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## Sluggish Soviet Steel Industry Holds Down Economic Growth

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# Sluggish Soviet Steel Industry Holds Down Economic Growth

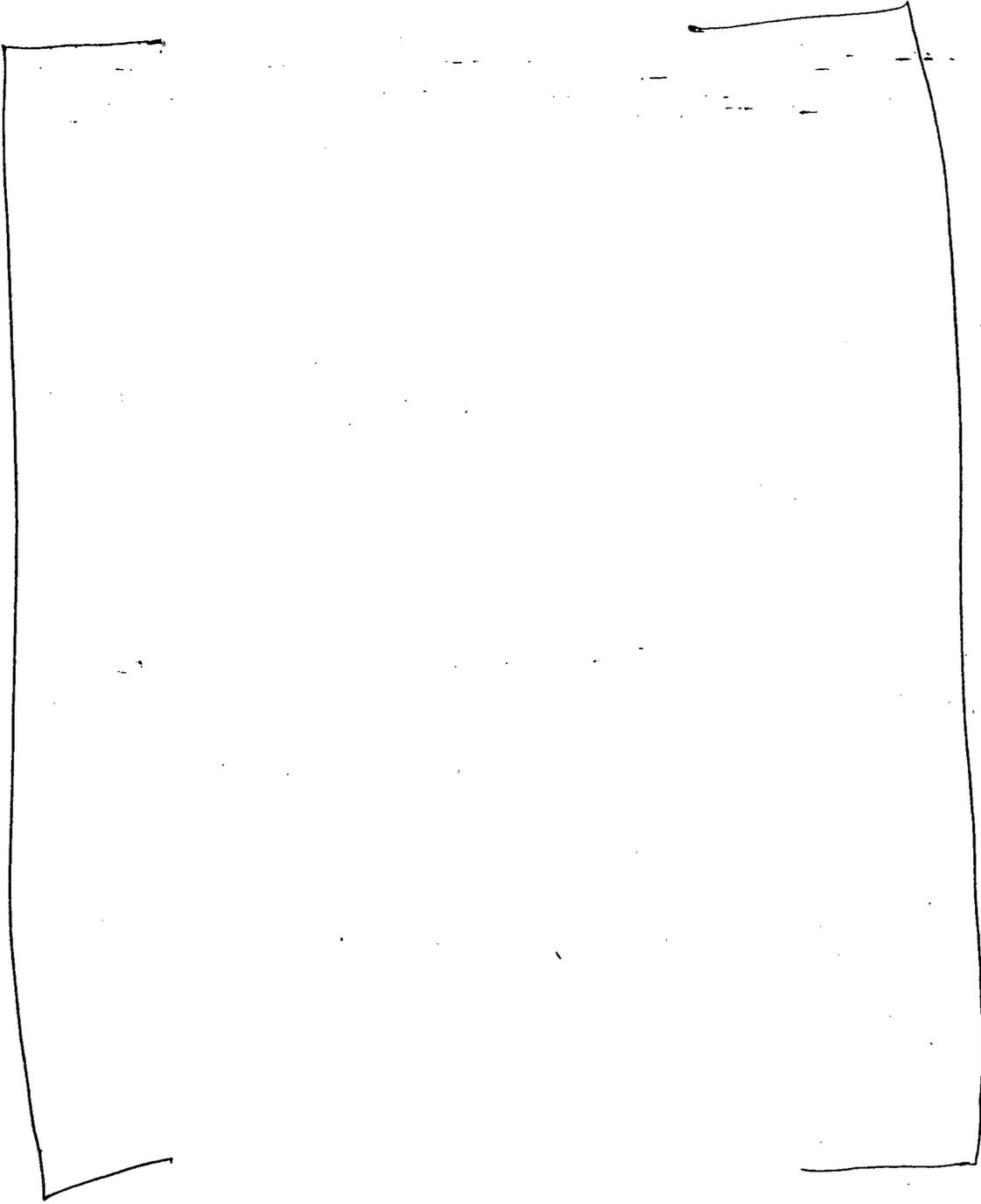
An Intelligence Assessment

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## Sluggish Soviet Steel Industry Holds Down Economic Growth

### Key Judgments

The Soviet steel industry has become a major drag on the economy. Shortages of steel, especially high-quality products, are holding back the growth of civilian machine building and other priority sectors of the civilian economy. Planned cutbacks in the growth of new fixed investment stem in large part from the lack of steel to support construction and the manufacture of producer durables.

The 1981-85 Plan calls for production of crude steel and rolled steel products to increase to 168 million metric tons and 118 million tons, respectively, by 1985--roughly the same level originally planned for 1980. These goals are beyond reach; we estimate that output of crude steel will be about 155 million tons in 1985 and rolled steel output about 108 million tons.

During the early 1980s, at least, lagging steel production could well be the most important bottleneck undercutting Soviet plans to provide steady increases in the production of military hardware while satisfying the demand for consumer durables and investment goods and maintaining exports, primarily to Eastern Europe. Shortfalls in steel production are likely to limit investment in key sectors of the economy such as electric power, transportation, and nonferrous metallurgy. If Soviet steel production continues at its present pace, military requirements could preempt about half of the growth in Soviet production of rolled steel products during the current plan and an even larger share of the increase in output of high-quality steel products.

To fill part of the gap between the supply of and demand for steel products in the USSR, Moscow has turned to Western suppliers. Net steel imports (including pipe) from the West now rank second only to grain in the Soviet import bill. Purchases of steel will have to continue well into the 1980s, aggravating the USSR's prospective hard currency bind.

The main cause of the deteriorating performance of the steel industry is inadequate past investment in all sectors of the industry--from mining to rolling and finishing steel products. Investment allocations have not been enough to support ambitious development plans, partly because real investment costs have been rising and allocations do not stretch as far as before. Although the USSR plans to increase investment in the steel industry by almost one-third in 1981-85 compared with 1976-80, the plan probably understates the amount of new investment required to achieve the

necessary capacity growth. In particular, the imbalances in capacity among the components of the industry—iron ore, coking coal, crude steel, and finished steel—are unlikely to be eliminated over the next several years, because of the long gestation periods involved in bringing new capacity on line.

In addition, shortfalls in the production of coking coal and iron ore and in the collection of scrap metal have pulled steel production down. Raw materials for the steel industry are likely to continue to be tight. As a result, the USSR would have to trim plans for steel production, cut exports, boost imports, or adopt some combination of these options. All of these choices are unpalatable. Shaving production plans would aggravate the steel shortages already plaguing many sectors of the economy. Cutting exports would weaken client states in Eastern Europe. Boosting raw material imports to the level needed to support planned 1985 steel production would cost at least \$2 billion annually at current market prices—this on top of the large amounts the Soviets will have to spend for Western steel products.

Raw materials shortages also will interfere with plans to modernize steelmaking capacity, thus depriving the USSR of potential savings of raw materials, energy, and labor. A longstanding Soviet objective is to replace a large share of older open-hearth furnaces with the basic oxygen furnaces and electric furnaces predominant in the rest of the world. The unpredictability of raw material supplies, however, will force the Soviets to keep the open-hearth furnaces, in which pig iron and scrap metal are completely substitutable.

Large purchases of steel products and Western processing technology will be needed through most of the 1980s at least. Imports of large-diameter pipe figure heavily in Soviet plans for the construction of oil and gas pipelines—including the proposed Siberia-to-Europe line, which will require about 3 million tons of high-quality steel pipe. Until at least the mid-1980s, the Soviets also will need to buy large amounts of cold-rolled steel for machine building, automobiles, and consumer durables, tin plate for canning and packaging, and various types of sheet products for use in transformers and electric motors. During 1981-85 the total value of Soviet steel imports will probably accumulate to about \$17-20 billion (in 1981 prices), substantially more than during 1976-80.

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The USSR is also seeking Western processing technology to reduce its dependence on imports of Western specialty steel and as part of an overall modernization program. The French are building the important Novolipetsk steel plant, which will produce 7 million tons of specialty steels per year when full capacity is achieved (1986 at the earliest). When Novolipetsk is fully operational, the Soviets should be able to reduce, if not eliminate, purchases of many types of Western steel (except large-diameter pipe). The West Germans are building a large steel plant near Kursk with a capacity to produce about 2 million tons annually. This plant, scheduled for completion in the mid-1980s, will use a technology that does not rely on blast furnaces and therefore uses much less coke. Both Novolipetsk and Kursk are critical to Soviet steel development, especially to production of specialty steels.

