and equipment, including $14 billion in 1985 alone. Moreover, turning to the West for large infusions of technology could strain hard currency resources and, on the basis of the poor performance with the Kama plant, would not guarantee that the Soviets would reap the full productivity benefits that new technologies have provided in the West. Even Western automotive manufacturers have experienced serious problems assimilating and training workers for new facilities employing plantwide automation. For example, the new [redacted]—which [redacted] is equipped with 250 robots, 50 automated guided vehicles, and computerized and laser inspection systems—is still producing at only one-half of its rated capacity because of problems assimilating the new equipment. The Soviets probably will confront such challenges of plantwide automation no earlier than the mid-1990s.

On balance, we believe that the modernization program of the last decade—albeit heavily oriented toward "hard" automation—will yield significant gains in product quality and productivity into the 1990s. Moreover, the cycle of modernization is well timed to support Gorbachev's broader objectives of economywide industrial modernization. To achieve the more ambitious objective of raising the motor vehicle industry to world standards, however, the Soviets must move to flexible forms of automation that can more easily accommodate rapid product change. To do this, they must overcome or circumvent deficiencies in key technologies that support factory automation, including arrays of linked minicomputers, sophisticated software engineering, vast numbers of microprocessor-operated controls, and high-speed telecommunications networks.[11] In addition, the Soviets will have to accommodate associated changes in organization, management, and employment that have been confronting Western automotive manufacturers for at least the past decade. Progress in the West, combined with Soviet deficiencies, suggests that the Soviet motor vehicle industry probably will not attain the standards of Western industry in this century.

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Appendix A

Primary Motor Vehicles Currently Produced by Plant and Model and Soviet Vehicle Designations [a]

Vehicle	Plant	Basic Model and Year Introduced [b]											
		1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Trucks	Belorussian												
	Gor'kiy				53			66					
	Kama River												
	Kremenchug								257		255		
	Kutaisi												
	Minsk							535 537	543				
	Ul'yanovsk					451				452			
	Ural				375				377				
	ZIL	157						130		131			
Cars	Gor'kiy												
	Lutsk												
	Moskvich												
	Ustinov												
	Volga												
	Zaporozh'ye												
	ZIL												
Buses	Kurgan												
	Likino												
	L'vov												
	Pavlovo												
	Riga												
	Yerevan												

[a] Until 1966, Soviet vehicle designation was based on a simple system of naming a vehicle by indicating the plant at which it was produced and assigning it a design number that was in an allotted batch of numbers for that plant. For example, for trucks made at the Gor'kiy plant, the abbreviation GAZ and any number from 1 to 99 were assigned (for example, GAZ-66). In 1966 a new system was developed, but it did not affect any models already being produced, only those to be put into future production. The new designators provide information on vehicle weight, type, design number, modification state, and export status. The plant abbreviation was retained. The new system consists of up to six digits following the abbreviation, with four being the usual (for example, KamAZ-5320). For trucks, the first digit indicates the gross weight range into which the vehicle fits:

1—below 1,200 kg
2—1,201 to 2,000 kg
3—2,001 to 8,000 kg
4—8,001 to 14,000 kg
5—14,001 to 20,000 kg
6—20,001 to 40,000 kg
7—over 40,000 kg

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
		7510				7420					7519				
		7525				549									
						5320		5511					4310		
						5410									
									260						
504						608							4540		
							5549				6422				
		469													
							4320						5557		
					133										
24-01		24-02					14				3102				
					969										
						2137									
						2140									
			2125												
2101	2102		2103			2103	2121			2105		2107			2108
				968											
											115				
	685														
			677												
			695		697										
			699								4202				
		3201													
		977				2203									
		977				2203									

For light vehicles and cars, though, the first digit refers to the "engine size":
- 1—less than 1.2 liters
- 2—1.2 to 2 liters
- 3—2 to 4 liters
- 4—more than 4 liters

The second digit for all vehicles denotes the vehicle type:
- 1—passenger cars
- 2—buses
- 3—trucks with sides
- 4—tractors
- 5—dump trucks
- 6—tanker trucks
- 7—vans
- 8—(not allotted, in reserve)
- 9—special vehicles

The third and fourth digits refer to the design sequence, usually starting with 01, but there are special sequences for high-mobility models. The fifth digit is used to identify modifications to the basic design or product improvements. For example, KamAZ-53212 designates a long-wheelbase version of the 5320. The sixth digit applies to types of export models. See *Jane's Military Vehicles and Ground Support Equipment· 1985*, Jane's Publishing Company Limited, London, pp. 437-438.

[b] These are only the primary models or family of vehicles produced at the major plants. This list does not include the numerous modifications of each vehicle, or any prototypes or vehicles not in series production.