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## Sluggish Soviet Steel Industry Holds Down Economic Growth

### Introduction

Steel production problems have gained a great deal of attention in the internal debate over Soviet economic policies and have significance for both economic growth and the Soviet balance of payments. An article in *Sotsialisticheskaya industriya* focused on steel's dismal performance in the first two months of 1982:

*The situation in the USSR of ferrous metallurgy has not changed for the better. The metallurgists failed to fulfill the two-month plan in terms of pig iron, steel, finished rolled metal products, and coke. Production of these most important types of output was 4 to 5 percent lower than it was in the same months last year. A shortage of metal is now being felt in all machine-building sectors and in construction, and this is affecting the rhythm and coordination of the work of the entire national economy.<sup>1</sup>*

This report assesses the causes of the current lag in production, giving special attention to problems in the production of iron ore, coking coal, and scrap metal; discusses the impact of raw materials supply on Soviet efforts to modernize steelmaking capacity; and examines some of the adjustments that Moscow has made and will have to make during the 1980s to cope with steel shortages.

### Background

#### Historical Development

By any yardstick, the Soviet iron and steel industry is huge. Crude steel output was 149 million tons in 1981—roughly one-fifth of total world production and some 40 million and 50 million tons more than output in the United States and Japan, respectively (see table 1).<sup>1</sup> The USSR is the world's largest producer of

rolled steel products, steel pipe, coking coal, iron ore, pig iron, and manganese.<sup>2</sup> It has about 40 percent of the world's proven reserves of iron ore and manganese and about 20 percent of the world's reserves of coal, much of which is suitable for coking. In 1980 the Soviet iron and steel industry:

- Accounted for about 6 percent of the total value of industrial output and about 9 percent of the value of industrial capital stock.
- Employed about 1.4 million workers—about 4 percent of the industrial labor force and more than triple the number of ironworkers and steelworkers in the United States.
- Consumed about 10 percent of the Soviet output of electric power and natural gas and about 25 percent of the country's production of coal.<sup>3</sup>

During the same period, the Soviets' ferrous metal sectors included:

- One hundred thirty iron ore mines with a total estimated capacity of 300 million tons of usable ore.<sup>4</sup>
- Ninety-two beneficiating plants to concentrate iron ore for shipment to blast furnaces.
- Thirty-six enterprises (with 138 blast furnaces) to produce pig iron, including the world's largest blast furnace at Krivoy Rog.
- Seventy-six steel mills, including the huge plants at Magnitogorsk and Krivoy Rog, whose total output exceeds the combined steel production of Italy and France (see figure 1).

With the backing of a leadership determined to ensure that there would be enough steel to support a broad range of ambitious military and industrial programs, steel production grew without interruption during 1950-75. The annual increments were steady, averaging about 4 million tons in the 1950s and about 5 million tons from 1960 through 1975. In 1971 the USSR achieved its longstanding goal of surpassing the United States in steel production and becoming the world's largest producer.

<sup>1</sup> This footnote and all subsequent footnotes appear at the end of the text.

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Table 1  
Million Metric Tons  
Soviet, U.S. and Japanese Production of Crude Steel

	USSR	United States	Japan
1950	27.3	87.8	4.8
1960	65.3	90.1	22.1
1965	91.0	119.3	41.2
1970	115.9	119.3	93.3
1975	141.3	105.8	102.3
1980	147.9	101.5	111.4
1981	149.0	108.9	101.2

Source: Data for the USSR are taken from annual issues of *Narodnoye Khozyaystvo SSSR*. Data for the United States and Japan are taken from various issues of the *Annual Statistical Report*, American Iron and Steel Institute. Data for 1981 are preliminary.

#### Production Peaks in Late 1970s

During 1976-80, the Soviet steel industry continued to develop, adding about 134 million tons of raw iron ore capacity, mainly in the Ukraine and Kursk; 5.6 million tons of pig iron capacity; 14.3 million tons of crude steel capacity; and 7.4 million tons of rolled steel capacity (all calculated in terms of potential annual production). Total investment in the iron and steel industry amounted to about 15 billion rubles--6 percent of total Soviet industrial investment and about 25 percent more than allocations to the steel industry during 1971-75.

Despite the capacity buildup, steel production faltered during 1976-80 as all sectors of the iron and steel industry fell considerably short of the original targets for 1980 (see table 2). Production of crude steel climbed from about 141 million tons in 1975 to a peak of about 152 million tons in 1978. Following a downturn in 1979 and 1980, output registered a slight improvement last year (see table 3). In 1980 steel production fell about 17 million tons short of plan. The cumulative gain in production achieved during

Table 2  
Million Metric Tons  
Planned and Actual Steel Production, 1980

	Planned	Actual	Shortfall (percent)
Iron ore	235	245	11
Coking coal	205	178	13
Pig iron	122	107	12
Crude steel	160 to 170	148	10
Rolled steel	115 to 120	103	12*
Steel pipe	19.8	18.1	9

\* Shortfall calculated on the midpoint of the range for the original 1980 target.

1976-80--less than 7 million tons--was not substantially greater than *annual* gains posted during 1960-75. Output of rolled steel products, pig iron, coking coal, and iron ore also has stagnated or declined since 1978.

There is little prospect for a near-term recovery. Indeed, performance in all sectors of the steel industry was lackluster at best in 1981. Production of crude steel rose slightly to 149 million tons, about 8 million tons below the 1981 plan.<sup>7</sup> Output of rolled steel products held at 103 million tons, about the same level achieved in 1977 and 6 million tons short of the 1981 target. Production of iron ore and coking coal leveled off or declined. Output of coking coal dropped to an estimated 175 million tons, about 6 percent below the 1977 peak. Moreover, the availability of scrap metal for steelmaking stagnated during the 1976-80 period at around 75-80 million metric tons.

#### Turnaround in Soviet Trade

The shortfalls in domestic steel production have led Soviet planners to increase markedly their imports from the West--both steel products and Western steelmaking equipment and technology. In 1970 the USSR was a net exporter of steel, but by the late

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Figure 1  
Major Iron and Steel Plants



1970s imports and exports were roughly in balance-- about 7 million tons on each side.<sup>4</sup> Buying expensive steel from the West and selling less expensive types to other Communist countries and the LDCs, however, caused the USSR's annual net steel hard currency import bill to rise from about \$2.5 billion in 1975 to about \$3.5 billion in 1981. Steel now ranks second only to grain in the Soviet import bill.

To compensate for domestic shortcomings, primarily in the production of rolled steel products, Moscow has sought Western steelmaking equipment and technology. Since 1975 the Soviets have spent at least \$1.5 billion on Western technology, primarily from West Germany, France, Italy, and Japan (see table 4). About half of Soviet expenditures since 1975 have been earmarked for the huge Novolipetsk specialty

steel plant, being built by the French, and the large steel plant near Kursk, being built with West German assistance.

**What Went Wrong?**

**Planning Errors**  
Soviet publications advance a number of reasons for the poor performance of the steel industry and the resulting shortages of steel products throughout the economy. A major problem has been the industry's inability to provide a broader assortment of high-quality steel products. This situation did not occur suddenly; it has been emerging for the last 20 years and stems directly from the consistent priority that

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Table 3

Million Metric Tons

Production of Rolled Steel and Related Products<sup>a</sup>

	1975	1976	1977	1978	1979	1980	1981 <sup>b</sup>	1985	
								Plan <sup>c</sup>	Estimated
Crude steel	141.3	144.7	146.7	151.5	149.0	147.9	149.0	168	155
Rolled steel products	98.7	101.4	101.4	105.4	103.2	102.9	103.0	118	108
Steel pipe	15.9	16.8	16.8	17.5	18.1	18.1	18.5	21.9	21
Iron ore	232.8	239.1	239.1	244.2	241.0	245.0	243	275	255
Pig iron	103.0	105.4	107.4	110.7	109.0	107.0	107.0	118	NA
Coking coal <sup>d</sup>	181.0	186.2	186.3	182.0	181.0	178	175	193	170

<sup>a</sup> All data taken from *Narodnoye khozyaystvo SSSR v godu*, unless otherwise indicated.

<sup>b</sup> Preliminary.

<sup>c</sup> Data for rolled steel products based on official Soviet plans. Data for all other products based on recent statements by I. Kazanets, Minister of Ferrous Metals, and *Summary of World Broadcasts*, SU/W1164/A/10, 11 December 1981.

<sup>d</sup> Data for 1975-78 are taken from the No. 4 issue of *Ugol* (the Soviet coal journal). Data for 1979-81 are estimated.

the USSR has given crude steel production. Despite rhetoric to the contrary, little priority has been accorded to improving the quality of steel products and modernizing steelmaking capacity. Thus the Soviets are paying the price for unbalanced investment decisions made at least a decade ago.

Despite the urgent advice of Soviet specialists, progress in reorienting investment priorities has been slow. According to a Soviet analysis, about 90 percent of annual investment in the steel industry in the late 1970s was earmarked for facilities to boost crude steel production.<sup>9</sup> Other studies indicate that if investment priorities were changed in favor of qualitative improvement and modernization, demand for steel products could be met for the foreseeable future with no increase in crude steel production or total capital investment.<sup>10</sup> While these claims may be exaggerated, the industry would benefit greatly from greater steelmaking efficiency.

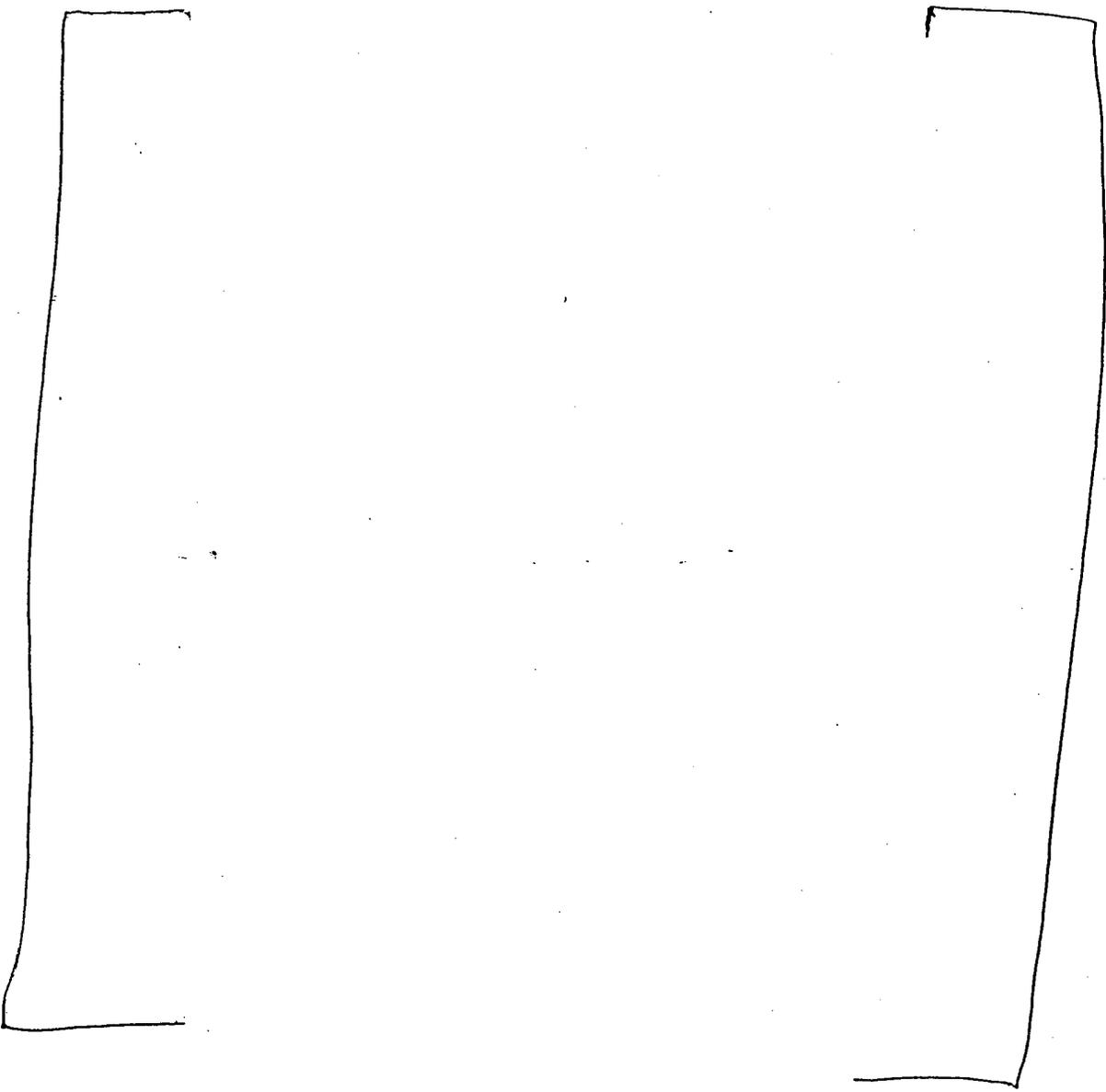
A basic measure of the efficiency of steelmaking operations is the yield obtained in the production of rolled steel products.<sup>11</sup> A longstanding Soviet objective

has been to improve the yield in steelmaking operations to at least the level achieved in the United States. In 1981 the Soviet yield was 69 percent, a ratio that has not changed much since 1950. The yield in the United States and Japan was about 74 percent and 87 percent, respectively, in 1981. In other words, the Soviets had to produce about 1.45 tons of crude steel to obtain 1 ton of rolled product in 1981, compared with about 1.35 tons in the United States and 1.15 tons in Japan.

If the Soviets could increase the yield in steelmaking, they would realize substantial benefits—an increased availability of steel products and a reduction in iron ore, coking coal, and scrap metal requirements. For example, at the 1981 level of production, every percentage point of increase in the yield would result in about 1.5 million tons of additional rolled steel products. Looked at in a different way, if the yield did not increase, an additional 1.5 million tons of rolled steel products could only be obtained by producing an additional 2.2 million tons of crude steel.

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Table 4



Rhetoric aside, Moscow seems not to be counting on an improvement in yield to ease steel shortages, at least during the current plan. Soviet plans call for crude steel production to increase to 168 million tons

by 1985 and rolled steel output to 118 million tons in that year--for an improved yield of about 70 percent.

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### Transportation Bottlenecks

The ferrous metals industry also has been hurt by increasing transportation delays—especially in the rail transport system. Transportation snarls are especially troublesome because Soviet steel plants typically operate with low inventories of iron ore and coking coal. According to the Minister of Ferrous Metals, I. Kazanets, Soviet steel plants normally maintain an iron ore inventory equivalent to 15 days of production. Steel plants in the United States and Japan usually maintain stockpiles adequate for several months. Similarly, Soviet steel plants usually operate with a week's supply of coking coal; US plants normally hold a 60-day stock.<sup>22</sup> Consequently, even small supply disruptions can limit Soviet steelmaking operations. There also have been reports that spot shortages of fuel and brownouts caused by electric power interruptions (the latter caused by transportation foulups) have curbed steel production, mainly in the western USSR. On balance, however, shortages of fuel or electric power probably have not been a primary cause of the shortfalls in Soviet steel production.

Because of transportation delays it is becoming difficult for the Soviets to deliver iron ore to the blast furnaces. The volume and the distance of iron ore shipments have increased greatly, straining an already overtaxed rail transport system. The production deficit in the Urals is especially troublesome for Soviet planners. Iron ore mined in the Urals presently accounts for only half of the region's requirements. For example, about one-third of the annual output of the Kursk Magnetic Anomaly (some 13 million tons) must be shipped to blast furnaces in the Urals, a distance of over 1,000 kilometers. Additional amounts of ore must be shipped to the Urals from the Kola Peninsula, the Ukraine, and Kazakhstan (deliveries of coking coal pose analogous problems, as discussed below). West Siberia also has become more dependent on ore from other regions to meet its requirements. About 3 million tons of ore must be shipped to Novokuznetsk from Rudnyy in Kazakhstan (see figure 2). Because no major expansion is slated in iron ore production in either Siberia or Kazakhstan, the Soviets may have to tap ore producers in the western USSR to provide Siberian blast furnaces with adequate amounts of iron ore.<sup>23</sup>

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Table 5

### Iron Ore Deposits, by Region

	Billion Metric Tons	Percentage Share
Total	63.7	100
Western USSR	41.2	65
Kursk Magnetic Anomaly	16.7	
Krivoy Rog	15.9	
Other	8.6	
Urals	6.1	9
Eastern USSR	16.4	26
Siberia	4.9	
Far East	1.7	
Kazakhstan	7.6	
Other	2.2	

Source: P. A. Shiryayev, *Metallurgicheskaya i ekonomicheskaya otsenka zhelezorudnoi bazy SSSR*, Moscow, 1978, p. 9. See also V. A. Boyarskiy, *Razvitiye otkrytoy dobychi rud*, Moscow, 1975, pp. 28-32.