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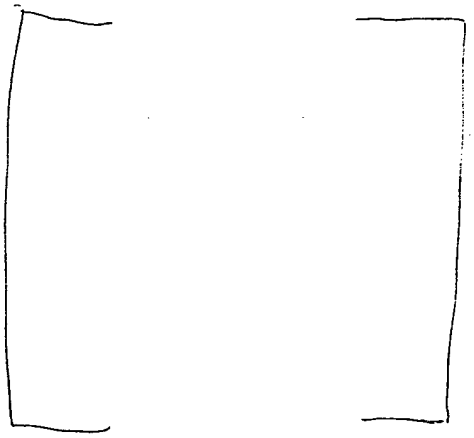
Appendix B

Methodology for Estimating Deliveries of Trucks to the Soviet Military

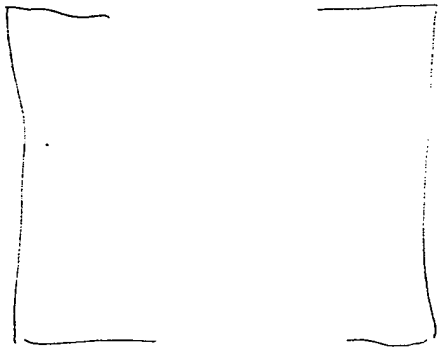
Our estimates of deliveries during 1975-85 of light, medium, and heavy trucks to the Soviet military forces are based on (1) estimates of military truck inventories and annual replacement rates; and (2) estimates of total Soviet truck production, production at each of the major plants, and the proportion of this production that is allocated to the Soviet military. The findings of both methods were, in our judgment, sufficiently in agreement to use the average of the two as our estimate of deliveries of trucks to the military.

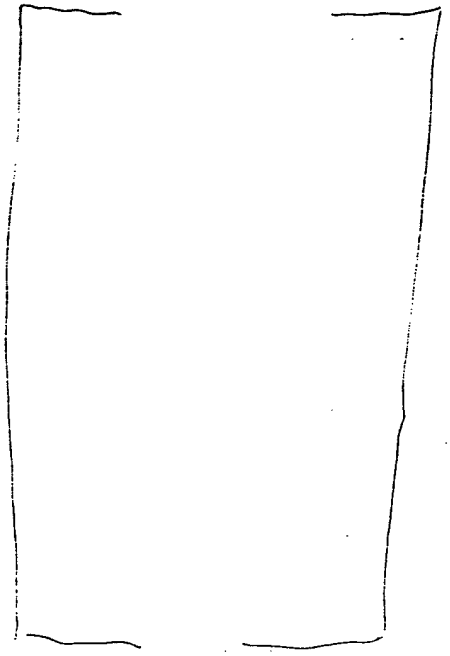
We estimate that 193,000 trucks were delivered to the Soviet military in 1975—11 percent were light vehicles; 71 percent, medium vehicles; and 18 percent, heavy vehicles. We estimate that 218,000 trucks were delivered in 1985—4 percent light, 63 percent medium, and 33 percent heavy.[1]

Estimating Inventories and Requirements



Estimating Supply





[1] For mathematical purposes, we have rounded each number off to the nearest thousand, but this does not imply that we believe that we are actually accurate to the nearest 1,000 in each case.

Table B-1
Estimated Deliveries of Trucks to the Soviet Military, 1975-85 (Based on Estimated Inventories and Replacement Rates)

	Deliveries
1975	169,000
1976	166,000
1977	166,000
1978	168,000
1979	168,000
1980	167,000
1981	176,000
1982	188,000
1983	189,000
1984	199,000
1985	206,000

Table B-2
Estimated Soviet Truck Production, 1975-85

	Light	Medium	Heavy	Total
1975	132,000	460,000	104,000	696,000
1976	136,000	463,000	117,000	716,000
1977	134,000	465,000	134,000	733,000
1978	134,000	470,000	157,000	761,000
1979	131,000	471,000	178,000	780,000
1980	139,000	459,000	189,000	787,000
1981	138,000	455,000	194,000	787,000
1982	139,000	436,000	205,000	780,000
1983	139,000	433,000	219,000	791,000
1984	140,000	429,000	231,000	800,000
1985	142,000	426,000	242,000	810,000

Total production (including jeeps and some minibuses and vans) has increased about 16 percent since 1975—from 696,000 to an estimated 810,000 in 1985. In addition, the mix—light, medium, and heavy—has changed considerably since 1975. There are slightly more light and substantially more heavy trucks being produced, both in total and as a proportion of total production.

Nearly all truck models are procured by the armed forces. The major exceptions to this are the 27- to 180-ton-capacity special mining and construction trucks manufactured at the Belorussian truck plant. Moreover, we believe that the armed forces have first call on newly produced trucks

Table B-3
Estimated Deliveries of Trucks to the Soviet Military, 1975-85
(Based on Estimated Military Production)

	Light	Percent of Total	Medium	Percent of Total	Heavy	Percent of Total	Total
1975	24,000	11	153,000	71	39,000	18	216,000
1976	22,000	10	154,000	70	44,000	20	220,000
1977	20,000	9	154,000	70	46,000	21	220,000
1978	20,000	9	156,000	70	47,000	21	223,000
1979	18,000	8	156,000	70	49,000	22	223,000
1980	18,000	8	154,000	70	48,000	22	220,000
1981	15,000	7	151,000	70	50,000	23	216,000
1982	13,000	6	146,000	68	56,000	26	215,000
1983	11,000	5	147,000	67	61,000	28	219,000
1984	11,000	5	146,000	65	68,000	30	225,000
1985	9,000	4	144,000	63	76,000	33	229,000

Table B-4
Estimated Deliveries of Trucks to the Soviet Military, 1975-85

	Light	Medium	Heavy	Total
1975	21,000	137,000	35,000	193,000
1976	19,000	135,000	39,000	193,000
1977	17,000	135,000	41,000	193,000
1978	18,000	137,000	41,000	196,000
1979	16,000	137,000	43,000	196,000
1980	15,000	136,000	43,000	194,000
1981	14,000	137,000	45,000	196,000
1982	12,000	137,000	53,000	202,000
1983	10,000	137,000	57,000	204,000
1984	10,000	138,000	64,000	212,000
1985	9,000	137,000	72,000	218,000