### Raw Materials Squeeze

During the 1970s, imbalances between steel production and the supply of essential raw materials for steelmaking, which have their origin partly in planning errors and transportation bottlenecks, were the decisive, immediate constraint on the growth of the Soviet steel industry. Problems in providing sufficient iron ore, coking coal, and scrap metal have been building for years and are likely to limit gains in Soviet steel production well into the 1980s.

**Iron Ore Production Stagnates.** The Soviets estimate that their reserves of iron ore are about 60 billion tons—40 percent of the world's total and enough to support the current level of ore production for well over two centuries (see figure 3). About two-thirds of the iron ore reserves are located in the western USSR—mainly at Krivoy Rog and the Kursk Magnetic Anomaly (see table 5). Moreover, about 70 percent of the country's iron ore deposits can be exploited by inexpensive open pit mining methods.<sup>24</sup> Depending on a variety of circumstances, production

Figure 3  
Major Iron Ore and Coking Coal Deposits



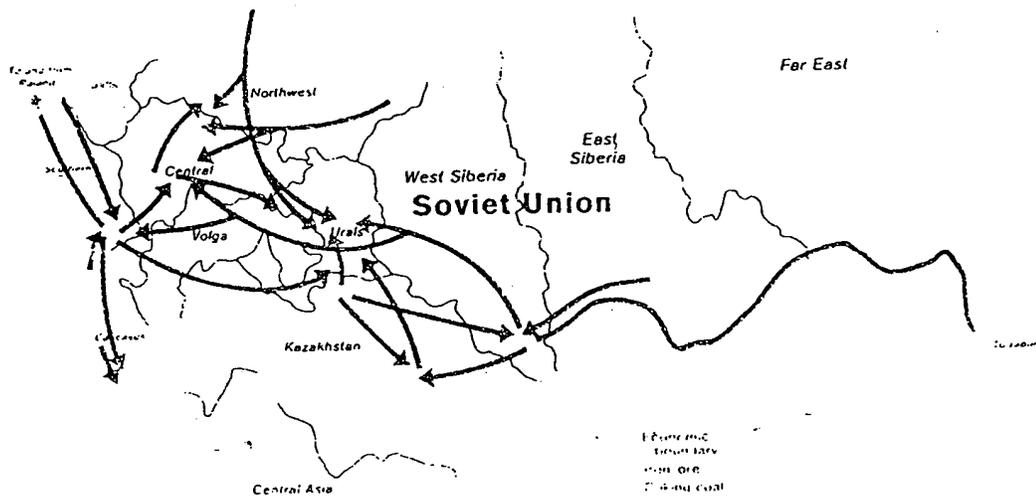
costs at open pit mines can be as little as one-fourth of the cost of underground operation:

During 1976-80, however, the iron ore sector turned in its worst performance since World War II. Output of usable iron ore amounted to 245 million tons in 1980, 12 million tons more than production in 1975, but 30 million tons below plan. Annual increments in production during 1976-80--2.4 million tons-- were only about one-third of the average annual gain registered routinely during 1950-75. Production dropped to 243 million tons in 1981, 2 million tons less than a year earlier, and about 9 million tons below the 1981 target. Production of iron ore has leveled off in the Urals, Krivoy Rog, and the Kursk Magnetic Anomaly--basins that account for about 80 percent of total Soviet iron ore production (see table 6)

The stagnation in iron ore production apparently caught Soviet planners by surprise. As recently as 1977, Soviet officials confidently predicted that production would easily reach 275 million tons by 1980 and 350 million tons by the mid-1980s." They overlooked two unfavorable trends of long standing:

- Annual additions of new mining capacity have been increasingly offset by rising mine depletion in older basins."
- Declining ore grades have resulted in a sharp increase in production costs as well as a growing share of investment that must be devoted to building new ore-enriching facilities.

Figure 2  
Regional Resource Movements in the Iron and Steel Industry



These trends cannot be reversed quickly or cheaply.

Gross annual additions of new iron ore capacity amounted to about 8 million tons of usable ore during 1976-80, about the same amount achieved yearly since the mid-1960s. At the same time, mine depletions rose to about 6 million tons per year during 1976-80, compared with about 3 million tons a decade earlier. The Soviet data suggest that about three-fourths of annual gross additions of new capacity now simply offset mine depletion.

The Soviets are plagued by increasing delays between the announced startup of new mines and the time those mines reach full capacity. These delays are caused by a failure to appreciate the increasingly poor

quality of the iron ore, the greater depths that must be mined, and the increasing investment in ore-enrichment facilities. In 1976 the Soviets announced the startup of new mines at Krivoy Rog and the Kursk Magnetic Anomaly with a combined annual capacity of 12 million tons. By 1979 these mines were producing annually only 4.5 million tons of ore." The Kostomuksha deposit in the Kola Peninsula originally was scheduled to reach full capacity of 24 million tons per year by the mid-1970s. The Soviets now claim that this deposit will be fully operational in 1985

Meanwhile, the average ferrous content of working deposits declined from 50 percent in 1950 to 44 percent in 1970 and 35 percent in 1980." Almost nine-tenths of Soviet iron ore must now be enriched compared with only one-third in the late 1950s."

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Table 6

Million Metric Tons, Usable Ore

Iron Ore Production, by Region <sup>a</sup>

	1970 <sup>b</sup>	1975 <sup>b</sup>	1976 <sup>b</sup>	1977 <sup>b</sup>	1978 <sup>b</sup>	1979 <sup>c</sup>	1980 <sup>d</sup>
Total	196	233	239	240	244	241	245
RSFSR	65	87	90	89	91	91	93 <sup>e</sup>
Eastern USSR	25	45	47	47	49	49	NA
Kola Peninsula	8	10	10	9	10	9	NA
Kursk Magnetic Anomaly	18	36	37	38	40	40	41 <sup>f</sup>
Urals	26	26	27	27	27	27	NA
Siberia	13	16	16	15	15	14	NA
Kazakhstan	18	21	22	23	25	24	26 <sup>g</sup>
Ukraine (Krivoy Rog)	111	123	127	126	127	126	126 <sup>g</sup>

<sup>a</sup> Because of rounding, components may not add to the totals shown.  
<sup>b</sup> *Soviet Geography: Review and Translation*, April 1979, p. 269.  
<sup>c</sup> Data for total production taken from *Narudnoye khozyaystvo SSSR*. Regional breakdown interpolated.  
<sup>d</sup> *SSSR i soyuzniye respubliki v 1980 godu*, Moscow: 1981.

Because of the steady fall in ore quality, the Soviets have had to divert increasing amounts of investment to building beneficiating facilities, raising both costs and labor requirements. Investment in ore beneficiation jumped from about 2 billion rubles during 1970-75 to more than 3 billion rubles during 1976-80.<sup>29</sup> About 70 percent of investment in the iron ore sector currently is going into these facilities, compared with about 40 percent in the late 1960s.<sup>30</sup> There are fewer rubles left for construction of new mines and modernization of older facilities.

The increase in the volume of raw ore that must be processed to obtain a ton of usable ore has resulted in a large rise in real investment costs—to about 102 rubles per ton of usable ore in the late 1970s compared with 61 rubles per ton a decade earlier (see table 9).<sup>31</sup> According to a Soviet estimate the average grade of iron ore will drop by 10 to 15 percent during the 1980s, pushing up costs and investment requirements even more.<sup>32</sup>

To meet the 1985 target for usable iron ore (275 million tons), production would have to increase by about 8 million tons per year during the remainder of

the current plan, roughly three times the average annual increase achieved during 1976-80. Because of the long leadtimes involved between the decision to build a new mine and bringing the mine up to full-capacity operation (seven to 12 years), the Soviets would have to accelerate the completion of new capacity to reach projected 1985 output. Even if the depletion rate does not increase, gross capacity of about 60 million tons would have to be put on line during the current plan (1981-85)—12 million tons per year—to achieve the 1985 target. The USSR never has been able to commission this much capacity in any plan period. Gross annual commissionings averaged about 8 million tons per year during 1976-80, fell to about 6 million tons in 1980, and probably did not exceed 4 million tons in 1981.

Soviet calculations, moreover, indicate that 60 million tons of additional iron ore capacity would require, at a minimum, a capital investment of about 6 billion rubles, which is equivalent to 30 percent of cumulative investment the Minister of Ferrous Metals said

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Table 7

Million Metric Tons

Production of Coking Coal, by Basin \*

	1970	1975	1976	1977	1978	1979	1980	1985	1990
Total <sup>b</sup>	164.8	181.0	186.2	186.3	182	181	178	170	168
Donets	84.3	88.5	89.1	86.8	82	80	74	67	68
Kuznets	46.9	56.1	59.4	59.9	60	60	55	53	53
Karaganda	16.9	18.1	18.9	19.0	19	19	27	26	23
Pechora	12.1	14.1	16.0	16.7	17	18	18	19	19
Other	4.6	4.0	3.8	3.9	4	4	4	5	5

\* Source: 1970, 1975-78 data are from No. 4 issues of Ugol', 1968-78. Because of rounding, components may not sum to the total shown.

<sup>b</sup> Does not include output at Neryungri in the South Yakutsk coal basin. Coking coal production is scheduled to increase to 6 million tons by 1985 and 13 million tons by 1990. All of the output will be exported to Japan under a long-term contract and thus has no effect on domestic supply.

<sup>c</sup> Estimated

was earmarked for the whole ferrous metals sector during 1981-85." (This estimate does not include planned investment for ore beneficiating plants.) The Soviets cannot afford to devote such a large portion of investment to iron ore mining, given competing demands from other sectors of the steel industry

*Falling Production of Coking Coal.* Soviet reserves of coking coal, like the ore reserves, are enormous—65 to 70 billion tons, an amount sufficient to support the current volume of production for well over three centuries." The bulk of Soviet coking coal deposits are located in heavily industrialized regions of the Donets and Kuznets basins close to major blast furnaces.

Nonetheless, during 1976-80 the Soviet coal industry turned in its worst performance in the postwar era. Coking coal production slipped from a peak of 186 million tons in 1977 to 175 million tons in 1981 (see table 7). Production is stagnant or in decline at the Donets and Kuznets basins, which account for nearly three-fourths of Soviet coking coal production

Two developments, similar to those in the iron ore sector, are hampering coking coal production:

- Mining conditions are deteriorating rapidly, especially in the Donets and Kuznets basins.
- Because of insufficient past investment, large amounts of new capacity are not coming on stream fast enough to offset stagnant or declining production elsewhere

In the Donets basin, which currently accounts for about 40 percent of total Soviet coking coal production, mining conditions are among the worst in the world. In terms of mine depth, thinness of the coal seams, and methane concentrations, most of the Donets mines would not belong in the category of proven reserves by Western standards. Production of coking coal in the Donets basin fell from 88 million tons in 1976 to 74 million tons in 1980. We estimate that this decline will continue well into the 1980s and that production will drop below 70 million tons by the end of the decade. At best, the Soviets may be able to stabilize coking coal production in other basins

Falling production in the Donets basin and reduced imports from Poland have hampered production of pig iron and crude steel, especially in the Ukraine where steel production declined by about 6 percent during 1978-80. To offset part of the coking coal shortages in the western USSR, the Soviets have been forced to move coking coal from the Kuznets basin, a distance of about 4,000 kilometers.

The present problems in the coal industry stem from years of insufficient investment allocations. Since the mid-1960s the coal industry has taken a back seat to oil and gas in investment priority. During the last 20 years, investment in oil and gas has increased by about 300 percent and 400 percent, respectively, and investment in the coal industry by only 50 percent. The coal industry's relatively low priority seems likely to continue during the 1980s. Up to three-fourths of the investment in energy during 1981-85 will be devoted to oil and gas, while a large portion of the remainder will go to support Moscow's ambitious nuclear power program. As a result, coal's share of investment in energy will continue to decline.

Because of lagging investment in the coal industry, the introduction of new capacity has slowed. We estimate that about 80 percent of gross annual commissions in the coal industry simply offsets depletion, compared with about 50 percent a decade ago.

*Scrap Metal in Short Supply.* About half of the steel produced in the USSR is smelted from scrap metal, a share that has not changed much in the last decade. According to a Soviet calculation, the cost of producing steel from scrap is about one-fifth that of producing steel from pig iron. Investment per ton of scrap-based steel is claimed to be dramatically less than the investment needed to smelt steel from pig iron, while transport costs to move scrap metal are reported to be far less than the cost of moving iron ore and coking coal. Accordingly, the industry has been urged to use more scrap metal in steel production. This proved to be easier said than done because the supply of scrap metal stayed at about 75-80 million tons per year in the late 1970s.

The lack of success in collecting more scrap metal seems to stem primarily from shortages of equipment to sort scrap metal and shortages of labor, especially skilled engineers. Soviet commentaries indicate that scrap-sorting procedures are slipshod; in many cases, only a perfunctory check is made to determine the type of scrap. Wages in the scrap metal industry are reported to be low by Soviet standards, and it tends to attract low-quality engineers.

Finally, scrap collection is poorly coordinated and ineffective because of the diffusion of responsibility for collection among many ministries for which the assignment is an unwelcome sideline. Press reports cite numerous instances in which scrap metal has been sent hundreds of kilometers to a metallurgical plant even though a similar plant may be nearby but subordinated to a different ministry. Some Soviet studies suggest that the amount of scrap "irretrievably lost" amounts to from 10-20 million tons per year in the machine-building and metalworking (MBMW) sector alone. Because MBMW accounts for about 40 percent of annual Soviet steel consumption, the total amount of scrap metal wasted annually nationwide is much higher.

Planners have complained about tight supplies of scrap metal for years, but in the past, planners had a fallback position. If supplies of scrap became uncomfortably tight, more pig iron could be used in the open-hearth furnaces (OHFs), which operate flexibly on pig iron and scrap. This option has become less available because of tight supplies of pig iron. Shortages of scrap metal curtail the operations of electric furnaces (EFs), which operate almost exclusively on it. These furnaces account for about 10 percent of Soviet steelmaking capacity.

#### Outlook

#### Production

The goals of the 11th Five-Year Plan (1981-85) resemble the production targets originally planned for 1980. Production of crude steel is scheduled to increase to 168 million tons by 1985, some 20 million

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tons more than 1980. Output of both rolled steel products and pig iron is to reach 118 million tons by 1985, while production of coking coal and iron ore is slated to rise by about 10 percent during the same period.<sup>44</sup> These goals are extremely dubious. The increments in production of crude steel, rolled steel, and pig iron would have to triple during 1981-85 compared with the increments during 1976-80. Coking coal production would have to jump by about 15 million tons during the current plan—another goal we consider unrealistic (see table 8). We expect shortfalls in the production of raw materials and in the introduction of new steelmaking capacity as well as stringent investment allocations that will probably limit Soviet production of crude steel and rolled steel products to 155 million tons and 108 million tons, respectively, by 1985—about the same tonnage increase achieved during 1976-80.

**Iron Ore.** We believe that Soviet production of iron ore will not exceed 255 million tons by 1985—about 10 million tons more than the 1980 total but some 20 million tons below the 1985 target. If the Soviets achieve planned 1985 iron ore production—275 million tons—the supply of ore would be sufficient to meet planned steel production in that year and maintain exports at 1980 levels. However, if our production estimate is reasonably accurate, the Soviets face an apparent supply gap of about 20 million tons by 1985.

To help balance domestic supply and demand of iron ore, the Soviets could trim exports (about 45 million tons per year),<sup>45</sup> boost imports (about 2 million tons per year), or try to make greater use of scrap metal in the OHFs and EFs. The last option will probably be limited by tight supplies of scrap metal.

Eastern Europe presently accounts for about 90 percent of Soviet exports of iron ore. The Soviets could cover anticipated domestic requirements by cutting exports to Eastern Europe by 50 percent. But this policy would reduce Moscow's economic leverage over its client states, and any Soviet decision to lower iron ore exports to Eastern Europe is likely to be based mainly on political rather than strictly economic considerations. The Soviets might phase out exports to

Table 8

Million Metric Tons

Actual and Planned Production of Steel and Related Products, 1981-85

	Production		Approximate Increments in Production	
	Actual 1980	Plan 1985	Actual 1976-80	Plan (1981-85)
Crude steel	148	168	7	20
Rolled steel	103	118	4	15
Iron ore	245	275	12	30
Pig iron	107	118	4	11
Coking coal	178	193	-3	15

the West, but the amounts involved are comparatively small—about 3 million tons per year—and most of the shipments are covered by long-term contracts

Although the Soviets could boost imports of iron ore, an increase from about 2-million tons in 1980 to 20 million tons by 1985 would push the cost up to roughly \$1 billion at current market prices. The Soviets in fact have been negotiating with Brazil to import iron ore in return for Soviet-manufactured products. Although the possibility of a sharp jump in Soviet iron ore imports cannot be dismissed, we still consider it unlikely because of the hard currency stringencies the USSR will face during the 1980s

Unless some remedy is taken, lagging production of iron ore would by itself limit Soviet steel production to 160 million tons by 1985, some 8 million tons less than planned. This estimate assumes that supplies of coking coal and scrap metal are adequate to meet the planned goal for steel production

**Coking Coal.** The Soviets will need about 210-215 million tons of coking coal to meet the 1985 Plan for steel production and to hold allocations to other industrial users at 1980 levels, including export commitments. To reach this goal, Soviet production of coking coal would have to increase by about 35

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million tons by 1985. If our estimate of mine depletion is reasonably correct, gross commissionings of new capacity would have to jump to about 170 million tons during 1981-85. Such an amount is unrealistic; it is almost twice the total commissionings in the coal industry during 1976-80 (including commissionings of steam coal). According to a rough calculation, the Soviets would have to invest from 5-9 billion rubles during 1981-85 to support commissionings of coking coal at this level.<sup>47</sup> The implied volume of investment is also unrealistic; at the upper end of the range it is about equal to total cumulative investment in all sectors of the coal industry during 1976-80

Coking coal production probably will decline from about 175 million tons in 1981 to less than 170 million tons by the late 1980s because of reduced production in the Donets basin. As in the case of iron ore, the Soviets will be forced to adjust by trimming plans for steel production, increasing imports, cutting exports, changing the pattern of domestic allocations, or adopting some combination of these options

Although we cannot predict how the Soviets will deal with shortages of coking coal, we can size the problems planners face. If the needs of the steel industry are fully met and the demands of all other consumers are held at or near 1980 levels (including export commitments), Soviet imports of clean coking coal would be about 30 million tons by 1985, about triple the average annual imports during the 1970s.<sup>48</sup> At current market prices—\$60 per ton—these imports would cost nearly \$2 billion. If imports are not increased and the needs of the steel industry are fully met, coking coal allocations to nonsteel users would have to be cut by 25 percent by 1985—an infeasible solution since these sectors include electric power, petrochemicals, and nonferrous metals. Conversely, if allocations to nonsteel users are held at 1980 levels and imports are not increased, the supply of coking coal available for ferrous metallurgy would drop by about 4 percent by 1985, compared with 1980.

The USSR could also trim exports, especially to Eastern Europe, to help avert part of the supply crunch. This policy, however, would aggravate an already unstable situation caused by uncertainties in coal exports from Poland—a major supplier to other

East European countries. Some reductions in sales to hard currency countries are possible but would not help much; the amounts involved are small. Moreover, most Soviet coking coal exports to hard currency countries are covered by long-term contracts

*Investment.* The priority to be given to investment in the steel industry is still unclear. In early 1981 Minister of Ferrous Metals I. Kazanets said that investment in the industry would increase by 30 percent during 1981-85 compared with that during 1976-80, suggesting cumulative investment would have to be about 20 billion rubles in the current plan.<sup>49</sup> More recently, however, President Brezhnev announced that total fixed investment in the country would be cut by 30 billion rubles during 1981-85. Whether this overall cut would affect allocations for ferrous metals is unknown. The Soviets claim in addition that the share of investment allocated for improvement in quality of steel products will be doubled during the 1981-85 Plan, with emphasis on substantially increasing production of cold-rolled steel, large-diameter steel pipe, and transformer steel.<sup>50</sup> Such claims, however, are not new; they have been a hallmark of Soviet plans since the mid-1960s.

We think, however, that because capital costs are increasing rapidly, investment increments at least on the order of those suggested by Minister Kazanets would be needed to recover the pre-1975 momentum of the industry. Indeed, according to Soviet studies investment requirements have been climbing in all important activities of steelmaking since the mid-1960s (see table 9). Investment per ton of rolled steel has almost doubled in the last 15 years. The Soviets cite a number of reasons for the increase in investment requirements. In ore mining, the steady decline in the average grade of the ore resulted in a 70-percent increase in investment per ton of ore during the 1970s alone. Although progress has been slow, the Soviets are producing relatively more sophisticated steel products (for example, cold-rolled sheet and tin plate) which requires additional rolling equipment, labor, and energy. Meanwhile, air and water pollution control equipment are taking a greater share of annual investments. The Soviets report that about 5

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percent of annual investment in the steel industry is currently earmarked for pollution control; as recently as the mid-1960s the Soviets probably invested even less in pollution control equipment.

#### Raw Materials Shortages Hold Back Modernization

Tight supplies of raw materials will retard the modernization of Soviet steelmaking capacity. A long-standing objective has been to replace much of the largely obsolete open-hearth-furnace steelmaking capacity with the basic oxygen furnaces (BOF) and electric furnaces that are dominant in the rest of the world. Nonetheless, open-hearth furnaces still account for most of Soviet steel output. The BOF, despite its low operating cost and higher efficiency, requires about one-half more pig iron per ton of steel than an OLF. To the extent that pig iron output is held back by slow growth in iron ore and coking coal supplies, conversions to the BOF will be delayed. Similarly, the availability of scrap metal will limit the pace at which the Soviets can install new EF capacity. Despite the fact that the EF requires less labor and is easier to maintain, it uses about twice as much scrap per ton of steel as an OLF and nearly five times more than a BOF (see table 10). Therefore, the Soviets will probably continue to rely heavily on the OLF, which operates flexibly on pig iron or scrap metal.

According to original Soviet plans, electric furnace capacity was to increase by 60 percent during 1981-85—an increase from roughly 15 million tons in 1980 to more than 25 million tons in 1985.<sup>17</sup> This total probably includes about 2 million tons of new electric furnace capacity scheduled for the Stary Oskol plant near Kursk. Stary Oskol will use a direct-reduction iron process that eliminates the need for blast furnaces. In this process, an iron sponge with a ferrous content of about 92 percent is produced, which can be used in electric furnaces with small amounts of scrap metal. Originally set for completion in 1979, the plant is unlikely to begin turning out steel before 1985 because of construction problems.<sup>18</sup> Aside from Stary Oskol, Soviet plans call for installation of about 5-6 million tons of scrap-based electric furnace capacity by 1985. To do this, however, would entail the commissioning of as much new electric furnace capacity during 1981-85 as was installed during the last decade, an unlikely outcome.<sup>19</sup> Part of the Soviet plan,

Table 9

Ruble

#### Real Capital Investment Per Ton of Additional Iron and Steel Capacity

	ton Ore <sup>a</sup>	Crude Steel	Rolled Steel Products <sup>d</sup>
1966-70	61	431.3	543
1971-75	NA	586.1	797
1976-80	102	760.5	1,065

<sup>a</sup> Although the sources are not specific, we believe that these prices are 1969 estimate prices for construction and 1973 wholesale prices for equipment adjusted by 1976 coefficients for construction and installation work.

<sup>b</sup> *Planovoe khozyaystvo*, No. 8, 1979, p. 56.

<sup>c</sup> *Vestnik akademii nauk SSSR*, No. 10, 1981, p. 72.

<sup>d</sup> N. P. Banny, *Ekonomika chernoy metallurgii SSSR*, Moscow, 1978, p. 137.

for example, hinges on commissioning three scrap-based electric furnace plants in Moldavia, Belorussia, and the Soviet Far East. These plants, which will have a combined annual capacity of 1.5 million tons and require a capital investment of about 1 billion rubles, are scheduled for completion in 1984.<sup>20</sup> But because work on these plants still has not begun and construction times are long, the plants probably will not be fully operational until the late 1980s at the earliest.

We believe that because of stringencies in scrap metal supply, the Soviets will be able to commission no more than 3 million tons of new electric furnace capacity by the mid-1980s. This new capacity would increase annual scrap metal demand by more than 2 million tons—about 50 percent of the increment in scrap metal supply the Soviets are likely to achieve by 1985. We project that the supply of scrap metal will increase from about 78 million tons in 1980 to 82 million tons in 1985, or an annual growth of about 1 percent. Various Soviet sources suggest that the supply of scrap metal increased by about 1 percent during 1976-80. A Soviet estimate indicates that the supply of scrap metal will have to increase to about 90 million tons by 1985, roughly 3 percent per annum, to meet fully the needs of the steel industry in that year.

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Table 10

Pig Iron and Scrap Metal Requirements, by Type of Steelmaking Furnace

Type of Furnace	Kilograms/ Metric Ton	Pig Iron		Scrap Metal		
		Pig Iron Charge as a Percent of Total Metal Charge	Estimated Soviet Use (percent)	Kilograms/ Metric Ton	Scrap Metal Charge as a Percent of Total Metal Charge	Estimated Soviet Use (percent)
Open-hearth	600	0 to 100	55	500	0 to 100	45
Basic oxygen	925	70 to 80	80	215	20 to 30	20
Electric	150	0 to 15	13	990	85 to 100	87

Source: Battelle Columbus Laboratories, *Energy Efficiency in Soviet Ferrous Metallurgy*, 15 October 1980.

We believe this target is unrealistic unless Moscow takes unusually tough measures to marshal additional resources behind a stepped-up scrap metal recovery campaign.<sup>24</sup> In particular, increased scrap metal recovery will entail a sharp jump in rail haulage and possibly the diversion of additional highly trained labor. If scrap metal supplies became tight enough, the Soviets could trim exports, presently some 1-2 million tons per year.<sup>25</sup> Like reductions in exports of iron ore and coking coal, such a cutback would most seriously affect Eastern Europe.

The share of steel produced in BOFs and EFs was to rise to 32 percent and 12 percent, respectively, by 1980, while the OHF share was scheduled to drop to about 56 percent.<sup>26</sup> But these goals were not achieved (see table 11). In 1980 the OHF still accounted for over 60 percent of Soviet steel production, much more than other major steel-producing countries. In the 1981-85 Plan, the shares of steel produced in BOFs and EFs are to increase to 33 percent and 16 percent, respectively; by 1985 the OHF share is supposed to drop to about 50 percent. The plan implies about a 15-million-ton increase in BOF-based steel, a 10-million-ton jump in EF-based steel, and a 5-million-ton drop in OHF steel, presumably by retiring some of the oldest OHF capacity.

Although the Soviets must modernize their steelmaking capacity, we doubt that much progress is possible during the current plan. More likely the share of steel

produced in BOFs probably will not change much during 1981-85 because of raw material constraints. The Soviets should be able to raise the share of EF steel from about 10 percent in 1980 to 13 percent in 1985—only about half of the planned increase. The share of OHF steel probably will fall from about 61 percent in 1980 to 58 percent in 1985, still far higher than in other steel-producing countries.

In effect, by neglecting modernization, the Soviets seem to have painted themselves into a corner. They must modernize the steel industry to break the current logjam in production. At the same time, the Soviets will have to defer any major program to modernize steelmaking capacity as long as uncertainties exist in the supply of iron ore, coking coal, and scrap metal.

**The Military Factor**

If our production estimates are accurate, steel will become an even greater bottleneck in the economy during the 1980s. Because of the importance of steel to economic growth, shortfalls in production will force cutbacks in key sectors of the civilian economy—transport, electric power, and nonferrous metals. Moreover, shortages of steel in the civilian economy are likely to be exacerbated by the steady increase in military requirements for steel products. The military preempted about 10 percent of Soviet production of

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Table 11

Percent

Soviet, U.S. and Japanese Steelmaking Capacity, by Type of Furnace

	USSR					United States 1980	Japan 1980
	1975	1980 Plan	1980 Actual	1985 Plan	1985 Estimate		
Open-hearth	65	56	61	51	58	12	0
Basic oxygen	25	32	29	33	29	61	75
Electric	10	12	10	16	13	27	25

Source: Data for the USSR are based primarily on *Kommunist vesozhennik st.*, No. 15, 1981, pp. 21-23. Data for the United States and Japan taken from the *Annual Statistical Report*, American Iron and Steel Institute, 1980.

rolled steel products in 1981—roughly 10 million tons. We believe that Soviet production of rolled steel products will increase at most by 5 million tons during 1981-85 over the level of 1980. If allocations for the military grow in line with overall projected growth in defense spending during 1981-85—about 4 percent per year—military requirements for rolled steel products could increase to about 12 million tons by 1985. In other words, larger military requirements could account for as much as 40 percent of the total increase in rolled steel production. For certain types of the highest quality steel products—high-tensile-strength alloys and superhard steel—the military's share of the increase would be even higher.

**Imports as a Safety Valve**

Imports of steel products and Western technology will be one of the options open to Moscow in dealing with problems in the steel industry. The viability of this option will depend upon how severe the hard currency shortages will be and the priority accorded the iron and steel sector.

Imports of large-diameter steel pipe will be critical for the construction of oil and gas pipelines. The proposed gas export pipeline alone will require about 3 million tons of steel pipe. We estimate that the Soviets will need to import at least 3 million tons of steel pipe per annum during the 1980s for all of their scheduled

pipelines. At current market prices—\$550 per ton—the cost of imported pipe could amount to about \$16 billion during the 1980s.

This projection assumes that the Soviets will not be able to produce pipe comparable in quality to imported pipe for the foreseeable future and that the Soviets would not forgo pipe imports in favor of domestically produced pipe that operates at lower pressures. The imported 56-inch pipe operating at 75 atmospheres of pressure can deliver about 35 billion cubic meters of gas per year. The best the Soviets have available is a 48-inch pipe operating at 75 atmospheres or a 56-inch pipe operating at 55 atmospheres. These pipes can deliver about 19 billion and 21 billion cubic meters of gas per year, respectively.<sup>4</sup> In other words, the Soviets would have to produce nearly twice as much pipe to deliver the same amount of gas the imported pipe can handle. In terms of steel requirements, for every ton of pipe not imported, the Soviets would have to produce and install about 1.7 to 1.8 tons.

The Soviets will continue to buy, at least until the mid-1980s, large amounts of cold-rolled sheet steel for machine building, automobiles, and consumer durables, tin plate for canning and packaging, and various types of high-quality products for use in transformers and electric motors. Imports of these steel products

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amounted to about \$2 billion in 1981, and purchases are expected to remain at least at this level until 1985. At current market prices, the steel import bill will accumulate to an estimated \$17.20 billion during 1981-85. If the Soviets decided to import iron ore, coking coal, and scrap metal in the amounts necessary to meet planned 1985 steel production, the 1981-85 import bill would climb to over \$25 billion. We doubt that the Soviet hard currency situation will be promising enough to allow them to import all these items, particularly when coupled with their need for grain and machinery. We expect that the Soviets will have less than \$20 billion available for steel imports."

The USSR will also need access to Western processing technology to reduce its dependence on imports of Western specialty steel and as part of an overall effort to modernize domestic steelmaking capacity. The French are helping to build the important Novolipetsk steel plant, which will produce 7 million tons of specialty steel per year when full capacity is achieved (1986 at the earliest). When Novolipetsk is fully operational, the Soviets may be able to eliminate purchases of many types of Western steel (other than large-diameter pipe). The West Germans are building a large plant near Kursk that reportedly will produce 2 million tons of steel per year when full capacity is achieved—perhaps by 1985. This plant will use the direct-reduction iron process, which eliminates the need for blast furnaces and thus lowers the need for coking coal. Both Novolipetsk and Kursk are critical to Soviet steel development plans, especially for specialty steels

If hard currency shortages force the Soviets to limit steel imports, Moscow could cut back production and cancel or stretch out projects that require large amounts of steel. Private automobiles, for example, account for about 2 to 3 percent of annual Soviet steel consumption, largely in the form of cold-rolled sheet steel which, in turn, is a major Soviet import." Moscow might therefore cut back on automobile production, reduce imports of cold-rolled sheet somewhat, and channel a greater portion of domestically produced sheet into higher priority applications. Similarly, the Soviets could stretch out plans for the completion of the Baikal-Amur Mainline railroad (BAM). Every kilometer of track requires about 150 tons of steel rails; completion of the BAM network will require about 500,000 tons of rails. Additional amounts of steel will be needed to build the bridges, tunnels, and ancillary facilities related to this project.

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## Footnotes

\* *Sovietisticheskaya Industriya*, 16 March 1982.

\* In connection with this paper, the development of the Soviet ferrous metals industry during 1975-85 was investigated using a large-scale multiregional, cost-minimizing linear programming model. The model was used to help identify critical resource constraints on steelmaking in 1980 and 1985, and to estimate maximum feasible crude steel production in 1985. The model results were consistent with production estimates derived independently. A research paper (to be published) provides a detailed description of the model.

\* Crude steel is the product in the first solid state after melting. All data on steel production refer to crude steel, unless otherwise indicated.

\* Pig iron is produced in blast furnaces, using coking coal, iron ore, and limestone. Coking coal is the chemical agent used to reduce the iron ore. Manganese is an additive used in any type of steel production to remove oxygen from the molten steel.

\* N. P. Banny, et al. *Ekonomika chernoy metallurgii*, Moscow, 1978, p. 5; K. I. Zhilyaev, et al. *Ekonomiya materialnykh resursov chernoy metallurgii*, Moscow: 1979, p. 5; and *Gazovaya promyshlennost*, June 1978, p. 10.

\* Usable iron ore is raw ore that has been cleaned and is suitable for concentration or direct shipment to blast furnaces. Raw ore is the product first extracted from the mine. It includes rock, dirt, and other debris.

\* The 1981 plan set the following targets: crude steel, 156.8 million tons; rolled steel products, 109 million tons; and iron ore, 252 million tons. See *Kommunist vooruzhennikh sil*, No. 15, 1981, pp. 18-23.

\* The Soviets suspended reporting on steel trade in 1976. Thus, judgments on the volume of steel trade since 1976 must be considered rough approximations, subject to a range of error of at least 1 million tons on both the import and export side.

\* N. F. Sklokin, *Ekonomicheskiye problemy povysheniya kachestva i razvitiya sortamenta chernikh metallov*, Moscow: 1979, p. 6.

\* *Kommunist*, No. 13, 1979, p. 17.

\* The yield is the ratio of production of rolled steel to production of crude steel. The yield is determined in part by the composition of the steel product mix. Because a large share of Soviet steel output consists of relatively simple types of products, their yield may never equal that of the United States or Japan.

\* See *Soviet Geography: Review and Translation*, April 1979, p. 270.

\* G. A. Braun, *Zhelezorudnaya baza chernoy metallurgii USSR*, Moscow, 1970, p. 5.

\* See, for example, *Gorniy zhurnal*, No. 11, 1977.

\* Depletion is defined here as the amount of capacity lost because of mine exhaustion and the lower productivity of older mines that are still operating.

\* See, for example, *Pravda*, 2 April 1979 and *Pravda*, 29 October 1979.

\* *Politicheskoye samoobrazovaniye*, No. 4, 1981, p. 13 and *Gorniy zhurnal*, No. 1, 1981, pp. 3-7.

\* K. I. Zhilyaev, *op. cit.*, p. 72.

\* *Gorniy zhurnal*, No. 1, 1979, pp. 1-3, and *Gorniy zhurnal*, No. 1, 1981, pp. 1-5.

\* *Ibid.*

\* *Planovoye khozyaystvo*, No. 7, July 1981, pp. 31-33.

\* *Planovoye khozyaystvo*, No. 12, December 1981, p. 28.

\* Calculated on the basis of a real investment cost of 102 rubles per ton of usable ore. Many of these projects have long leadtimes; therefore some of the investment that will result in increased capacity during the current plan was allocated during 1976-80. By the same token, some investments during 1981-85 will not result in new capacity until later plan periods.

\* I. I. Novitskiy, *Energoticheskoye toplivo SSSR*, Moscow: 1979, pp. 10-14. See also V. A. Shelest, *Regionalnyye energoekonomicheskiye problemy SSSR*, Moscow: 1978, pp. 113-116.

\* A major use of coking coal is to chemically reduce iron ore in blast furnaces. The Soviets use about half a ton of coking coal per ton of pig iron.

\* For a detailed assessment of the outlook for Soviet coal production see, *USSR: Coal Industry Problems and Prospects*, FR 80-10154 (Unclassified), March 1980.

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" In addition Soviet imports of coke and coke products from Poland averaged about 9 million tons per annum during 1972-79. Imports fell to about 5 million tons in 1980 and probably dropped further in 1981.

" The approximate distance between Washington, D.C. and Los Angeles, California.

" See [ ] March 1980, pp. 5-6 for an explanation of the methodology to estimate mine depletion in the coal industry. The estimates for mine depletion include both steam and coking coal. Since 1978, the Soviets have suspended detailed reporting for steam and coking coal. Our analysis may understate the severity of the depletion problem with respect to coking coal because the bulk of Soviet production comes from basins where the depletion problem appears most severe.

" G. A. Norotkov, et al, *Vtorichnye chernye metally*, Moscow: 1979, p. 5.

" *Pravda*, 22 January 1979, p. 1.

" *Voprosy ekonomiki*, No. 10, 1981, p. 122. The primary reason for lower investment is that electric furnaces are less costly than open-hearth furnaces.

" *Stal'*, No. 8, 1979, p. 572.

" A. Voronov, USSR Deputy Minister of Ferrous Metallurgy, *Pravda*, 9 June 1979, p. 2.

" *Ibid.*

" *Voprosy ekonomiki*, No. 7, 1979, pp. 35-66. See also *Sovetskaya Rossiya*, 24 March 1982, p. 1.

" N. P. Banny, *op. cit.*, p. 4.

" Goals for crude steel, pig iron, iron ore, and coking coal are based on statements by the Minister of Ferrous Metals reported in *Agitator*, No. 13, 1981, pp. 31-33. See also, *Summary of World Broadcasts* [ ] 11 December 1981, for details. The plan for rolled steel production is based on Soviet goals for the 11th Five-Year Plan.

" This total includes both concentrated iron ore and iron ore pellets.

" This estimate is based on the most recent available data on investment per ton of coal at selected Soviet basins. In the mid-1970s, such investment was 55 rubles and 30 rubles at the Donets and Kuznets basins, respectively. See *Planovoye khozyaystvo*, No. 6, 1975, p. 66 for details.

" This section presents some key findings of earlier research. For details and explanation of the methodology, see *The Soviet Coal Industry: An Update*.

" *Agitator*, No. 13, 1981, pp. 31-33.

" *Sotsialisticheskaya Industriya*, 3 January 1982, p. 1.

" See *Planovoye khozyaystvo*, No. 3, 1977, p. 124, for details.

" *Summary of World Broadcasts*, 27 November 1981, p. A14. A more recent source states that the Soviets are planning a 50-percent increase in electric furnace capacity during 1981-85. See, *Stal'* No. 3, 1982, p. 2 for details.

" *Energy Efficiency in Soviet Ferrous Metals*, Battelle Columbus Laboratories, 15 October 1980, p. 47.

" *Soviet Geography: Review and Translation*, September 1981, pp. 448-452.

" *Stal'* No. 8, 1979, p. 572.

" This estimate is a rough approximation. Hard data on Soviet scrap exports have not been available since 1976. Exports amounted to 1.8 million tons in that year.

" *Stal'*, No. 2, 1979, p. 117.

" *Stroitelstvo turboprovodov*, No. 5, 1981, p. 14.

" *Avionobilnaya promyshlennost'*, No. 11, 1979, p. 8.

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